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Population density and tillering of andropogon grass submitted to different cutting heights

Densidade populacional e perfilhamento de capim-andropógon submetido a diferentes alturas de corte

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ABTRACT

The objective of this study was to evaluate the tillering dynamics and population density of *Andropogon gayanus* cv. Planaltina, submitted to different cutting heights during the dry and rainy season. A randomized block design was adopted in a split plot scheme. In the main plot, the three cutting heights (10, 20, and 30 cm) were allocated, while the subplots included the following periods: dry (October, November, and December) and rainy (April, May, and June). During the dry period at the height of 10 cm, there was a higher population density of tillers, with 1298.44 tillers m^{-2}. The appearance rate was higher in October for heights of 10 and 30 cm and in December for 20 cm. The 10-cm height provided a higher mortality rate. The survival rate and the stability index were higher in October, with 88.47% and 1.38, respectively. In the rainy season, specifically June, the pasture had a higher height (130.06 cm). The rate of appearance and the stability index were higher in April and during June there was greater mortality, while at the 20-cm height, there was less mortality and greater survival (85.71%) of the tillers. The 20-cm cut height provides a higher survival rate and lower mortality rate of andropogon grass in the dry and rainy season.

Keywords: *Andropogon gayanus*, mortality, pasture, tiller, survival

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RESUMO

Objetivou-se avaliar a dinâmica de perfilhamento e densidade populacional de perfilhos de capim Andropogon gayanus cv. Planaltina, submetido a diferentes alturas de corte durante o período seco e chuvoso. Adotou-se o delineamento em blocos ao acaso em esquema de parcelas subdivididas. Na parcela principal alocaram-se as três alturas de corte (10, 20 e 30 cm) e nas subparcelas, os períodos: seco (outubro, novembro e dezembro) e chuvoso (abril, maio e junho). No período seco, na altura de 10 cm houve maior densidade populacional de perfilhos, com 1298,44 perfilhos/m2. A taxa de aparecimento foi maior em outubro para as alturas de 10 e 30 cm e no mês de dezembro na altura de 20 cm. A altura de 10 cm proporcionou maior taxa de mortalidade. A taxa sobrevivência e o índice de estabilidade foram superiores no mês de outubro, com 88,47% e 1,38, respectivamente. No período chuvoso, no mês de junho, o pasto obteve maior altura (130,06 cm). A taxa de aparecimento e o índice de estabilidade foram superiores no mês de abril e durante o mês de junho ocorreu maior mortalidade, enquanto que na altura de 20 cm, houve menor mortalidade e maior sobrevivência (85,71%) dos perfilhos. A altura de 20 cm de corte proporciona maior equilíbrio no desenvolvimento dos perfilhos.

Palavras-chave: Andropogon gayanus, mortalidade, pasto, perfilho, sobrevivência

INTRODUCTION

The productivity and growth patterns of a grass are due to the continuous emission of leaves and tillers. This process is important mainly after cutting or grazing to restore the leaf area of the plant and allow the pasture to persist. However, factors related to grazing management influence the processes of formation, development, and tissue death in the plant, and they also determine the increase or decrease in the number of individuals in the ecosystem through changes in the population dynamics of tillers (BARBERO et al., 2015).

Among the factors that affect the biomass flow of a forage grass, tillering is the most influential on the accumulation of forage (SILVA & PEDREIRA, 1997). Tiller population density, a structural variable, is affected by changes in morphogenic responses and by the frequency and intensity of cutting or grazing. Adjustments in the defoliation process between the frequency and intensity of cutting or grazing generate different responses in production and nutritional value of forage, which can promote changes in the demographic patterns of tillering of forage plants (DIFANTE et al., 2008).

There are other factors that interfere in the structural modifications of the pasture in addition to the cutting intensity: the water availability and the interaction of the plant with the environment, a fundamental point to support both the growth and the maintenance of the productive capacity of the pasture and reduce losses due to senescence (GARCEZ NETO et al., 2002). Thus, knowledge and understanding of the growth and developmental dynamics of plants that comprise pastures as well as their morphophysiological changes in response to interfering agents and the search for greater and more sustainable

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productivity of pasture production systems is essential for management species of forage grasses that are not commonly used in Brazil, such as andropogon grass (SOUSA et al., 2010). Given the above background, the objective of this study was to evaluate whether different cutting heights influence the structural characteristics of *Andropogon gayanus* cv. Planaltina at different periods of the year.

