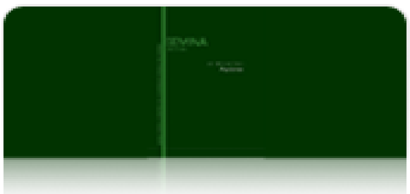

Semina: Ciências Agrárias
ISSN: 1676-546X
semina.agrarias@uel.br
Universidade Estadual de Londrina
Brasil

Fernandes Rodrigues, Luan; dos Santos, Antonio Clementino; Silveira Junior, Otacílio; Donizetti dos Santos, José Geraldo
Productivity of Urochloa brizantha 'Marandu' influenced by strategic rest periods and nitrogen levels
Semina: Ciências Agrárias, vol. 38, núm. 5, septiembre-octubre, 2017, pp. 3203-3213
Universidade Estadual de Londrina
Londrina, Brasil

DOI: 10.5433/1679-0359.2017v38n5p3203

Productivity of *Urochloa brizantha* 'Marandu' influenced by strategic rest periods and nitrogen levels

Produtividade de *Urochloa brizantha* cv. Marandu influenciada por estratégias de período de descanso e doses nitrogenadas

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Abstract

The effects of two strategic rest periods and associated nitrogen levels on the agronomic and productive characteristics of *Urochloa brizantha* 'Marandu' were evaluated. The trial was conducted in a completely randomized 4 × 2 split-plot design, with four blocks. The treatments consisted of associations between two rest periods and four nitrogen levels. The rest periods included one at the end of 28 days (RP_{28days}) and another when the canopy height was 40 cm (RP_{40cm}) and nitrogen levels of 0, 150, 300, and 450 kg N ha^{-1} $year^{-1}$ was applied as ammonium sulfate. The following variables were evaluated: rest period (RP) per cycle, total dry matter (TDM), dry matter (kg ha^{-1}) and proportion (%) of leaf blade (LB), stem, and senescent material (SM), tiller mass, forage density, leaf area index, height, leaf:stem ratio, and crop growth rate (CGR). The variables height, TDM, LB dry matter, stem dry matter, CGR, and forage density exhibited a linear relationship with RP_{28days} and a quadratic relationship with RP_{40cm} with increasing N levels. The proportions of LB and stem had linear relationships with N levels for RP_{28days} and RP_{40cm}. The leaf:stem ratio was affected by increasing N levels and it fit the quadratic model for both rest strategies. The SM proportion had a quadratic relationship only with RP_{28days}. The tiller mass had a linear relationship with RP_{28days}, whereas SM dry matter showed a linear relationship for RP_{40cm}. The use of the RP_{40cm} reduced the period needed to begin a new grazing cycle. The level of 450 kg N ha^{-1} is recommended for RP_{28days} and levels between 380 to 400 kg N ha^{-1} provided better results for RP_{40cm}.

Key words: Grazing frequency. Grazing interval. Rotational grazing.

Resumo

Objetivou-se avaliar os efeitos de duas formas de período de descanso combinado com doses de nitrogênio nas características agronômicas e produtivas do capim *Urochloa brizantha* cv. Marandu. O experimento foi conduzido em delineamento em blocos casualizados em arranjo com parcelas subdivididas 4x2, com 4 blocos. Os tratamentos consistiram de combinações entre dois períodos de descanso e quatro doses de nitrogênio, sendo os períodos de descanso de 28 dias (PD_{28dias}) e altura de 40 cm (PD_{40cm}) e as doses de nitrogênio de 0, 150, 300 e 450 kg de N ha^{-1} ano^{-1}, aplicadas na forma de sulfato de amônio. As variáveis estudadas foram: período de descanso (PD) por ciclo, massa seca total (MST), massa seca (em kg ha^{-1}) e proporção (em %) de lâmina foliar (LF), colmo e material morto (MM), massa por perfilho, densidade de volume de forragem, índice de área foliar (IAF), altura, relação folha:colmo e taxa de crescimento cultural (TCC). As variáveis altura, MST, massa seca de LF, massa seca de colmo, TCC e densidade de forragem

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Received: May 23, 2017 Approved: Aug. 03, 2017

apresentaram comportamento linear para PD_{28dias} e quadrático para o PD_{40cm} com crescentes doses de N. As proporções de LF e colmo apresentaram comportamento linear com as doses de N para PD_{28dias} e PD_{40cm}. A relação folha:colmo apresentou efeito com as doses de N, se enquadrando no modelo quadrático para ambos as formas de período de descanso. A proporção de MM apresentou comportamento quadrático somente no PD_{28dias}. A massa por perfilho apresentou efeito linear para o PD_{28dias}, enquanto a massa seca de MM apresentou efeito linear para o PD_{40cm}. O uso do PD_{40cm} permitiu reduzir o tempo de espera para o aproveitamento da forragem nas parcelas. A dose de 450 kg de N ha^{-1} é recomendada para o PD_{28dias} e doses entre 380 a 400 kg de N ha^{-1} permitiram melhores resultados para PD_{40cm}.
Palavras-chave: Frequência de pastejo. Intervalo de pastejo. Pastejo rotativo.

