

**Forage yield, chemical composition and morphogenesis of *Brachiaria brizantha* cv. Piatã
under regrowth periods**

**Rendimento de forragem, composição química e morfogênese de *Brachiaria brizantha*
cv. Piatã sob períodos de rebrota**

**Rendimiento de forraje, composición química y morfogénesis de *Brachiaria brizantha* cv.
Piatã bajo períodos de rebrote**

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Abstract

With the objective to evaluate the effects of regrowth period (14, 21, 28, 35 and 42 days) on green dry matter yield (GDMY), chemical composition and morphogenetic and structural characteristics of *Brachiaria brizantha* cv. Piatã, was carried out an experiment under greenhouse with natural conditions of light and temperature. GDMY yields and regrowth, leaf blade length, and leaf lifespan rate increased consistently ($P<.05$) with regrowth period, however the nitrogen, phosphorus, magnesium and potassium contents decreased as regrowth period, while calcium contents were not affected by regrowth period. Maximum GDMY, leaf appearance and elongation rate, and leaf blade length were obtained with regrowth periods at 38.2; 41.1; 31.3 and 38.9 days, respectively. These data suggest that cutting at 35 to 42 regrowth days were optimal for obtain maximum yields and regrowth of rich forage and pasture persistence.

Keywords: chemical composition; green dry matter; leaves

Resumo

Com o objetivo de avaliar o efeito do período de rebrota (14, 21, 28, 35 e 42 dias) sobre a produção e composição química da forragem e características morfogênicas e estruturais de *Brachiaria brizantha* cv. Piatã foi realizado um experimento em casa-de-vegetação sob condições naturais de luminosidade e temperatura. O aumento do período de rebrota resultou em maiores ($P<0,05$) rendimentos de forragem e vigor de rebrota, contudo implicou em decréscimos significativos dos teores de nitrogênio, fósforo, magnésio e potássio, enquanto que os de cálcio não foram afetados. As taxas de senescência foram diretamente proporcionais aos períodos de rebrota, ocorrendo o inverso quanto à taxa de aparecimento de folhas. Os maiores rendimentos de forragem, taxas de aparecimento e de expansão foliar e o tamanho médio de folhas foram obtidos, respetivamente, aos 38,2; 41,1; 31,3 e 38,9 dias, respectivamente. O período de descanso mais adequado para o manejo de pastagens de *B. brizantha* cv. Piatã, visando a conciliar produção, vigor de rebrota e qualidade da forragem, situa-se entre 35 e 42 dias.

Palavras-chave: composição química; folhas; matéria seca verde

Resumen

Para evaluar el efecto del período de rebrote (14, 21, 28, 35 y 42 días) sobre la producción de forraje y la composición química y las características morfogénicas y estructurales de

Brachiaria brizantha cv. Piatã fue se realizo un experimento en invernadero bajo condiciones naturales de luz y temperatura. El aumento del período de rebrote resultó en mayores rendimientos de forraje ($P < 0,05$) y vigor de rebrote, sin embargo, implicó disminuciones significativas en los contenidos de nitrógeno, fósforo, magnesio y potasio, mientras que los niveles de calcio no se vieron afectados. Las tasas de senescencia fueron directamente proporcionales a los períodos de rebrote, ocurriendo lo inverso en cuanto a la tasa de aparición de hojas. Los mayores rendimientos de forraje, tasas de aparición y de expansión de las hojas y y el tamaño promedio de las hojas se obtuvieron, respectivamente, en 38,2; 41,1; 31,3 y 38,9 días de rebrote, respectivamente. El período de descanso más adecuado para pasturas de *B. brizantha* cv. Piatã, con el objetivo de conciliar la producción, el vigor del rebrote y la calidad del forraje, se sitúa entre 35 y 42 días de rebrote.

Palabras clave: composición química; hojas; materia seca verde

1. Introduction

The experiment was conducted with the objective of evaluating the effect of rest periods on the productive performance of tropical pastures in soils under forest vegetation from Amazon. In the tropical regions, pastures cultivated represent the most economical source for feeding cattle. However, given the climatic oscillations, fodder production during the year has seasonal fluctuations, abundance during the rainy season (October to May) and deficit in the dry season (June to September), which negatively affects the productivity indexes Animal (Costa et al., 2009).