MATERIAL AND METHODS

The experiment was carried out in the Caprinoculture Sector of the Department of Zootechnics of the Center for Agricultural Sciences of the Federal University of Piauí from September 2011 to June 2012, in an area located in the municipality of Teresina, PI. According to the Köppen classification, the climate is Aw, tropical and rainy (megathermic), with a dry winter and rainy summer. The maximum temperature during the experimental period was 36.91°C in September 2011; the average temperature was 28.63°C in October of the same year. The average rainfall from October to December was 105.2 mm and between April and June it was 59.23 mm. The accumulated rainfall from September 2011 to June 2012 was 1208.1 mm (Figure 1).

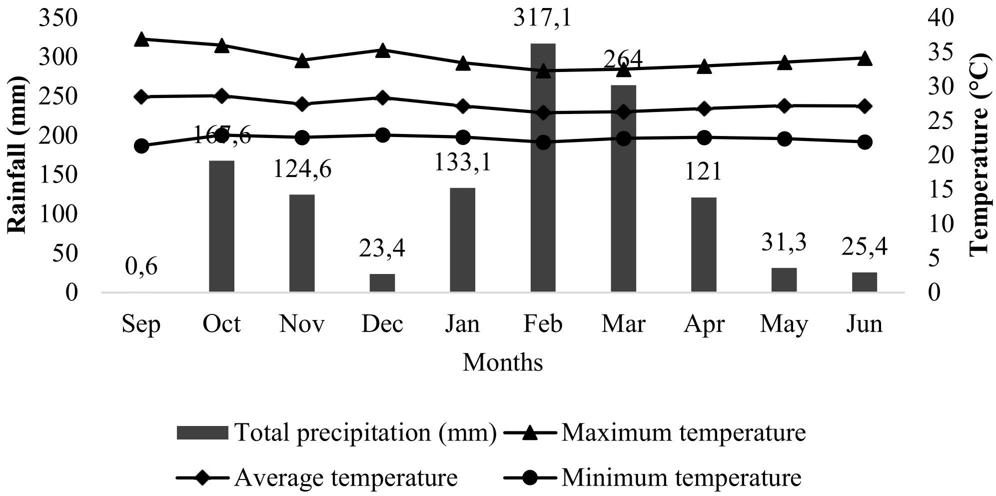

Figure 1. Rainfall and maximum, average, and minimum temperature from September 2011 to June 2012, in Teresina, PI.

The soil in the experimental area is of the type Red-Yellow Latosol, medium texture, dystrophic, classified according to the methodology proposed by EMBRAPA (2006). Before the implementation of the experiment, soil samples were taken in the 0–20 cm layer to determine fertility; this analysis showed the following results: pH (H_2O) = 5,5; Ca (cmol$_c$ dm$^{3(-1)}$) = 0,2; Mg (cmol$_c$ dm$^{3(-1)}$) = 0,1; Al (cmol$_c$ dm$^{3(-1)}$) = 0,2; K (cmol$_c$ dm$^{3(-1)}$) = 0,12; H + Al (cmol$_c$ dm$^{3(-1)}$) = 3,7; sum of bases (cmol$_c$ dm$^{3(-1)}$) = 0,43; CTC (cmol$_c$ dm$^{3(-1)}$) = 4,0; aluminum saturation (%) = 32,0; base saturation (%) = 10,0; P - Mehlich-1 (mg dm$^{3(-1)}$) = 2,40.

The experimental area was planted in the year 2000 and sown with andropógon grass (*Andropogon gayanus* Kunth var. Bisquamulatus (Hochst) Hack. Cv. Planaltina), being used until the period

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prior to the experiment in rotated grazing by goats. In January 2011, liming was carried out with the application of 1.1 t/ha dolomitic limestone in order to increase base saturation to 35%. In March 2011, the cut was made with a mechanical brushcutter to standardize the height of the pasture (20 cm on average). It was fertilized in coverage with 50, 40, and 40 kg ha^{-1} of N, P_2O_5, and K_2O, in the form of urea, simple superphosphate, and potassium chloride, respectively.