Introduction

Urochloa brizantha 'Marandu' is a widely distributed grass in Brazil because of its high adaptability to soil and climatic conditions in the country, especially in the Cerrado. Pastures of the genus *Urochloa* are known to have high forage dry matter (DM) production and, generally, these species have medium to high nutrient requirements. Therefore, strategies are necessary to maintain productivity through the replacement of nutrients withdrawn from livestock grazing, avoiding long-term degradation (ARTUR, 2011). Contemporary approaches to the consumer market dictate the need for environmentally friendly and sustainable production, imposing trade barriers on markets that do not conform to consumer expectations (WALKER et al., 2013) and obliging farmers to invest in known practices and methods that allow higher use efficiency of agricultural inputs and higher system productivity (CARVALHO; ZABOT, 2012; VALENTIM; ANDRADE, 2009).

Among the macronutrients needed for plants, nitrogen is significant in plant production and its absence often limits the development of aerial growth, as well as the root system. The importance of nitrogen fertilization has been emphasized for higher forage growth rate and increased productivity, and therefore, increased carrying capacity for grazing (MESQUITA et al., 2010; FIALHO et al., 2012). Despite the importance of fertilization in rotational grazing systems, other environmental factors affect production in this type of system, influencing forage quantity and quality (DOS ANJOS et al., 2016). Losses in plant or animal production are typically determined using the standard method of pasture occupation based on fixed intervals (days), usually 30 days (PEREIRA et al., 2015).

Therefore, pasture management as a function of canopy height may be ideal because of its correlation with the photosynthetic capacity of the plant to recover from losses caused by grazing, and because this variable is correlated with 95% light interception, which is considered ideal for animal grazing (CARNEVALLI et al., 2006; DA SILVA et al., 2015). Gimenes et al. (2011) concluded that the pre-grazing height of 25 cm in a rotating system with Marandu grass exhibited the best results among all nitrogen levels tested, demonstrating that adequate pasture management is essential for productive responses to nitrogen fertilization.

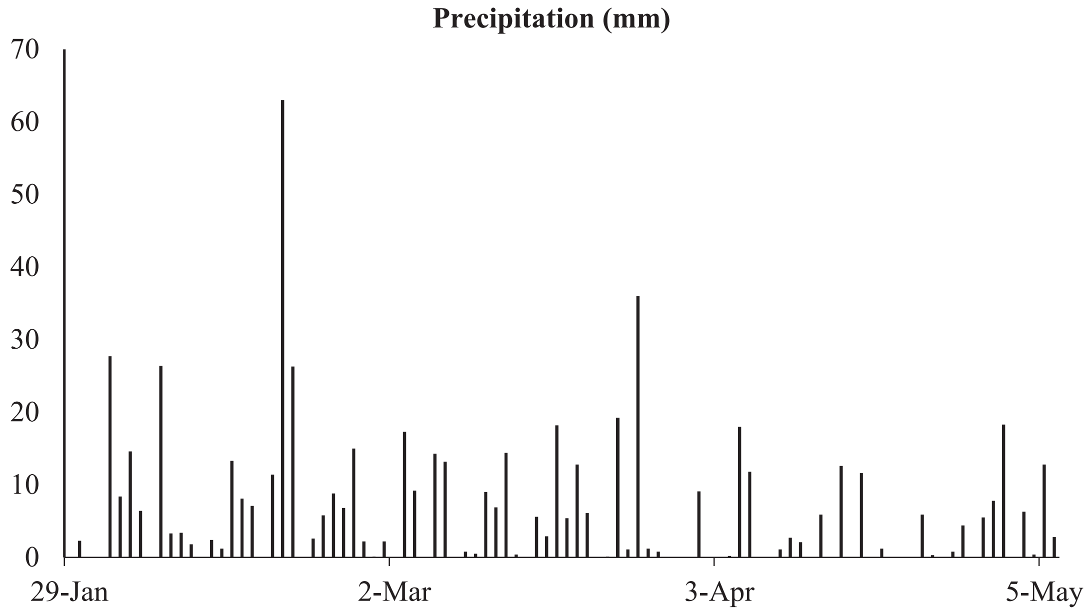
Thus, the goal of this study was to evaluate the effects of two strategic rest periods associated with nitrogen levels on the agronomic and productive characteristics of *Urochloa brizantha* 'Marandu'.

