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Structural characteristics and chemical composition of andropogon grass pasture managed under different defoliation intensities and rest periods[1]

Características estruturais e composição química do pasto de capim-andropógon manejado sob diferentes intensidades de desfolha e períodos de descanso

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SUMMARY

This study aimed to evaluate the agronomic, structural traits and chemical composition of andropogon grass subjected to different defoliation intensities and rest periods. Two defoliation intensities (15 and 30 cm) and four rest periods (25; 35, 45 and 55 days) were evaluated in a factorial completely randomized design, with four replications. The rest period promoted a linear decreasing effect (P <0.05) on the dry biomass of leaf blades in the two defoliation intensities. The dry biomass of stems showed an increasing linear effect (P <0.05) according to the rest periods in the two defoliation intensities. Production was recorded at 2427.71; 2907.39; 3325.72 and 3749.45 kg ha^{-1} for the periods of 25; 35; 45 and 55 days, respectively. The dry matter content showed an increasing linear effect (P <0.05) as a function of the rest periods evaluated in the two defoliation intensities. The rest period indicated a decreasing linear trend (P <0.05) for the crude protein content in the two defoliation intensities. A decrease of 0.9 and 0.7 g kg^{-1} was verified for each day of the rest period. For each additional day in the rest period, there was an increase of 1.2 and 1.5 g kg^{-1} DM in the neutral detergent fiber content at intensities of 15 and 30 cm. The andropogon grass pasture managed with a 25-day rest period and defoliation intensity of 30 cm showed high leaf/stem ratio and good nutritional value.

Keywords: forage dry mass, nutritive value, stem elongation

RESUMO

Objetivou-se avaliar as características agronômicas, estruturais e a composição química da forragem de capim-andropogon submetido e diferentes intensidades de desfolha e períodos de descanso. Foram avaliadas duas intensidades de desfolha (15 e 30 cm) e quatro períodos de descanso (25; 35; 45 e 55 dias) em delineamento inteiramente casualizado em arranjo fatorial, com quatro repetições. O período de descanso proporcionou efeito linear decrescente (P<0,05) sobre a biomassa de lâminas foliares secas nas duas intensidades de desfolha. A biomassa de colmos secos apresentou efeito linear crescente (P<0,05) em função dos períodos de descanso nas duas intensidades de desfolha. Foi registrado produção de 2427,71; 2907,39; 3325,72 e 3749,45 kg ha-1 para os períodos de 25; 35; 45 e 55 dias, respectivamente. O teor de matéria seca apresentou efeito linear crescente (P<0,05) em função dos períodos de descanso avaliados nas duas intensidades de desfolha. O período de descanso indicou comportamento linear decrescente (P<0,05) para o teor de proteína bruta nas duas intensidades de desfolha. Foi registrado diminuição de 0,9 e 0,7 g kg-1 para cada dia de período de descanso. Para cada dia a mais de período de descanso foi registrado aumento de 1,2 e 1,5 g kg-1 de MS no teor de fibra em detergente neutro nas intensidades de 15 e 30 cm. O pasto de capim-andropógon manejado com período de descanso de 25 dias e intensidade de desfolha de 30 cm apresentou alta relação folha/colmo e bom valor nutricional.

Palavras-chaves: massa seca de forragem, valor nutritivo, alongamento do colmo

INTRODUCTION

Andropogon grass is a perennial grass resilient to soils of low fertility and water restriction, as in the Northeast region, due to a very deep root system. In addition, it is characterized by rapid regrowth as a consequence of the high tillering rate (MACHADO et al., 2010). This grass presents high elongation of the stem, which requires to design the grazing management to control this characteristic. Thus, the frequency and intensity of defoliation are important determinants of grazing management, as they promote changes in the structural characteristics of the canopy (SOUSA et al., 2010).

A high frequency of defoliation allows greater control of stem elongation, consequently a higher leaf appearance rate that will result in a higher leaf/stem ratio. As a result, the pasture presents better nutritional quality, since the leaf is an organ of the plant that represents the main source of nutrients for ruminants (RODRIGUES et al., 2008).

The adoption of an inadequate rest period when managing pastures at high frequency of defoliation and severe defoliation intensity impairs the recovery of organic reserves, which are used in the regrowth process, compromising pasture persistence (GOMIDE et al. al., 2002; LUPINACCI, 2002). In order to understand how the structural alterations of the pasture behave according to the interactions with the environment, it is of fundamental importance to define management strategies that ensure the subsequent regrowth and persistence of pasture (RODDRIGUES et al., 2014).