A randomized block design was adopted with treatments in a split plot scheme to assess the tillering dynamics and population density. In the main plot, the three cutting heights (10, 20, and 30 cm) were allocated, while the subplots included the periods: dry (October, November, and December) and rainy (April, May, and June). Each treatment was allocated in a 9.0 m² area, with six replicates, totaling 18 experimental units for each experimental period.

At the beginning of the work, a uniform cut was made in all the experimental units at a 20-cm height, marking the beginning of the assessments that took place in the dry period of 2011 and at the end of the rainy period in 2012. When the height of the forage canopy reached 50 cm, treatments were allocated.

To determine the height of the canopy, a graduated ruler was used, and five points were collected per experimental unit. The evaluation of the demographic patterns of the tillers and the respective rates of appearance, mortality, and survival was carried out according to Carvalho et al. (2000) using four PVC rings of 0.071 m² in area, 30 cm in diameter, and 10 cm in height in areas representative of the average pasture condition of each plot, according to visual assessment of height and forage mass. The rings were introduced into the soil at a 8.0-cm depth, keeping 2.0 cm above the surface. All tillers kept in the PVC circle were counted and, subsequently, they were marked every 28 days with smooth wire covered with plastic of different colors, which represented each generation of tillers.

The first tiller assessment was carried out in September 2011, and at each 28-day cycle all marked tillers were counted, new tillers were marked, and the dead tiller wires collected. Missing tillers were considered dead as well as dry or in an advanced stage of senescence. In this way, the tillers that belonged to all generations were always recounted with each new assessment. Three generations of tillers (G1 to G3) were identified in each period. Based on the counts, tiller appearance rate (TAR), survival (TSR), and mortality of basilar tillers (MRbT) were calculated:

$$\text{TAR} = \frac{\text{n° of new tillers marked x 100}}{\text{n° of live tillers in the previous marking}}$$

$$\text{TSR} = \frac{\text{n° number of surviving tillers x 100}}{\text{n° of live tillers in the previous marking}}$$

MRbT = 100 –TSR

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The population stability index (SI), calculated based on the relationship between survival rates and tiller appearance, was obtained by the following equation:

$$SI = TSR (1+ TAR),$$

where: TSR and TAR are survival rates and tiller appearance during that same period, respectively (BAHMANI et al., 2003).

Estimates of population density of tillers (PDT) were obtained independently of those of demographics of tillering, due to the reduced area of the ring (0.071 m^2). In this way, the number of tillers was obtained by counting the total tillers contained within a 0.0625 m^2 (0.25 x 0.25 m) metal frame that was introduced into four clumps by picket at random every 28 days.

The data of tillering dynamics and population density were subjected to analysis of variance (Proc GLM) and the means compared by the Tukey test at a 5% probability, using the statistical package SAS version 8.11.

RESULTS AND DISCUSSION

There was no interaction ($P > 0.05$) between cutting heights and months during the dry period on the population density of tillers (PDT) (Table 1); there was only variation among cutting heights. At the 10-cm height, there was a higher PDT, with 1298.44 tillers m^2. More lenient cuts provide greater PDT, as according to Barbosa et al. (2014), when the pasture is managed in a low forage supply, the tillers have a higher density, but are lighter. By contrast, in high offers the tillers are less numerous, but heavier. This response pattern characterizes the phenotypic plasticity of forage grasses and consists of a mechanism known as compensation between tiller size and density (SANTOS et al., 2011).