Material and Methods

The trial was conducted at the School of Veterinary Medicine and Animal Science of the Federal University of Tocantins - UFT, Araguaina – TO, located at 07°12′28″S and 48°12′26″W, from January 2015 to May 2015. Cuttings were performed from February 2015 to May 2015, and the mean results of the cycles of each treatment were used. The natural vegetation is characterized by the ecotone Amazon Forest-Cerrado. The altitude is 277 m and the climate of the region, according to Köppen (1948), is classified as Aw (hot and humid, with well-defined seasons) with an average annual precipitation of 1828 mm. The average temperature and relative humidity are 26° C and 76%, respectively. Figure 1 shows the precipitation data during the experimental period.

The soil of the experimental area was classified as Typic Orthic Quartzarenic Neosol (EMBRAPA, 2013). Samples were taken from 0 to 20 cm depth to verify soil fertility at the beginning of the trial, and the analyses were performed at the Laboratory of Soil, Faculty of Animal Science/PGCAT at UFT. The results are provided in Table 1.

Figure 1. Precipitation data from January to May 2015.



Source: INMET, 2015.

Table 1. Chemical characteristics of the soil from the experimental area before the trial.

pH $CaCl_2$	OM	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	ECEC	$CEC_{pH7.0}$	Al sat	BS
	g dm^{-3}	mg dm^{-3}	----------------------------$cmol_c$ dm^{-3}----------------------------								------%------	
4.78	17.0	13.1	0.08	1.44	0.61	0.05	3.34	2.12	2.17	5.46	2.30	38.83

SB = Sum of bases; OM = Organic matter; ECEC = Effective cation exchange capacity; $CEC_{pH7.0}$ = Cation exchange capacity at pH 7.0; Al sat = Aluminum saturation; BS = Base saturation.

After soil characterization, 1.0 t ha^{-1} of limestone (RTNP = 90%) was used to correct the soil. The area of pasture was already established with Marandu grass, divided into plots of 6 × 3 m (18 m²), and these were subdivided into subplots of 3 × 3 m (9 m²). In addition, 80 kg ha^{-1} P_2O_5 and 100 kg ha^{-1} K_2O were applied as single superphosphate and potassium chloride, respectively (CFSEMG, 1999). The fertilizers were mixed and were distributed homogeneously by hand in each plot. Phosphate fertilization occurred in a single application at the beginning of trial, whereas potassium fertilization was divided into two applications.

The experimental design was a completely randomized 4 × 2 split-plot design, with four blocks. The treatments consisted of combinations between two rest periods and four nitrogen levels. The established rest periods included a fixed period at the end of 28 days (RP_{28days}) and a rest period when average canopy height in the subplot reached 40 cm (RP_{40cm}). Thus, the sampling period (in days) differed between the variable cycle and the fixed period. Nitrogen levels (0, 150, 300, and 450 kg N ha^{-1} $year^{-1}$) were applied as ammonium sulfate.

At the end of each production cycle, a cutting was performed and the height of the plot was measured with a measuring tape. The canopy height of systems with variable day cycles was monitored daily and was then represented by the average of 10 readings in each plot. Subsequently, the vegetative material was collected using a 0.5 m^2 square and a harvesting machine at 20-cm height above the soil surface (CAMARGO, 2010). Then, the material was homogenized using a brush cutter and the sampled plots were cleaned with a rake.

After sampling and weighing the green forage, subsamples of approximately 300 g were taken. These were placed in plastic bags, properly identified, and taken to the laboratory to calculate the leaf area index, and separate the leaf, stem + sheath, and senescent material to evaluate the agronomic characteristics. Subsequently, the components were weighed, packed in paper bags, and placed in a forced-air ventilation oven, with a temperature between 58 and 65° C for 72 h to obtain their dry masses. The following variables were evaluated: rest period (RP) per cycle, total dry matter (TDM), dry matter (kg ha^{-1}), and proportion (%) of leaf blade (LB), stem, and senescent material (SM), tiller mass, forage density, leaf area index (LAI), height, leaf:stem ratio, and crop growth rate (CGR).

