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# Tillering dynamics of Alexandergrass pasture under nitrogen fertilization

[*Dinâmica do perfilhamento da pastagem de Papuã sob fertilização nitrogenada*]

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## ABSTRACT

This study was carried out to evaluate the effect of nitrogen fertilization on tillering dynamics of Alexandergrass (*Urochloa plantaginea* (Link) Hitch) grazed by beef heifers in a rotational stocking grazing method. The experiment was conducted in a completely randomized design following a repeated measure arrangement, three levels of nitrogen (Zero, 150 and 300kg ha$^{-1}$) and two area repetition. The classification of tillers into categories (basal and axillary) showed a greater number of basal tillers, due to their higher appearance rate, in the absence of nitrogen fertilization. Nitrogen fertilization promoted higher axillary tiller density. The use of nitrogen promotes the renewal of axillary tillers of Alexandergrass, without compromising the stability of the tiller population.

Keywords: axillary tiller, basal tiller, stability index, tiller density, *Urochloa plantaginea*

## RESUMO

*Esse estudo foi conduzido para avaliar o efeito da fertilização nitrogenada no perfilhamento do Papuã (Urochloa plantaginea (Link) Hitch) pastejado por novilhas de corte em um método de lotação rotacionada. O delineamento foi inteiramente casualizado com arranjo de medidas repetidas, três níveis de nitrogênio (Zero, 150 e 300kg ha$^{-1}$) e duas repetições de área. A classificação dos perfilhos em categorias (basais e axilares) mostrou um maior número de perfilhos basais, devido à sua maior taxa de aparecimento, na ausência de adubação nitrogenada. A fertilização nitrogenada promoveu maior densidade de perfilhos axilares. O uso de nitrogênio promove renovação dos perfilhos axilares no Papuã, sem comprometer a estabilidade da população de plantas.*

*Palavras-chave: perfilhos axilares, perfilhos basais, índice de estabilidade, Urochloa plantaginea*

## INTRODUCTION

The beef cattle industry in Brazil is a pasture-based activity and among the most used forages plants of the genus *Urochloa* stand out. Forages of this genus occupy an area of 94 million hectares, 55% of the total area used for pasture in Brazil (Ferraz, 2003). In the state of Rio Grande do Sul, within this genus Alexandergrass (*Urochloa plantaginea* (Link) Hitch) is the most prominent species, widespread and used for its good adaptation to the climate of the region.

Plants of the genus *Urochloa* exhibit great flexibility of use and management, and Alexandergrass is known for its spontaneous occurrence in summer crops. Although it is considered a weed, it has high production potential and favorable characteristics for grazing, besides high digestibility (Oliveira Neto *et al.*, 2013). Among the favorable characteristics of forage to grazing, tillering is used as a means of growth, increase in productivity and, mainly, survival of the plant community in established pastures (Hodgson, 1990). According to Garcez Neto *et al.* (2002), tillering is the structural characteristic that determines the morphological

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plasticity and is genetically determined. However, it can be influenced by nutritional, environmental and management factors.

The use of nitrogen interferes with the dynamics of plant populations in pastures (Caminha *et al.*, 2010). The positive effect of nitrogen on tillering is shown in faster formation of axillary buds and the emergence of the corresponding tillers, affecting the growth of grasses and stimulating the renewal of tillers (Fagundes *et al.,* 2006). According to Caminha *et al.* (2010), this renewal favors a greater density of young tillers in the pasture, a favorable condition to increases its productivity.

The canopy structure is directly related to the size, quality and efficiency of the photosynthetic apparatus of the plant community. Changes in leaf area directly influence the capacity of light interception by the canopy, promoting changes in its structural characteristics. These characteristics include the tillering dynamics and, hence, the tiller density. The alterations made in the sward structural characteristics are crucial, interfering in the way the forage is presented to the grazing animal and the ease of grasping and consuming, which determine the animal production in the system (Lemaire and Chapman, 1996).

Studies on the tillering dynamics of tropical grasses have been conducted (Zanine *et al.*, 2013; Santos *et al.,* 2014), however, there is no evidence in the literature of studies evaluating these parameters in Alexandergrass. This study aimed to evaluate the patterns of tillering of Alexandergrass forage as grazed in response to nitrogen fertilization.