Table 1. Population density of vegetative tillers and height of andropogon grass submitted to different cutting heights during the dry season

Heights (cm)	Months			Average	SEM**	p-value		
	Oct	Nov	Dec			Hei	Months	Hei*Mon
PDvT (tillers m^{-2})[1]								
10	1284,00	1308,66	1302,66	1298,44a	58,896	0,0006	0,9873	0,9989
20	945,33	994,00	992,66	977,33b				
30	833,33	815,16	801,83	816,77b				
Average	1020,88A	1039,27A	1032,38A					
HEI (cm)								
10	28,61	51,42	61,75	47,26a	2,786	0,9409	0,0002	0,8581
20	31,54	55,08	55,76	47,46a				
30	37,83	53,37	56,15	49,12a				
Average	32,66B	53,29A	57,89A					

[1]PDvT= Population density of vegetative tillers; HEI=heights. *Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance. **SEM= standard error of the mean

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The cutting height × month interaction during the dry period was not significant ($P > 0.05$) with regard to the height of the pasture, with variation only among the evaluated months. In October, the pasture had a lower height (32.66 cm). The reduced height at the beginning of the assessments can be justified by the fact that the pasture underwent stress in the first cut of assessment, which may have compromised its initial development, corroborating the higher mortality rate of the tillers in October (Table 2). Araújo et al. (2015) worked with andropogon grass in different forage offerings and observed that in the lowest forage offer (11%), the height of the pasture was lower, while in the highest forage offer (19%), the height was higher. This behavior was not observed in the present study, in which the cutting height did not influence the final height of the pasture.

The cutting height influenced the tiller appearance rate (TAR) during the dry period ($P < 0.05$) (Table 2). The highest averages were observed in October for the heights of 10 and 30 cm (85.30 and 75.97%, respectively) and in December at the 20 cm height (75.97%). Over the months, there was a reduction in the appearance of basal tillers at the 10- and 30-cm heights, while this behavior was not observed at the 20 cm height. The reduction in TAR was due to the decrease in rainfall (Figure 1): Tillering is influenced by environmental conditions and management practices, and when they are in unfavorable conditions, they reduce the production of buds potentially capable of originating new tillers (LEMAIRE et al., 2008).

Table 2. Appearance, mortality, and survival rate of andropogon grass tillers submitted to different cutting intensities during the dry season

Heigths (cm)	Months			Average	SEM*	p-value		
	Oct	Nov	Dec			Hei	Months	Hei*Mon
	TAR (%)[1]							
10	85,30Aa	10,21Ba	0,96Bb	43,44				
20	18,35Bb	4,03Ba	75,97Aa	39,07	5,87	0,0547	<0,0001	<0,0001
30	75,97Aa	3,21Ba	0,46Bb	31,58				
Average	58,37	6,27	38,3					
	MRbT (%)							
10	84,48Aa	82,89Aa	84,48Aa	83,95				
20	71,76Aa	43,53Bb	71,76Aa	62,35	3,992	<0,0001	<0,0001	<0,0001
30	76,83Aa	19,12Bc	17,57Bb	37,84				
Average	77,69	48,51	57,94					
	TSR (%)							

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10	84,62Aa	17,11Bb	15,51Ba	39,08				
20	93,47Aa	56,46Ba	28,23Ca	59,39	4,666	<0,0001	<0,0001	0,0043
30	87,31Aa	19,12Bb	23,16Ba	43,2				
Average	88,47	30,9	22,3					

Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance, * SEM = standard error of the mean; 1TAR = tiller appearance rate; MRbT = mortality rate of basal tillers; TSR = tiller survival rate

When evaluating the tillering dynamics of Marandu grass grown at two heights (15 and 30 cm), Difante et al. (2008) observed that the rate of appearance of basal tillers was influenced by the time of the year: In months with greater precipitation, there was a favor of forage production and thus greater appearance of tillers, and that the highest TApP was observed at the height of 15 cm, due to the greater entry of light through the canopy.

The mortality rate of basal tillers (MRbT) was influenced by the cutting heights and months (P < 0.05). In October, the tillers had the highest mortality at all cutting heights (77.69%); however, at the 10-cm height, mortality remained high throughout the dry period. According to Murphy & Briske (1992), in pastures kept at lower intensities, with a high rate of appearance, tiller mortality is a compensatory mechanism for maintaining the balance of the tiller population with regard to the availability of light and water. Another factor that may have possibly contributed to the superiority of MRbT at the 10 cm height was the elimination of the apical meristem of the tillers, which can determine its mortality (GOMIDE, 1994).