Data were submitted to the appropriate statistical analyses to calculation descriptive statistics and test for normality, followed by an analysis of variance (ANOVA). When the ANOVA was significant ($P < 0.05$), comparisons by F-test were conducted for the main effects and the interaction of these effects. The variables that were shown to be affected by nitrogen in the ANOVA were submitted to regression analysis using polynomial models, considering the significance level of the F-test and the coefficient of determination. The Sisvar software (version 5.1) was used to perform the analysis.

Results and Discussion

All variables differed significantly ($P < 0.05$) between the rest periods. No significant interactions between nitrogen levels and rest periods ($P > 0.05$) were detected for the proportions of leaf, stem, and senescent material, senescent material DM, and leaf:stem ratio (Table 2). Only the number of tillers did not produce a significant change ($P > 0.05$) in the fit of the regression model for nitrogen levels. Table 2 shows that all variables were influenced in diverse ways when submitted to different rest strategies, illustrating that the type of management adopted affects agronomic and productive results of Marandu grass.

Means differed between RP_{28days} with RP_{40cm}, with higher means for RP_{40cm} (Table 2). This resulted because of the effect of the longer period (in days) at lower N levels on the overall mean for RP_{40cm} and, because more days were required to reach the mean height of 40 cm, mean days was higher (35.3 days) than that of RP_{28days}. However, the regression model applied for this variable (Figure 2a) demonstrated a linear reduction of days to RP_{40cm} with increasing N levels, allowing a new grazing cycle before the method based on fixed days (RP_{28days}) in some cases. The ideal point for grazing was influenced by environmental conditions that were not controlled in this trial, such as water availability.

The LAI (Figure 2b) was influenced by N levels, exhibiting a linear relationship with RP_{28days} ($P < 0.01$) and RP_{40cm} ($P < 0.05$). Although RP_{28days}

exhibited an increase of 85.48%, RP_{40cm} showed a reduction of 18.06% when comparing the treatments without fertilization and with 450 kg N ha^{-1}. Height is an essential tool in pasture management because it is easy to measure and it has practical applications. In addition, height is correlated with structural characteristics of the pasture and forage mass. A positive linear response ($P < 0.01$) was observed with N levels for RP_{28days} and a quadratic response for RP_{40cm} (Figure 2c). Fertilization with 450 kg N ha^{-1} (43.30 cm) promoted an increase of 45.74% in Marandu grass height compared to 0 kg N ha^{-1} (29.71 cm) in RP_{28days}. Regarding RP_{40cm}, the level of 381.25 kg of N ha^{-1} resulted in the maximum response in height, being 42.25 cm. However, because the intention was to evaluate the resting period (in days) at 40 cm, the results were within the range of the desired height.