The objective of this study was to evaluate the agronomic and structural characteristics and chemical composition of andropogon grass managed in different intensities of defoliation and rest periods.

MATERIAL AND METHODS

The experiment was carried out at the Forage Sector of the Center for Agrarian and Environmental Sciences of the Federal University of Maranhão, in Chapadinha, Lower Parnaíba region, at 03°44’33” S latitude, 43°21’21” W longitude, from February to June 2015. The species used was andropogon grass (*Andropogon gayanus* Kunth) cv. Planaltina.

The maximum temperature of the year 2015 was 34.65°C and the average temperature was 29.48°C. The mean rainfall from January to June was 166.00 (mm) and from July to December was 10.23 (mm). Cumulative rainfall throughout the year was 1057.40 (mm) (Figure 1).

The soil of the experimental site was flat and was classified as Yellow Latosol according to Embrapa (1999). Soil samples were collected at a depth of 0 to 20 cm, and then sent to the soil analysis laboratory to determine the chemical properties (CANTARUTTI et al., 1999): pH = 4.3; organic matter = 18.0 g/dm³; phosphorus = 8.6; sulfur = 6.0 mg/dm^3, potassium = 1.3; calcium = 4.0; magnesium = 3.0; hydrogen + aluminum (H + Al) = 34.0; aluminum = 6, cation exchange capacity = 40.0; sum of bases = 11 mmolc/dm^3, base saturation = 19.0%.

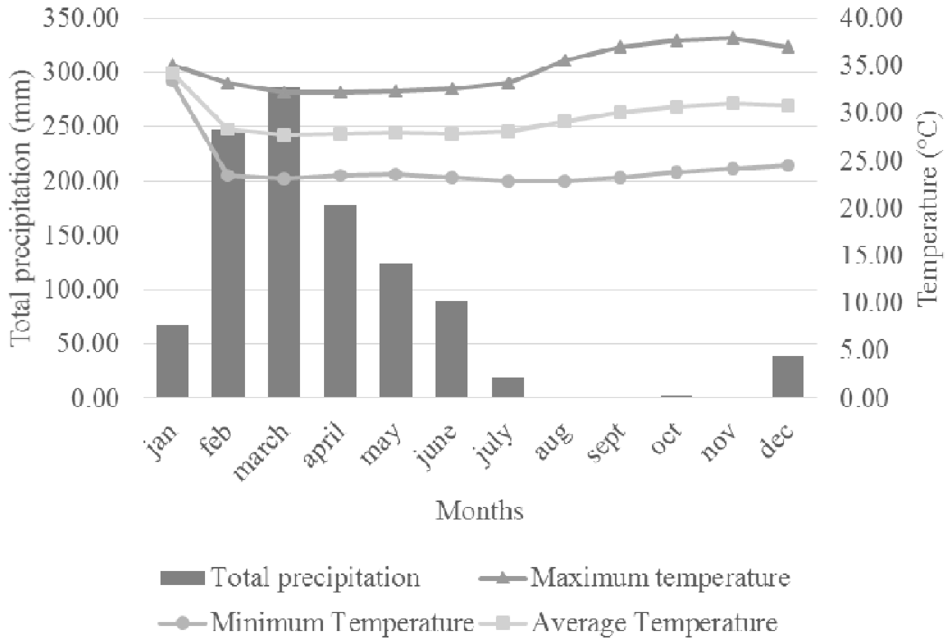

Figure 1. Data from precipitation (mm) and temperature (ºC) in the period from january to december 2015

Liming was carried out with the goal of increasing the base saturation to 60%, recommended level for andropogon grass, using dolomitic limestone. Maintenance fertilization was performed with 60 kg ha^{-1} P_2O_5, 60 kg ha^{-1} K_2O and 200 kg ha^{-1} N as single superphosphate, potassium chloride and urea, respectively (VILELA et al., 1998). Fertilization with nitrogen and potassium was applied in a three-fold interval, one in the standardization cut and the others after the evaluation cuts, while the phosphorus was applied at once.

The experiment was carried out in a 2x4 factorial completely randomized design, two defoliation intensities (15 and 30 cm) and four rest periods (25; 35, 45 and 55 days), with four replications, each replicate represented by plots of 179 m^2, totaling 32 experimental units.