The survival rate (TSR) was higher in October for all heights, with a reduction with the advance of the dry period. Despite the reduction in TSR, the pasture with a 20-cm cutting intensity managed to maintain higher TSR values, with an average of 59.39%. It is worth noting that this pasture showed lower TAR (18.35%) at the beginning of the dry period; however, there was a higher TSR for that same period (93.47%), which influenced the superiority of TSR during the dry period. In pastures with a low rate of appearance, tiller tends to survive longer, a phenomenon that serves as a compensatory mechanism to stabilize the tiller population and, thus, guarantee its persistence in the area under different environmental conditions (Santos et al., 2011).

The stability index was influenced by the cutting heights and the months (P < 0.05) during the dry period (Table 3). The highest averages of stability were observed in October for all evaluated heights: They were greater than 1.0, data that reflect the appearance and survival of tillers.

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Table 3. Andropogon grass pasture stability index submitted to different cutting heights during the dry season

Stability index								
Heigths (cm)	Months			Average	SEM*	p-value		
	Oct	Nov	Dec			Hei	Months	Hei*Mon
10	1,56Aa	0,27Bb	0,21Ba	0,8	0,082	0,0686	<0,0001	<0,0001
20	1,05Ab	0,57Ba	0,48Ba	0,706				
30	1,53Aa	0,17Bb	0,15Ba	0,676				
Average	1,38	0,36	0,302					

Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance, * SEM = standard error of the mean

The superiority in the stability index observed in October is due to the higher rates of appearance and survival (Table 2), relative to the subsequent months. It is worth mentioning that the reduction in the stability index over the dry period is justified by the reduction in rainfall in November and December. Among the cutting heights, the pasture managed at a 20-cm height showed greater stability in November relative to the other evaluated heights. This outcome is the result of the higher TSR and lower MRbT that this pasture presented in that month. According to Bahmani et al. (2003), when the stability index is equal to 1, the tiller population is in balance, while values below 1 mean that pastures have compromised stability, and the tiller population tends to decrease.

PDvT was not influenced by the cutting intensities and the months ($P > 0.05$) over the rainy period (Table 4). It can be seen that the average tiller density was lower compared with the dry period (Table1). This inferiority may be related to the lower incidence of rainfall during this period, with an average of 59.23 mm. By contrast, in the months of assessment during the dry period, there was a rainfall of 105.2 mm. This superiority in precipitation shows that the year 2012 presented an irregular rainfall distribution.

Table 4. Population density of vegetative tillers and height of andropogon grass submitted to different cutting heights during the rainy season

PDvT (Tillers m^{-2})[1]								
Heigths (cm)	Months			Average*	SEM**	p-value		
	Apr	May	Jun			Hei	Months	Hei*Mon
10	478	511,33	526,66	505,33a	21,118	0,0779	0,5782	0,9987
20	386	420	444	416,66a				
30	486,66	500	514	500,22a				
Average	450,22A	477,11[a]	494,88A					
HEI (cm)								
10	59,25	87,91	92,22	79,79b	6,581	<0,0001	0,0002	0,7969
20	78,52	119,68	121,45	106,55b				

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30	112,81	170,34	176,51	153,22a
Average	83,53b	125,98a	130,06a	

[1]PDvT= Population density of vegetative tillers; HEI=heights. * Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance. **SEM= standard error of the mean

Although the height of the pasture did not present an interaction effect (P > 0.05) between the cutting heights and the months during the rainy season, the 30-cm cutting intensity provided greater height to the pasture (153.22 cm); among the months, there was a lower height (83.53 cm) in April. The pasture had a lower height in April, a factor that provided a higher TAR (Table 5), different from the subsequent months. The highest heights observed probably provided a low light intensity at the base of the lawn, which is recognized as one of the main factors that interfere in the tillering of pastures kept higher (SBRISSIA & DA SILVA, 2008), due to the competition between tillers that occurs particularly by light.