The use of appropriate management practices is an alternative to reduce the effects of seasonality in forage production. The growth stage at which the plants was harvested directly affects the yield, chemical composition, regrowth capacity and persistence (Dim et al., 2015; Paiva et al., 2019). Cuts or less frequent grazing provide greater forage yields, however, concomitantly decreases occur accented in their chemical composition, with greater deposition of fibrous material, decrease in leaf/stem ratio (Costa et al., 2007; Pereira, 2013; Nascimento et al., 2019). Therefore, one must seek the balance between yield and forage quality, to ensure the nutritional requirements of animals while securing the persistence and productivity of pastures.

The productivity of forage grasses stems from the continuous emission of leaves and tillers, important process for the restoration of leaf area after cutting or grazing and ensuring its sustainability. The formation and leaf development are essential for plant growth, given the

role of leaves in photosynthesis, starting point for the formation of new tissues (Paiva et al., 2019). Grass morphogenesis during vegetative growth can be characterized by three factors: the rate of appearance, elongation rate and longevity of the leaves. The appearance rate and longevity of the sheets will determine the number of living leaves/tiller (Nabinger & Carvalho, 2009; Taiz et al., 2017; Avelino et al., 2019). These characteristics are determined genetically and can be affected by environmental factors and management practices.

This study evaluated the effects of rest period on the forage production, regrowth, chemical composition and morphogenetic and structural characteristics of *Brachiaria brizantha* cv. Piatã.

2. Methodology

The research was performed under controlled conditions using the quantitative method. As there are still gaps about the effect of the rest period on the productive performance of tropical pastures, it was decided to use the hypothetical-deductive method (Pereira et al., 2018).

The experiment was conducted in a greenhouse using a Yellow Latosol, clay texture, forest phase, which had the following chemical characteristics: pH = 5.1; Al = 1.1 cmol/dm³; Ca + Mg = 2.3 cmol/dm³; P = 3 mg/kg and K = 87 mg/kg. The experimental design was in randomized blocks with three replications. The treatments consisted of five rest periods (14, 21, 28, 35 and 42 days). The establishment fertilization consisted of 40 and 44 mg/dm³ of phosphorus and nitrogen in the form of urea and triple superphosphate, respectively. The grass standardization cut was performed 35 days after thinning the plants at a height of 10 cm above the ground.

The parameters evaluated were green dry matter yield (GDMY), leaf appearance rate (LAR), leaf expansion rate (LER), leaf senescence rate (LSF) and leaf blade length (LBL). The LER and LAR were calculated by dividing accumulated leaf length and total number of leaves in tillers, respectively, by regrowth period. The LBL was determined by dividing the total leaf elongation of the tillers by the number of leaves. The grass regrowth vigor was evaluated through the production of GDMY at 21 days after the first cut.

The LSR was obtained by dividing the length of the leaf that was yellowish or necrotic by the regrowth period. N contents were analyzed according to the procedures described by Silva & Queiroz (2002); while the contents of P, Ca, Mg and K were determined according to

the methodology described by Silva (2009). P and K contents were quantified after nitroperchloric digestion. P was determined by colorimetry; K by flame photometry and Ca and Mg contents by atomic absorption spectrophotometry.

Data were subjected to analysis of variance and regression considering the significance level of 5% probability, using the Sisvar statistical analysis program (Ferreira, 2011). To estimate the response of the evaluated parameters, as a function of the rest periods, the choice of regression models was based on the significance of the linear and quadratic coefficients by Student's t-test at 5% probability.

3. Results and Discussion

Table 1 shows the effects of rest periods on GDMY productivity and chemical composition of grass. The GDMY were significantly ($P < 0.05$) enhanced with plant regrowth age and the highest values were obtained with cuts at 35 (8.80 g/pot) and 42 days (8.01 g/pot) (Table 1). The relationship between regrowth periods and GDMY was fitted to the quadratic regression model, being described by the equation $Y = 6.324 + 0.7724 X - 0.01012 X^2$ ($R^2 = 0.91$), and the maximum value obtained at 38.2 days. Similar results were reported by Costa et al. (2009) evaluating different genotypes of *B. brizantha* at different plants ages cuts.