## MATERIAL AND METHODS

The experiment was approved by the Ethics Committee for Animal Experimentation of Universidade Federal de Santa Maria (Protocol 138/2014). This study was carried out in the Animal Science Departament at Universidade Federal de Santa Maria (UFSM), in Santa Maria, State of Rio Grande do Sul, Brazil, from December to April of 2014. The Köppen climate classification in the region is humid subtropical (Cfa), and the soil is classified as Paleudalf (Sistema…, 2006), a type of Alfisol. The mean values for the chemical characteristics of the soil on the experimental area were: pH-$H_2O$: 5.8; % clay: 21.0m $V^{-1}$; P: 14.4mg $L^{-1}$; K: 128.3mg $L^{-1}$; % OM: 2.5m $V^{-1}$; $Al_{3+}$: 0.7cmol $L^{-1}$; $Ca_{2+}$: 5.3cmol $L^{-1}$; $Mg_{2+}$: 2.5cmol $L^{-1}$; $pH_7$: 9.2. The meteorological data of the trial period were obtained from the UFSM Meteorological Station.

The experimental area, divided into six experimental units (paddocks), comprised 4.8 hectares (ha). Each paddock was subdivided into four plots of 0.2 ha. Alexandergrass (*Urochloa plantaginea* (Link) Hitch) pasture was established in December 2013 by an existing seed bank in the area. Fertilization consisted of 90kg $ha^{-1}$ $P_2O_5$ and 60kg $ha^{-1}$ $K_2O$. A mowing canopy height homogenization was performed on January 8th, 2014. The treatments were Zero, 150 or 300kg $ha^{-1}$ of nitrogen (N) in urea form. The total amount of N was split into three doses of similar amount, the first applied on January 8th, and the others on February 10th and February 26th.

The grazing method was rotational stocking. The criterion to determine the rest period was 210 degree-days (DD). The first three grazing cycles lasted 16 days (4 days graze, 12 days rest), considering the average daily temperature for the months of January and February (26.4°C). The last two cycles lasted 24 days (6 days graze, 18 days rest), considering the average daily temperature for the months of March and April (21.7ºC). Thermal sum (TS) was calculated by the equation: TS= $\sum$(Tmd) -10, where: Tmd is the daily average temperature of the cycle; the value of 10 grade is the minimum temperature required for growth of warm season forage species (Westphalen, 1975). The utilization of the pasture comprised five grazing cycles (1- Jan./21 to Feb./05; 2- Feb./06 to Feb./21; 3- Feb./22 to March/09; 4- March/10 to April/02; 5- April/03 to April/26 of 2014).

Sixteen Angus heifers with initial age and body weight (BW) of 15 months and 276.0±17.4kg, respectively, were the test animals utilized (two heifers in paddocks not receiving N and three in the other experimental units). For the maintenance of the post-grazing canopy height at 30cm±10%, 22 regulator animals were used. Canopy height was measured through readings at 30 points at pre and post-grazing. The stocking rate (kg $ha^{-1}$ BW), was calculated by the sum of heifer-test average weight, with the average weight of each regulator animal, multiplied by the number of days in which they remained in each replication, divided by the number of days of the experimental cycle.

The first generation of tillers was marked, in three fixed areas, before starting the first grazing cycle. In this occasion, Alexandergrass tillers were differentiated into basal and axillary and marked with plastic wires of same color. Each new grazing cycle the living tillers marked in the previous generation were counted again and the new generation of tillers was marked with plastic wires of a different color. The dynamics of tillering was carried out from the identification and counting of the remaining living tillers and the appearance of new tillers.

We calculated the tiller appearance rate (TAR), mortality (TMR) and survival (TSR; tillers tiller$^{-1}$ m$^{-2}$). The population stability index (SI) of tillers was calculated according Bahmani *et al.* (2003), in which: SI = TSR*(1 + TAR). Tiller population density (tillers m$^{-2}$) was evaluated during the grazing cycles by counting live tillers, at three fixed areas of 0.0625m² per plot. The number of tillers was quantified after forage cutting within three areas of 0.0625m² each, later, those samples were dried and weighed. Site filling, which measures the relationship between the emergence of leaves and the occupation of leaf shoots to form tillers, was calculated by dividing the TAR by leaf blade appearance rate.