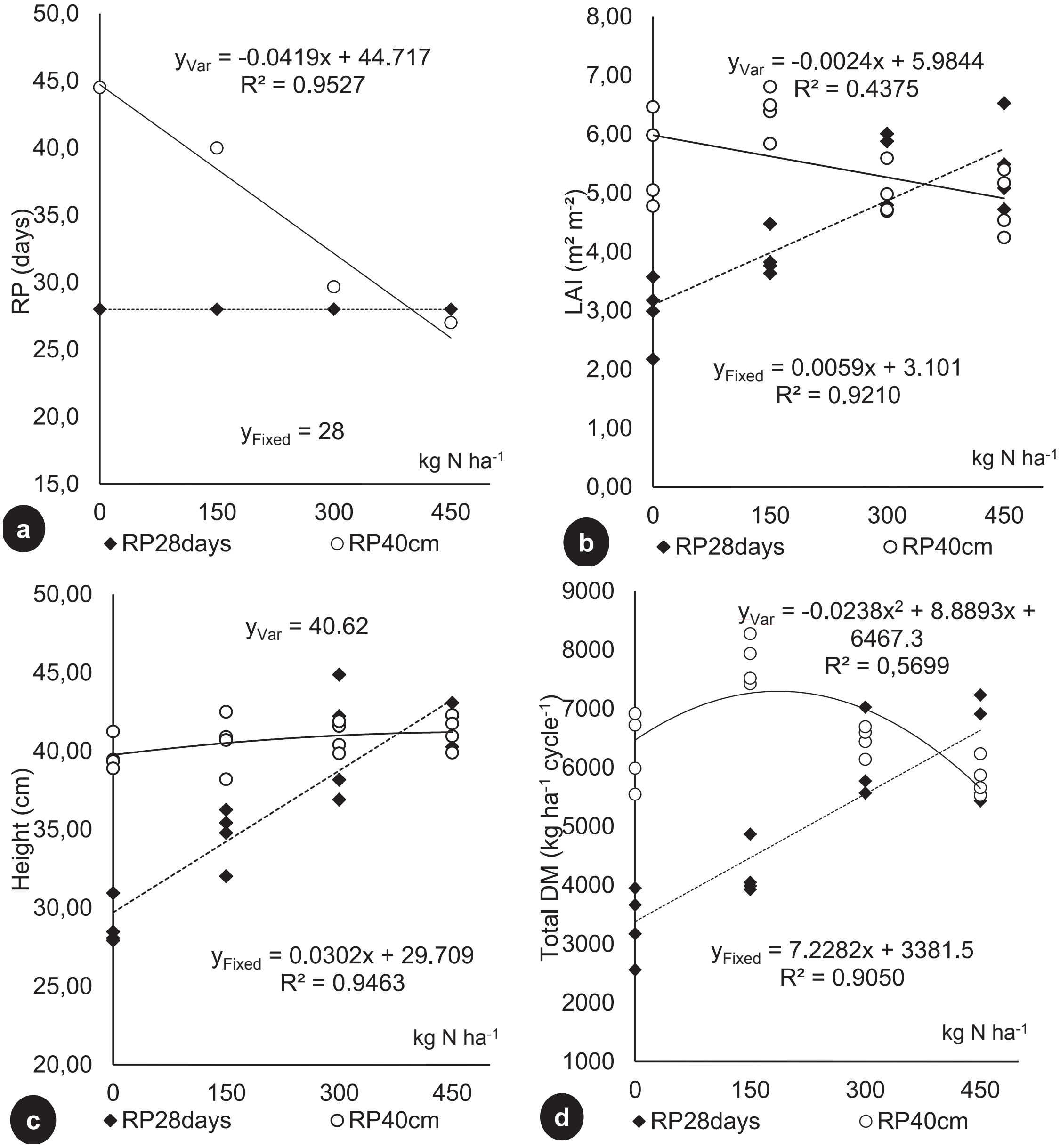
Table 2. Means, coefficients of variation (CV), and P values for rest period per cycle (RP), total dry matter (TDM) proportion and dry matter of leaf blades (LB), stem, and senescent material, leaf:stem ratio, height, forage density, leaf area index, tiller mass, and crop growth rate of Marandu grass treated with different rest periods.

			P value		
Variable	**RP_{28days}**	**RP_{40cm}**	**RP¹**	**RP x L²**	**CV (%)**
RP (days)	28.0	35.3	>0.0001	>0.0001	0.00
TDM	5007.9	6592.4	>0.0001	>0.0001	8.83
LB (%)	79.58	71.19	>0.0001	0.4828	3.37
Stem (%)	15.30	21.41	>0.0001	0.8153	12.99
Senescent material (%)	5.12	7.40	0.0001	0.1287	17.37
LB (kg ha^{-1})	3930.28	4701.62	0.0002	>0.0001	9.65
Stem (kg ha^{-1})	832.47	1407.86	>0.0001	0.0021	13.97
Senescent material (kg ha^{-1})	245.11	482.93	>0.0001	0.0655	19.61
Leaf:stem ratio	6.40	3.83	0.0002	0.0705	26.20
Height (cm)	36.50	39.74	>0.0001	0.0001	3.51
Forage density	134.92	166.20	>0.0001	>0.0001	7.41
LAI	4.42	5.45	>0.0001	>0.0001	6.80
Tiller mass	1.08	1.55	>0.0001	0.0003	14.14
CGR	178.85	192.43	0.0430	0.0295	9.14

¹RP = Rest period; ²L = Nitrogen level.