When the pasture reached the established rest period, the evaluations were carried out, the sward height was measured with a ruler graduated up to 2.5 meters, defined as the distance from the ground to the curvature of the last leaf. In each plot, the average of 40 points was taken.

Tiller population density (TPD, tiller/m^2) was estimated from the count of live tiller at two points within each plot (ZANINI et al., 2012), using a 0.50 x 0.75 m PVC frame, which was randomly cast at each repetition. After counting, the material contained inside the frame was cut to estimate the forage biomass production; the samples were cut at the height established for the

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intensities of 15 and 30 cm (adapted from HERLING et al., 1998), the material was packed in properly identified plastic bags and sent to the laboratory and the plots were uniformed to start a new evaluation cycle.

The material was separated into leaf, stem (true stem + sheath) and dead material (SILVA et al., 2015), the fractions were placed in identified paper bags and then weighed and dried in a forced circulation air oven at 55°C to constant weight and then weighed again. Thus, leaf dry biomass (LDB), stem dry biomass (SDB), dead forage biomass (DFB) and total dry forage biomass (TDFB) were estimated. The leaf/stem ratio (L/S) was determined by dividing LDB by SDB (PINTO et al., 1994).

Samples, which were pre-dried in an oven, were ground in 1-milliliter Willey sieves for analysis of DM content (%natural matter) and, based on DM, crude protein (CP), mineral matter (MM), according to AOAC procedures (2010); neutral detergent fiber (NDF), according to the methodology of Van Soest et al. (1991) and acid detergent fiber (ADF) and acid detergent lignin (ADL), according to the methodology of Van Soest et al. (1963).

The collected data were tabulated and grouped according to the cycles during the rainy season. With the rest period with 25 and 35 days, it was possible to evaluate four cycles (February/March, March/April, April/May, May/June). For the rest periods of 45 and 55 days, two cycles were evaluated (February/April; April/May); the evaluation of the third cycle would be completed in the rainy/dry transition period.

Data were subjected to tests that ensure the basic assumptions of homoscedasticity and normality, so that the data were tested by analysis of variance. Tukey's test was then applied at 5% probability to explore the effects of defoliation intensity. Regression analysis was applied to the rest period by testing the first and second order polynomial models at the 5% probability level. For the estimation of means, the PROC GLM was used and for the regression analysis, the PROC REG of the statistical software SAS 9.0 (2002).

RESULTS AND DISCUSSION

There was no interaction effect ($P > 0.05$) between rest periods and defoliation intensity for dry biomass of leaf blades (LDB), dry biomass of stems (SDB), dead forage biomass (DFB) and total dry forage biomass (TDFB) (Table 1).

Defoliation intensity did not affect leaf dry biomass ($P > 0.05$). The rest period promoted a linear decreasing effect ($P < 0.05$) on LDB in the two defoliation intensities. It was observed that in the intensity of 15 cm, there was a reduction of 19.52 kg of leaves for each additional day in the rest period, whereas in the intensity of 30 cm, a reduction of 35.41 kg was recorded for each additional day.

This reduction in leaf biomass is associated with the fact that, tropical grasses subjected to long rest periods, presented a decrease in the leaf appearance rate due to the greater stem elongation, because the elevation of the node increases the distance for the leaf to emerge (DURU & DUCROCQ, 2000). Veras et al. (2010) observed a similar behavior for the percentage of leaves in the monocrop pasture of andropogon grass, with a reduction in leaf participation when the regrowth age increased from 35 to 63 days.

Table 1. Biomass production of forage of andropogon grass handled in function of different periods of rest and defoliation intensities

Intensity of defoliation (cm)	Rest period (days) 25	35	45	55	Means	Equation	R^2	p-value IdxRp	CV (%)
Dry biomass of leaf blade (kg ha^{-1})									
15	2826.7	2795.0	2612.8	2229.5	2616.0	Y=3391.37-19.52x	0.67	0.1479	13.32
30	3497.7	2637.3	2539.1	2289.9	2808.3	Y=4142.52-35.41x	0.43		
Means	3162.2	2716.1	2576.0	2259.7	-	-	-		
Dry stem biomass (kg ha^{-1})									
15	2427.6	2907.3	3325.7	3749.4	3102.5	Y=1349.22+43.83x	0.69	0.9238	16.91
30	2068.2	2802.2	2898.3	3394.5	2790.8	Y=1160.80+40.75x	0.44		
Means	2247.9	2854.8	3112.0	3571.9	-	-	-		
Dead forage biomass (kg ha^{-1})									
15	887.0	1288.4	1528.0	2015.5	1429.7^a	Y=-8.13+35.87x	0.75	0.4011	21.82
30	746.8	1170.8	1216.1	1450.0	1145.9^b	Y=284.01+21.55x	0.45		
Means	816.9	1229.6	1372.0	1732.7	-	-	-		
Total dry forage biomass (kg ha^{-1})									
15	6141.4	7006.8	7441.8	7490.6	7020.2	Y=5196.58	-	0.9781	17.26
30	5438.3	6610.4	6653.6	7134.4	6459.2	Y=4406.59	-		
Means	5789.8	6808.6	7047.7	7312.5	-	-			