Table 5. Appearance, mortality, and survival rate of andropogon grass tillers submitted to different cutting intensities during the rainy season

Heights (cm)	Months			Average	SEM*	p-value		
	Apr	May	Jun			Hei	Months	Hei*Mon
	TAR (%)[1]							
10	40,61Aa	7,71Ba	3,98Ba	17,43	2,18	0,2617	<0,0001	0,0293
20	25,61Aa	16,08ABa	6,49Ba	16,06				
30	29,75Aa	2,91Ba	4,81Ba	12,94				
Average	31,99	16,06	12,94					
	MRbT (%)							
10	12,12	35,65	37,74	28,50a	2,177	0,0042	<0,0001	0,6591
20	6,10	18,69	18,81	14,53b				
30	5,01	27,98	26,99	19,99ab				
Average	7,74B	27,44a	27,84A					
	TSR (%)							
10	87,88	64,34	62,25	71,49b	2,173	0,0019	0,0512	0,667
20	94,64	81,31	81,18	85,71a				
30	94,98	72,01	73,01	80,00ab				
Average	92,50A	72,55B	72,15B					

Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance, * SEM = standard error of the mean; 1TAR = tiller appearance rate; MRbT = mortality rate of basal tillers; TSR = tiller survival rate

Unlike the dry period, there was no interaction between cutting intensities and months (P > 0.05) on tiller mortality, which was on average 90% less than the dry period. In April, the tillers had a higher rate of appearance (31.99%) and a lower rate of mortality (7.74%); among the heights, at the 20-cm cutting intensity, the pasture obtained tillers with lower mortality,

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while the pasture with a 10-cm intensity showed a higher MRbT, a behavior similar to the dry season (Table 2). At the lowest cutting height, mortality may be related to the beheading of the apical meristem, because regardless of the period of the year, these values were higher in relation to the other cutting intensities. At the 30-cm height, the higher mortality rate might be related to the higher pre-grazing height that this pasture presented (Table 4), which may have influenced the shading of the basal tillers.

This behavior was also observed by Santos et al. (2011) when working with *Brachiaria decumbens* cv. Basilisk, managed at four heights (10, 20, 30, and 40 cm). Those authors observed higher mortality of vegetative tillers at the highest heights. The authors justified that smaller vegetative tillers were shaded and, as a result, died due to competition for light with older and larger tillers.

For the tiller survival rate, there was no interaction between cutting heights and months for the rainy season ($P > 0.05$). With regard to the evaluated months, there was superiority in April, the month in which there was a lower mortality rate. Among cutting heights, there was greater tiller survival when cut to 20 cm, justified by the lower MRbT observed for that height.

For the stability index, there was no interaction between cutting heights and months during the rainy season ($P > 0.05$). Among the evaluated months, in April there was a higher stability index, with an average of 1.21 (Table 6), justified by the higher values of appearance and survival of tillers observed in that month (Table 5).

Table 6. Andropogon grass pasture stability index submitted to different cutting heights during the rainy season

Stability index								
Heights (cm)	Months			Average	SEM*	p-value		
	Apr	May	Jun			Hei	Months	Hei*Mon
10	1,22	0,68	0,64	0,87b	0,035	0,0350	<0,0001	0,1558
20	1,18	0,83	0,86	0,96a				
30	1,23	0,74	0,76	0,91ab				
Average	1,21A	0,75B	0,75B					

Means followed by equal capital letters in the lines and lowercase letters in the columns, do not differ by the Tukey test at 5% significance, * SEM = standard error of the mean;

Among the evaluated heights, 20 cm provided greater stability (0.96), a fact justified by the lower MRbT and higher TSR in relation to the other heights. Despite the reduction in the stability index over the rainy season, there were higher averages relative to the dry period. Caminha et al. (2010) evaluated the survival and stability of the tillers population in Marandu grass pastures at different times of the year and observed that the tillering and grass recovery capacity occurs when favorable conditions are established, such as temperature and rainfall, and that in the natural cycle of variation in the number of tillers in the pasture throughout the year, the periods of

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greatest availability of growth factors, there is an increase in the number of plants per area.
Tillering dynamics are highly influenced by the cutting height and time of year. Andropogon grass pasture with 10 cm cutting intensity provides greater tiller density; however, the 20 cm intensity is recommended because it provides a higher survival rate and a lower grass mortality rate during the dry and rainy seasons.

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