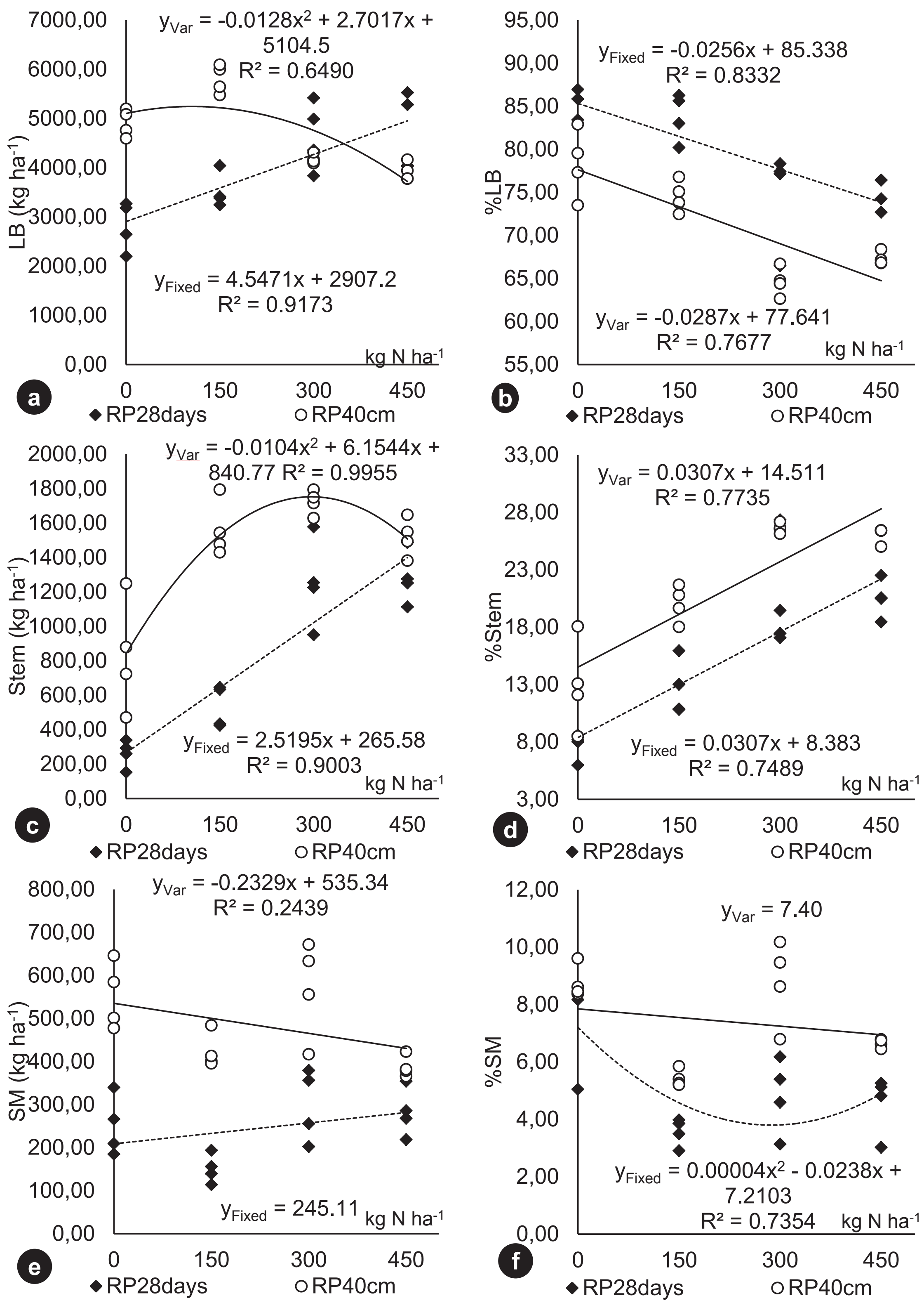
TDM was affected ($P < 0.01$) by both RP strategies with increasing N application (Figure 2d). TDM for RP_{28days} exhibited a linear behavior, with minimum and maximum values of 3381.5 and 6634.2 kg ha^{-1} $cycle^{-1}$, respectively, corresponding to a 96% increase in TDM production. This suggests that the increase in nitrogen levels allowed greater recovery and phytomass production in the cutting interval under RP_{28days} management. The RP_{40cm} fit the quadratic model and the level for maximum production was 186.75 kg N. Benett et al. (2008) verified a decrease in dry matter yield of Marandu during the second and third cuttings, being 179 and 141 kg ha^{-1} N, respectively.

Figure 2. Rest period (a), leaf area index (b), height (c) and total dry matter (d) of Marandu grass treated with different rest periods and increasing N levels.



There were significant differences ($P < 0.01$) in DM and the proportion of leaf blade (LB) and stem for RP_{28days} and RP_{40cm}. The DM content of the LB and stem (Figure 3a and Figure 3c) increased by 70.38% and 426.91%, respectively, with minimum and maximum values of 2907.2 and 4953.4 kg ha^{-1} for LB and 265.58 and 1399.36 kg ha^{-1} for stem in $RP_{28days,}$ respectively. On the other hand, N levels of 105.54 and 295.88 kg ha^{-1} resulted in the maximum yield of LB and stem of 5247.6 and 1751.27 kg ha^{-1} DM, respectively, for RP_{40cm}. Although LB in kg ha^{-1} increased with increasing N fertilization, the proportion of LB (Figure 3b) declined linearly by 85.34% and 77.64% without nitrogen fertilization, and 73.82% and 64.72% when 450 kg N ha^{-1} was applied to RP_{28days} and RP_{40cm}, respectively. The proportion of stem (Figure 3d) changed by 1% with the application of 32.57 kg N ha^{-1} for both rest periods.