Means followed by different letters lowercase letters in columns and capitals in the lines differ by Tukey test at 5% probability.
R^2 = coefficient of determination, CV = coefficient of variation, Id = intensity of defoliation, Rp = rest of period.

The higher LDB in the 25-day rest period may lead to positive effects on animal performance, since the leaf has better nutritional value than the stem. As recorded by Silva et al. (2014), the leaf of the andropogon grass presented lower fiber content and higher CP content.

The SDB showed an increasing linear effect (P <0.05) as a function of the rest periods in the two defoliation intensities. Increases of 43.83 and 40.75 kg were recorded for each day of the rest period at post-grazing heights of 15 and 30 cm, respectively (Table 1). The lowest stem production was found in the pasture of 25 day-rest period in relation to 55 days. This is because grasses subjected to long periods of rest present a high leaf area index causes shading in the base of the canopy, in this situation, the stem elongation is a strategy to elevate its leaves in search of light (GOMIDE et al., 2007).

Shorter rest periods seem to be the solution for controlling the excessive stem elongation in grasses, as recorded in the work of Cândido et al. (2005) with Mombasa grass. It is observed that the high elongation of the stem provides a reduction in the crude protein content, increase in the fiber content (CÂNDIDO et al., 2005), and thus can influence the behavior of grazing animals.

Analyzing the defoliation intensity, there was no effect on the stem elongation. This result is confirmed by Sousa et al. (2010), who analyzed andropogon grass and concluded that frequency is more determinant than the intensity of defoliation in determining changes in sward structure.

There was an increasing linear effect (P <0.05) of the rest period on dead forage biomass at the two intensities evaluated. There was an increase of 35.87 and 21.55 kg dead forage for each day of rest period, for intensities of 15 and 30 cm, respectively. The rest period of 25 days resulted in a lower amount of dead forage in relation to the period of 55 days.

This result is probably associated with the high senescence rate of the grass with age, because as soon as the plant stabilizes the number of leaves, the first leaves begin to die, given the intense shading in the base of the canopy. Cândido et al. (2006) observed that as the rest period of the pasture increases, the senescence rate increases.

The highest biomass of dead forage was found in the defoliation intensity of 15 cm, possibly this result is associated with the fact that the andropogon grass has high elongation of the apical meristem (SOUSA et al., 2010), therefore, the use of a very high grazing intensity caused a greater removal of apical meristems due to the greater decapitation of tillers, thus increasing the proportion of dead material.

The high accumulation of dead material in the pasture is indicative of low nutritive value of the forage, since the increase of this characteristic means loss of forage and, consequently, impaired structure of the forage canopy, interfering with animal behavior, dry matter intake and the animal performance.

There was no effect (P> 0.05) of the intensity and rest periods on TDFB. Probably, there may have been a compensating effect on the production of leaves and stems (Table 1). In the lower rest period, there was higher production of leaves and lower production of stems, as the rest period was prolonged, the reverse occurred.

In addition, the tiller population density may have contributed, since in the lower rest period there was a higher density in relation to the period of 55 days (Table 2), thus characterizing the size/density compensation mechanism, that is, high density of light tillers and low density of heavy tillers, as reported by Sbrissia & Silva (2008).

The rest period promoted a linear decreasing effect (P <0.05) on the leaf/stem ratio in the two defoliation intensities. The reduction in the leaf/stem ratio with increase in the rest period is justified by the increase in stem elongation and reduction in leaf number, either by senescence (CÂNDIDO et al., 2005) or even by the reduction in the appearance rate caused by the elevation of the stem, as a result of the elevation of the internode distance and negatively affecting the appearance of new leaves.