A completely randomized design following a repeated measure arrangement was used, with three treatments and two area replications for treatments. After testing normality of data distribution, the variables were analyzed using the *Mixed* procedure of SAS® version 9.2. We performed a structure selection test, following the Bayesian Information Criterion (BIC) to determine the model that best fit the data. When not fitted to regression models, the mean values were compared using the 'lsmeans' procedure (10% of probability). When the interaction between treatments and evaluation cycles was significant at 5% probability the variable responses were modeled according to days of pasture utilization using polynomial regression to third order. In regression analysis, the model was selected based on the significant level of linear and quadratic coefficients, using the Student's t-test (Test "t"; 10% probability).

## RESULTS

The post-grazing canopy height (29.5cm) was similar in all paddocks ($P= 0.1324$) across N levels evaluated. During the experimental period (January to April 2014), the average temperature was 24.1°C, insolation was 211.7 hours and rainfall was 143.3mm. We observed no interaction between levels of N × grazing cycles ($P> 0.05$) for any of variables evaluated ($P> 0.05$). Higher stocking rates were observed in the paddocks that received nitrogen fertilizer, regardless of the level ($P< 0.10$; 2506.1±102.1kg ha$^{-1}$ BW). The lower stocking rate was observed without the use of N (1982.2±102.1kg ha$^{-1}$ BW).

The number of marked tillers in the first generation was similar among all paddocks ($P> 0.10$). The population density of basal tillers (Figure 1) was higher ($P< 0.10$) in the absence of N fertilization (557.4±27.2 tillers m$^{-2}$), intermediate at the level of 300kg ha$^{-1}$ N (462.7±21.6 tillers m$^{-2}$) and lower at the level of 150kg ha$^{-1}$ N (386.1±19.0 tillers m$^{2}$). The population density of axillary tillers (Figure 1) showed higher value ($P< 0.10$) at the level of 300kg ha$^{-1}$ N (1644.8±120.1 tillers m$^{-2}$), intermediate at the level of 150kg ha$^{-1}$ N (1338.0±108.6 tillers m$^{-2}$) and lowest at the level of Zero kg ha$^{-1}$ N (752.3±88.6 tillers m$^{-2}$).

The density of basal tillers (Figure 2) was higher ($P< 0.10$) in the first four grazing cycles (508.8±24.8 tillers m$^{-2}$). In the fifth grazing cycle, the value of this variable was lower (308.3±24.8 tillers m$^{-2}$). The population density of axillary tillers (Figure 2) showed lower values ($P< 0.10$) and similar to each other in the first and second (514.4±137.6 tillers m$^{-2}$), intermediate (1178.4±137.6 tillers m$^{-2}$) in the third cycle and higher (2008.9±137.6 tillers m$^{-2}$) values in four and five grazing cycles, which were not different from each other.

In basal tillers, the appearance rate (Figure 3) was higher ($P> 0.10$) in the absence of N (1.05±0.02 tillers tiller$^{-1}$ m$^{-2}$), with lower values (0.95±0.02 tillers tiller$^{-1}$ m$^{-2}$) when Alexandergrass received nitrogen fertilizer, regardless of the level. Nitrogen fertilization did not change ($P< 0.10$; Figure 3) the survival rate (0.94±0.02 tillers tiller$^{-1}$ m$^{2}$), mortality rate (0.06±0.02 tillers tiller$^{-1}$ m$^{-2}$) and population stability index of these tillers (1.8±0.06).