Figure 3. Dry masses and proportions of Leaf Blade, Stem and Senescent Material of Marandu grass submitted to different rest periods and increasing N levels.



The DM of SM decreased linearly ($P < 0.01$) by 19.58% when 450 kg N ha^{-1} was applied instead of no N fertilization for RP_{40cm} (535.34 and 430.53 kg ha^{-1}, respectively) (Figure 3e). The proportion of SM exhibited quadratic behavior ($P < 0.05$) for RP_{28days}, with a minimum of 3.67% when 297.5 kg N ha^{-1} was applied (Figure 3f).

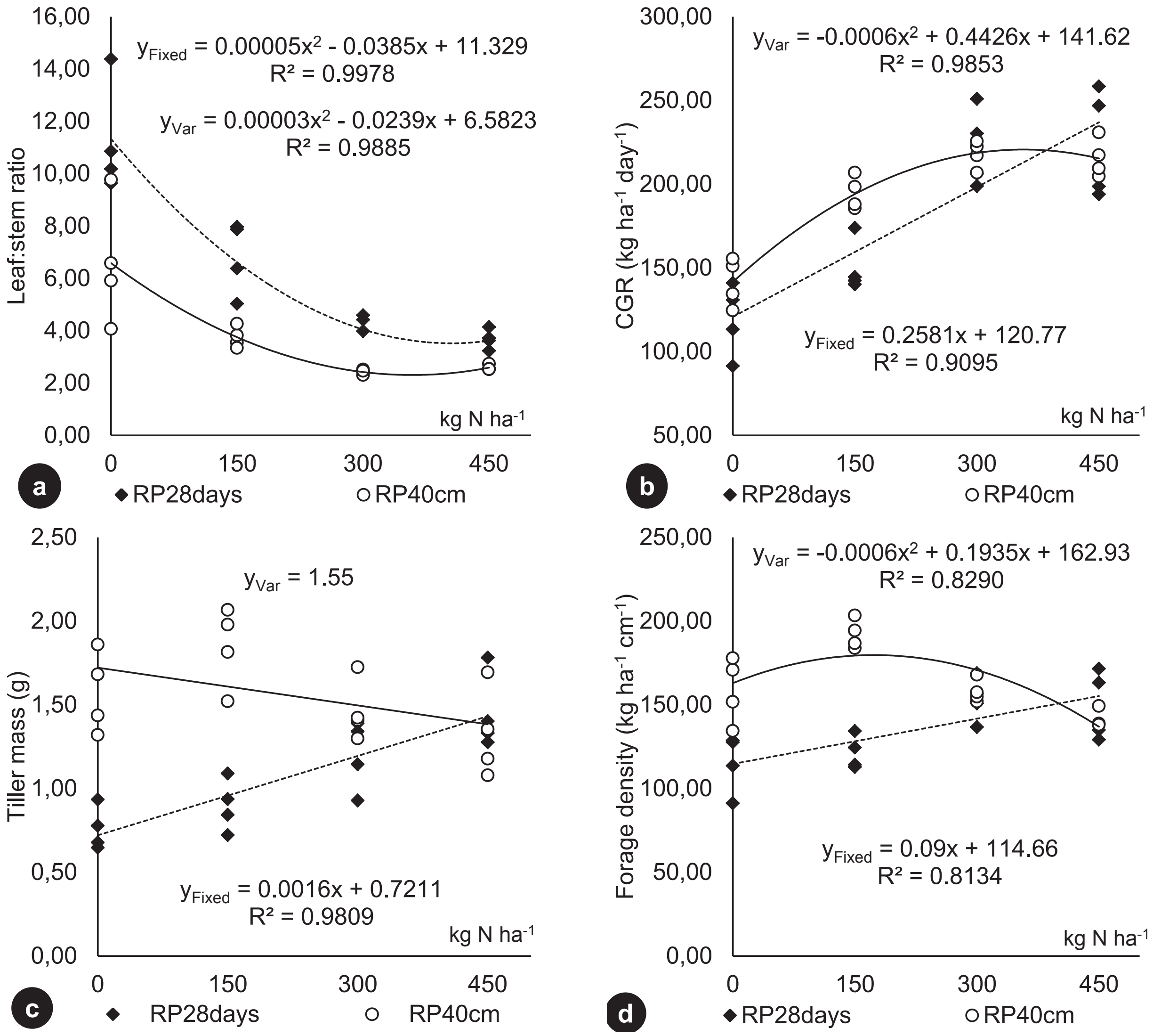
Fontes et al. (2014) reported that higher grazing intensities promoted an increase in the proportion of stems in the botanical composition of the pasture. The authors stated that this leads to lower forage density and a higher leaf:stem ratio at greater heights. Cordeiro (2013), when evaluating forage mass and its morphological components in deferred Marandu pastures with nitrogen levels, verified a percent increase in senescent material. The same author observed that pastures managed at lower heights had a higher proportion of live leaves because there was no shading of older foliage, which is a requirement for the beginning of the senescence process. Moura et al. (2017) verified that there was no change in forage supply when examining a rest period of 30 days and 95% LI in Marandu grass pastures under rotational grazing, but there was an increase in stem and dead material components in the total forage mass when a rest period of 30 days was used, reducing forage quality.