Table 1. Green dry matter yield (GDMY), regrowth vigor, concentrations of nitrogen (N), phosphorus (P), calcium Ca), magnesium (Mg) and potassium (K) of *Brachiaria brizantha* cv. Piatã, as affected by rest periods.

Rest period (days)	GDMY (g/pot)	Regrowth vigor (g GDMY/21 days)	N	P	Ca	Mg	K
			----- g/kg -----				
14	2.91 d	1.84 c	21.68 a	1.62 a	4.98 a	3.73 a	17.33 a
21	4.53 c	3.11 b	20.16 a	1.58 ab	4.92 a	3.53 ab	16.98 a
28	7.72 b	4.61 a	17.33 b	1.54 b	4.81 a	3.17 bc	16.54 a
35	8.80 a	5.19 a	14.88 c	1.51 b	4.77 a	2.89 c	15.22 b
42	8.01 ab	4.37 a	11.93 d	1.47 c	4.70 a	2.83 c	14.09 c

- Means followed by the same letter do not differ ($P > .05$) by Tukey test.

SOURCE: Research Data

The regrowth vigor was significantly ($P < 0.05$) affected by the regrowth period, with higher GDMY yields obtained with cuts at 28, 35 and 42 days, which did not differ ($P > 0.05$).

The effect of regrowth plant age was adjusted by quadratic regression model and described by the equation $Y = -3.25 + 0.4317 X - 0.0054664 X^2$ ($R^2 = 0.96$) and the maximum GDMY of regrowth estimated at 33.8 days. Costa et al. (2007) noted that the maximum regrowth vigor of *Brachiaria humidicola* occurred between 28 and 35 days after cutting the grass plants. Regrowth speed is highly correlated with the preservation of apical meristems, because with their preservation the formation of photosynthetic tissues occurs through the expansion of new leaves, while with the removal of apical meristems the new growth depends on the development of new buds, notably of basal origin, for leaf production (Difante et al., 2011; Cunha et al. 2012).

The calcium contents were not affected ($P > 0.05$) by the regrowth period, while the N, P, Mg and K decreased with the advance of the grass growing stage, evidencing a dilution effect of its contents with the increase of the forage yield. The effect of regrowth period was linear and negative, being described by the equation $y = 27.11 - 0.3539 x$ ($r^2 = 0.98$); $y = 1.69 - 0.005285 x$ ($r^2 = 0.97$); $y = 5.12 - 0.01014 x$ ($r^2 = 0.98$); $y = 4.20 - 0.03486 x$ ($r^2 = 0.96$) and $y = 19.32 - 0.117 x$ ($r^2 = 0.94$), respectively to the levels of N, P, Ca, Mg and K. In general, higher concentrations were recorded with regrowth periods between 14 and 28 days (Table 1).

Table 2 reports the effects of rest periods on the morphogenetic characteristics of the forage grass. The relationship between regrowth periods and the LAR, LER and LBL was adjusted to quadratic regression model, defined respectively by the equations: $Y = 0.27 - 0.005153089 X + 0.0000626826 X^2$ ($R^2 = 0.98$); $Y = 1.11 X + 0.093937 X - 0.001501429 X^2$ ($R^2 = 0.96$) and $Y = 4.38 + 0.4510157 X - 0.005797727 X^2$ ($R^2 = 0.97$). The maximum values for LAR, LER and LBL were obtained at 41.1; 31.3 and 38.9 days, respectively (Table 2). In pastures of *B. humidicola* and *Brachiaria dictyoneura*, Costa et al. (2009) found higher LER in the period between 21 and 28 days of regrowth. The LAR, LER and LBL obtained in this study, regardless of the regrowth periods were higher than reported by Difante et al. (2011), evaluating *B. brizantha* cv. Marandu in field conditions under different intervals between cuts, estimated average values of 0.083 leaves/tiller/ day; 1.61 cm/day/tiller and 18.59 cm for LBL.

Table 2. Leaf appearance rate (LAR), leaf elongation rate (LER), leaf blade length (LBL)

and leaf senescence rate (LSR) of *Brachiaria brizantha* cv. Piatã, as affected by rest periods.