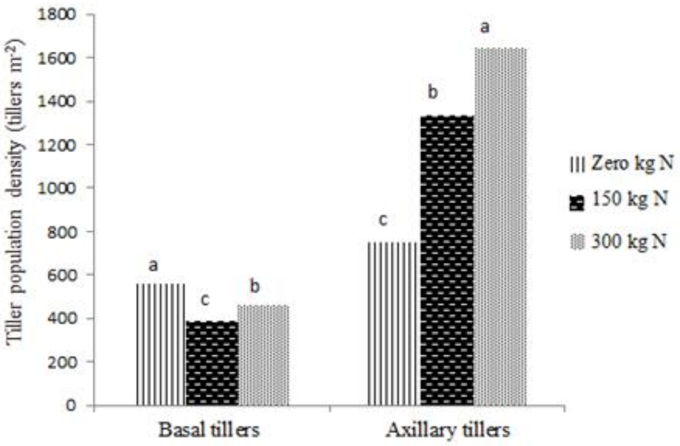

Figure 1. Population density of basal and axillary tillers (tillers $m^{-2}$) of Alexandergrass as a function of levels of nitrogen (N). Different letters indicate that the means differ from each other (P< 0.10).

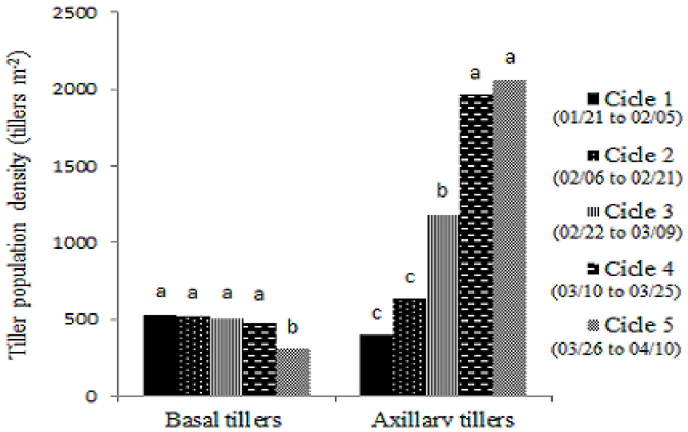

Figure 2. Population density of basal and axillary tillers (tillers $m^{-2}$) of Alexandergrass as a function of the grazing cycles evaluated. Different letters indicate that the means differ from each other (P< 0.10).

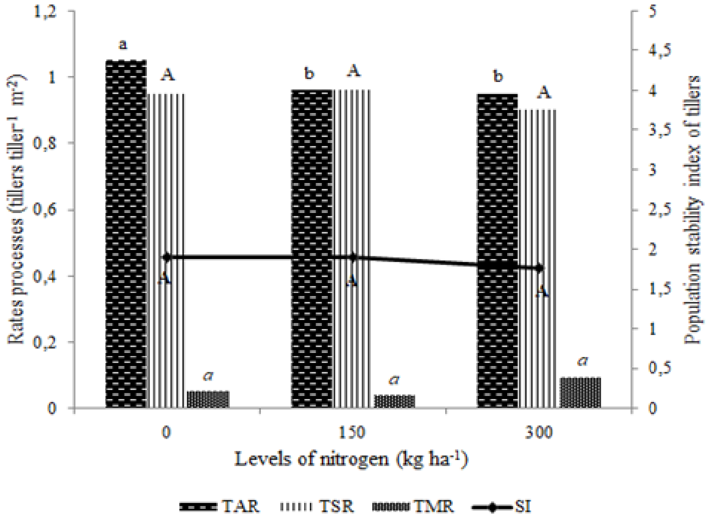

Figure 3. Rate of appearance (TAR), survival (TSR) and mortality (TMR) of basal tillers (tillers $tiller^{-1}$ $m^{-2}$) and stability index (SI) population of basal tillers of Alexandergrass as a function of the nitrogen (N) rates applied. Different letters indicate that the means differ from each other (P< 0.10).

In axillary tillers, the appearance rate (Figure 4) was higher (P< 0.10) at level of 300kg ha$^{-1}$ N (2.77±0.32 tillers tiller$^{-1}$ m$^{-2}$) and lower (1.92±0.13 tillers tiller$^{-1}$ m$^{-2}$) at levels Zero and 150kg ha$^{-1}$ N, similar to each other. The survival rate (Figure 4) was higher (P< 0.10) at levels of Zero and 150kg ha$^{-1}$ N (0.93±0.01 tillers tiller$^{-1}$ m$^{-2}$), which were not different from each other, and lower at level 300kg ha$^{-1}$ N (0.88±0.01 tillers tiller$^{-1}$ m$^{-2}$). At level 300kg ha$^{-1}$ N, the mortality rate (Figure 4) was higher (0.11±0.02 tillers tiller$^{-1}$ m$^{-2}$) compared to levels Zero and 150kg ha$^{-1}$ N (0.05±0.02 tillers tiller$^{-1}$ m$^{-2}$), which did not differ from each other (P< 0.10). The population stability index of these tillers (2.8±0.22) was not affected by levels of N applied (P> 0.10; Figure 4).