The reduction in the leaf/stem ratio leads to a decrease in the nutritional value of forage grasses, consequently reducing grazing efficiency (GOMIDE et al., 2007). The leaf/stem ratio is a very important characteristic of sward structure, which directly influences the ingestive behavior of ruminants in tropical pastures and has a positive correlation with animal consumption (GONTIJO NETO et al., 2006).

Tiller population density (DPP) showed a linear decreasing response (P> 0.05) to the rest periods when managed with a defoliation intensity of 15 cm, with a reduction of 2.59 tillers for each additional day in the rest period. For the intensity of 30 cm, no linear regression effect was observed (Y = 530.10) (Table 2).

Table 2. Mean values of leaf/stem ratio, tiller population density and height of pastures of andropogon grass in function of different periods of rest and defoliation intensities

Intensity of defoliation (cm)	Rest period (days)				Means	Equation	R^2	p-value	CV (%)
	25	35	45	55				IdxRp	
Leaf/stem ratio									
15	1.19	0.98	0.77	0.6	0.89_b	Y=1.67-0.02x	0.79		
30	1.58	0.96	0.9	0.68	1.03^a	Y=2.08-0.03x	0.68	0.138	17.25
Means	1.39	0.97	0,84	0,64	-	-	-		
Tiller population density (tillers/m^2)									
15	626.6	600.3	592.0	541.5	586.7^a	Y=694.92-2.59x	0.38		
30	506.8	488.5	481.4	473.0	492.2^b	Y=530.10	-	0.6725	37.35
Means	566.7	488.5	536.7	541.5	-	-	-		
Height (cm)									
15	1.19	1.70	2.03	2.26	1.79^b	Y=0.39+0.04x	0.86		
30	1.46	1.94	2.1	2.22	1.93^a	Y=0.96+0.02x	0.79	0.1185	7.52
Means	1.33	1.82	2.07	2.24	-	-	-		

Means followed by different letters lowercase letters in columns and capitals in the lines differ by Tukey test at 5% probability.
R^2 = coefficient of determination, CV = coefficient of variation, Id = intensity of defoliation, Rp = rest of period.

The reduction in the DPP can be explained by the size/density compensation mechanism of tillers, since the rest period of 25 days presented high density, with the extension of the period, there is self-thinning of the smaller tillers to the detriment of the growth of the larger tillers (SBRISSIA & SILVA, 2008), thus ensuring heavier tillers, but at low density. Moreover, the high participation of stems in the 55-day period promoted greater shading in the base of the canopy, thus hindering the passage of light, consequently inhibiting the development of new basal buds (PORTELA et al., 2011).

There was effect of defoliation intensity on DPP ($P < 0.05$); and the lowest density was observed at the height of 30 cm, resulting from the greater shading in the base of the tiller (Table 2)

Sward height increased linearly ($P < 0.05$) according to defoliation intensities (Table 2). The increase in height with the increase of the rest period is related to the greater stem elongation, which is due to the lower DPP observed, because, according to Sbrissia & Silva (2008), pastures under long rest periods have low DPP, however longer tillers, culminating, thus, in greater sward height.

No effect ($P > 0.05$) from the interaction between rest periods and defoliation intensity was verified on dry matter, crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (Table 3).

There was a linear increase in the dry matter content as a function of the rest periods evaluated in the two defoliation intensities (Table 3). This result can be explained by the greater participation of the stem over time, as observed in this

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study, because when the plant is closer to maturity, there is an increase in the fiber constituents and a reduction in the cellular content, consequently a decrease in the water content (COSTA et al., 2007; SÁ et al., 2010).

A similar result was reported by Silva et al. (2014) for andropogon grass subjected to different regrowth ages, 35 (26.01%); 45 (29.34%); 63 (28.02%) and 77 (33.39%), with values close to those observed in this study.