Rest period (days)	LAR (leaves/day/tiller)	LER (cm/day/tiller)	LBL (cm)	LSR (cm/day/tiller)
14	0.214 a	2.13 a	9.8 c	--
21	0.190 b	2.45 a	11.2 b	--
28	0.178 c	2.52 a	13.1 a	0.074 b
35	0.171 cd	2.61 a	13.8 a	0.087 a
42	0.166 d	2.43 a	14.0 a	0.098 a

- Means followed by the same letter do not differ ($P > .05$) by Tukey test.

SOURCE: Research Data

The LER, due to its high correlation with biomass production, has been used as a criterion for the selection of forage germplasm (Pedreira et al., 2009). In this study, the correlation between GDMY and LER was positive and not significant ($r = 0.77$; $P > 0.05$), whereas with the LAR has significant negative correlation ($r = -0.93$; $P < 0.01$). The LER and the LAR explained in 59 and 86%, respectively, increments in GDMY, depending on the age of the plants. The LAR directly affects the three structural characteristics of turf: leaf size, tiller density and number of leaves/tiller (Lemaire et al., 2011; Dim et al., 2015). The correlation between LAR and LER was negative and significant ($r = -0.82$; $P < 0.05$). According Pereira (2013), LAR and the LER have a negative correlation, indicating that the higher the LAR, the less time is available for plant elongation.

LSR was affected ($P < 0.05$) by resting period; the senescence process only occurred after 21 days of regrowth, with the highest rates observed at 42 and 35 days resting period (Table 2), which were lower than those reported by Difante et al. (2011) for *B. brizantha* cv. Marandu, who obtained LSR of 0.102; 0.109 and 0.170 cm/day/tiller, respectively for plant cuts with three, four and five leaves emerged, which had an average leaf lifespan of 65.1 days. Gonçalves (2002) estimated at 34.4; 43.1; 45.5 and 48.4 days leaf lifespan of *B. brizantha* cv. Marandu, respectively managed at 10, 20, 30 and 40 cm above soil ground level.

Leaf senescence is a way for a plant to recycle some of the valuable and often scarce mineral nutrients, such as N and P. Senescence is a natural process that characterizes the last phase of development of a leaf, which begins after the complete expansion of the first leaves, whose intensity increases progressively with the increase of the leaf area, which implies the shading of the leaves inserted in the leaf. lower portion of the stem (Pedreira et al., 2009; Lemaire et al., 2011). The last stage of leaf development is its senescence, which is a natural

process started after its full expansion and progressively incremented with the increase of the leaf area, as a result of the shading of the leaves inserted in the lower portion and the low supply of photosynthetically active radiation. besides strong competition between tillers for light, nutrients and water in the most diverse strata of the plant (Nabinger & Carvalho, 2009).

When reaching a leaf number (LN) in each tiller, the balance between the LAR and the senescence of the leaves that exceeded its life period is established, so that a new leaf appears, the senescence of the preceding leaf is necessary, in order to maintain relatively constant the LN (Lemaire et al., 2011). Senescence negatively affects forage quality, however it represents an important physiological process in grass tissue flow, remobilizing about 35; 68; 86 and 42% of N, P, Ca and Mg, respectively, of senescent leaves and used for the production of new leaf tissues (Sarmiento et al., 2006; Costa et al., 2014). In this work, a reduction in macronutrient levels was observed with the increase of the rest period. However, there is some mechanism of translocation between the old leaves and the new leaves in expansion, since the macronutrient levels did not fall below the critical levels which could make forage productivity unfeasible.

4. Final Considerations

The increase in the rest period resulted in higher GDMY and plant vigor regrowth, however caused significant decreases in N, P, K, Mg contents, while Ca content was not affected.

The leaf blade length and senescence rate were directly proportional to the rest period, while the opposite occurred on the leaf appearance rate, while the leaf expansion rate was not affected by rest period.

In the management of *B. brizantha* cv. Piatã pastures, in order to obtain higher GDMY, plant regrowth vigor and forage quality, it is suggested rest periods between 35 and 42 days.

Experiments are suggested under field conditions and preferably with the use of animals in order to endorse the recommended rest periods for the grass.

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