The leaf:stem ratio (Figure 4a) exhibited a quadratic effect for RP_{28days} ($P < 0.01$) and RP_{40cm} ($P < 0.05$). The minimum values of 3.92 and 1.82 were obtained with the application of 385 and 398.33 kg N ha^{-1} for RP_{28days} and RP_{40cm}, respectively. This variable is important because it allows for the evaluation of the increase in the proportion of leaves, which is a valuable variable for grazing livestock, and proportions of stems, both of which contribute to forage growth. Castagnara et al. (2011) stated that the leaf:stem ratio is essential for animal nutrition, because it is associated with the ease of forage prehension. The decrease in leaf:stem ratio found in RP_{28days} caused by the increase in N level may be related to rapid plant development because of nitrogen. Consequently, it increases the proportion of stems and decreases the proportion of leaves in the botanical composition of the pasture, corroborating the findings of Rodrigues et al. (2008). Although both RP_{28days} and RP_{40cm} exhibited quadratic behavior with nitrogen fertilization, RP_{40cm} displayed smaller differences among levels, suggesting greater uniformity, regardless of N level.

Increasing nitrogen levels resulted in positive linear and quadratic behavior ($P < 0.01$) for CGR in RP_{28days} and RP_{40cm} (Figure 4b). Relative to RP_{28days}, there was an increase of 93.69% in CGR with 450 kg N ha^{-1} compared to 0 kg N ha^{-1}, with minimum and maximum values of 120.77 and 233.92 kg ha^{-1} day^{-1}, respectively. The RP_{40cm} had a maximum estimated value of 223.24 kg ha^{-1} day^{-1} at 368.33 kg N ha^{-1}. The results are in agreement with Silva et al. (2015) that N application directly benefits the CGR because of rapid restoration of the LAI and an increased net assimilation rate.

Nitrogen level influenced ($P < 0.01$) tiller mass and forage density (Figure 4c and 4d), except for tiller mass in RP_{40cm} ($P > 0.05$, mean = 1.55 g). Tiller mass and forage density were fitted to the positive linear model for RP_{28days}, with minimum and maximum values of 0.72 and 1.44 g for tiller mass and 114.66 and 157.16 kg ha^{-1} cm^{-1} for forage density, respectively, with an increase of 50% and 37.07% comparing the highest N level to the treatment without fertilization. After fitting to the quadratic model, the period showed maximum forage density of 182.05 kg ha^{-1} cm^{-1} for 111.87 kg N ha^{-1}. Forage density determines intake rates in tropical pastures along with the leaf:stem ratio (FONTES et al., 2014). Costa et al. (2010) stated that nitrogen fertilization is a management strategy that promotes an increase in forage density and leaf production, positively influencing DM production.

Figure 4. Leaf:stem ratio (a), crop growth rate (b), tiller mass (c), and forage density (d) of Marandu grass treated with different rest strategies and N levels.



Conclusions

The use of RP_{40cm} reduced the period needed to begin a new grazing cycle.

The level of 450 kg N ha^{-1} is recommended for RP_{28days}, and levels between 380 to 400 kg N ha^{-1} produced better results for RP_{40cm}.

Acknowledgments

I thank the 047/2012 PRÓ-AMAZÔNIA: BIODIVERSITY AND SUSTAINABILITY/ CAPES and the PROGRAM OF SUPPORT FOR EXCELLENCE CENTERS/PRONEX/SECT/ CNPq for funding this research.

I also appreciate the National Council for Scientific and Technological Development (CNPq) for financial support and CAPES for granting the scholarship.

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