Table 3. Composition chemical of forage of andropogon grass in function of different rest of periods and intensity of defoliation

Intensity of defoliation (cm)	Rest period (days) 25	35	45	55	Means	Equation	R^2	p-value IdxRp	CV (%)
Dry Matter*									
15	176.8	213.7	239.0	260.0	222.4	Y=111.5+2.8x	0.95	0.285	2.51
30	175.2	214.6	238.9	259.2	222.0	Y=112.6+2.7x	0.98		
Means	176.0	214.2	239.0	259.6	-	-	-		
Crude Protein**									
15	101.3	88.9	80.4	75.8	86.6	Y=120.7-0.9x	0.93	0.113	2.91
30	97.3	90.0	82.2	76.1	86.4	Y=114.9-0.7x	0.91		
Means	99.3	89.4	81.3	75.9	-	-	-		
Neutral detergent fiber **									
15	691.0	711.2	718.8	728.8	712.4[b]	Y=634.1+1.2x	0.86	0.681	2.46
30	693.1	719.9	733.4	737.9	721.0[a]	Y=661.9+1.5x	0.62		
Means	692.0	715.5	726.1	733.3	-	-	-		
Acid Detergent Fiber **									
15	354.8	368.4	379.9	387.1	372.5[b]	Y=328.2+1.1x	0.90	0.075	3.56
30	359.5	379.3	376.3	392.4	376.9[a]	Y=33.85+1.0x	0.78		
Means	357.1	373.8	378.1	389.8	-	-	-		
Lignin **									
15	84.2	94.8	116.6	123.6	104.8	Y=48.8+1.4x	0.81	0.120	8.46
30	89.6	89.9	121.2	109.3	102.5	Y=66.1+0.9x	0.59		
Means	86.9	92.3	118.9	116.4	-	-	-		

Means followed by different letters lowercase letters in columns and capitals in the lines differ by Tukey test at 5% probability.
R2 = coefficient of determination, CV = coefficient of variation, Id- = intensity of defoliation, Rp = rest of period.
* g kg^{-1}; ** g kg^{-1} of DM.

There was a linear decreasing effect (P <0.05) for the crude protein content according to the rest period. The lowest protein value was observed in the shorter rest period, justified by the higher leaf/stem ratio (Table 1).
Furthermore, the reduction in protein content is associated with a reduction in

the deposition of high digestibility nutrients at the expense of the greater deposition of fiber tissues with the advance from the vegetative to the reproductive phase (RODRIGUES et al., 2004; VASCONCELOS et al., 2009), a phenomenon that occurs even through an adaptation mechanism, since, it will ensure the support of the tiller. Similar behavior was registered by Silva et al. (2014) for andropogon grass according to different regrowth ages.

A behavior contrary to that of the crude protein was observed for the neutral detergent fiber (NDF) content, with a linear increasing effect (P <0.05) as a function of the rest periods at the two defoliation intensities (Table 3). The increase in NDF contents of andropogon grass with advancing rest period is justified by the increase in stem production and reduction in the production of leaf blades (Table 1).

As the plant grows and ages, there is an increase in stems more resistant to its support, avoiding the occurrence of tiller falling, also occurring the increase of fiber carbohydrate fractions (HENRIQUES et al., 2007). The defoliation intensity influenced (P>0.05) the NDF content, being the highest value observed for intensity of 30 cm in relation to that of 15 cm (Table 3). This result probably occurred due to the low rate of tissue turnover in the lower intensity management.

High NDF content promotes a reduction in the voluntary intake of dry matter, because it causes physical limitation caused by the rumen filling effect, reducing the passage rate, that is, high NDF forage will remain in the rumen longer, thus becoming evident the negative correlation of intake with NDF (PIRES et al., 2006).

Effect similar to that of NDF was found for acid detergent fiber (FDA), which increased linearly (P <0.05) as a function of rest periods. The lower ADF content in the shorter rest period, 25 days, may be associated with a greater participation of leaf blades, in which another explanation is due to the greater participation of vegetative tillers. The highest ADF content in pastures subjected to long rest periods is attributed to the lower leaf renewal rate and greater stem elongation (VALENTE et al., 2010).

There was a linear decreasing effect (P <0.05) for lignin according to rest periods. It is evident that the changes occurring in the chemical composition of forage plants are due to maturity, since over time there is deposition of fiber constituents and reduction in potentially digestible components (MARI, 2003). Increased lignin content impairs the nutritional quality of the forage, resulting in a rapid decline in digestibility (LAZZARINI et al., 2009).

The rest period lasting 55 days resulted in lower leaf production and higher production of stems and dead material. The sward structure and chemical composition was impaired when managed under long resting period. In turn, when managed with 25 days of rest at an intensity of defoliation of 30 cm, it presented higher leaf/stem ratio, less amount of dead forage and better nutritional value. Therefore, it is recommended to use andropogon grass managed with 25-day rest period and defoliation intensity of 30 cm.

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