The appearance rate of basal tillers and population stability index of axillary tillers fitted to a negative linear regression model (P< 0.10) according to the accumulated thermal sum in the period of pasture use (Table 1). The other variables did not fit any tested regression model.

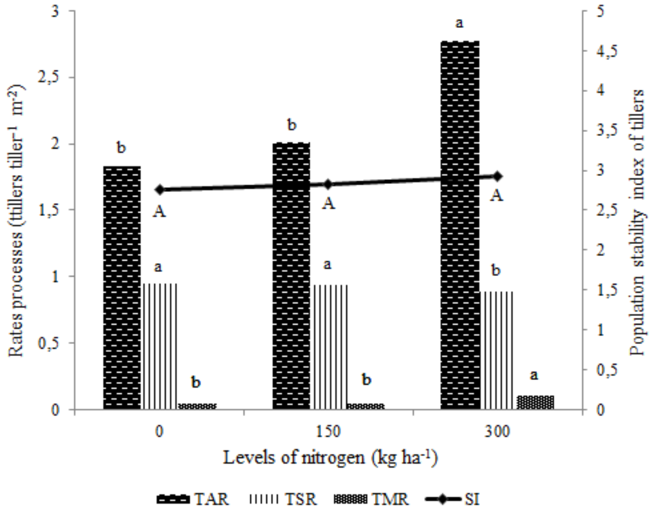

Figure 4. Rate of appearance (TAR), survival (TSR) and mortality (TMR) of axillary tillers (tillers tiller$^{-1}$ m$^{-2}$) and stability index (SI) population of axillary tillers of Alexandergrass as a function of the nitrogen (N) rates applied. Different letters indicate that the means differ from each other (P< 0.10).

Table 1. Regression models for the variables related to the tillering as a function of the accumulated thermal sum in the period of use of the Alexandergrass

| Variables | Regression models | $r^2$* | VC** | P*** |
|---|---|---|---|---|
| Appearance rate of basal tillers[1] | $\hat{Y} = 1.12 - 0.0001x$ | 38.0 | 7.5 | 0.0049 |
| Population stability index of axillary tillers | $\hat{Y} = 3.88 - 0.0009x$ | 27.1 | 27.2 | 0.0032 |
| Site occupation of basal tillers | $\hat{Y} = 0.25 - 0.00009x$ | 37.8 | 20.0 | 0.0066 |

*Determination coefficient, %; **Variation coefficient, %; ***Probability of thermal sum; [1]tillers/tiller/m²

The site filling of basal tillers did not vary according to levels of N (P> 0.10; 0.18±0.01). The site filling of axillary tillers was higher (P< 0.10) at level 300kg ha-1 N (0.62±0.07) and lower (0.39±0.06) at levels Zero and 150kg ha$^{-1}$ N, which were not different from each other. The site filling of basal tillers fitted to a negative linear regression model (P< 0.10) according to the thermal sum accumulated during pasture use (Table 1).

## DISCUSSION

Meteorological data of the study period, compared with the historical average, show similarity in observed average temperature (24.1°C) while the average insolation (hours) was 12.6% higher. Rainfall values registered were lower than the historical average in the months of January, February and April. In March, the rainfall recorded was 49.5% higher than the historical average (151.7mm).

The stocking rate in paddocks subjected to N fertilization, regardless of the level, was 26% higher than the stocking rate in the unfertilized paddocks. The stocking rate is positively influenced by N fertilization and is the result of pasture management to keep given the increase in forage production. This higher stocking rate is due to the extra weight necessary in order to maintain the target post-grazing height of the sward in all N levels tested similar. The greater herbage accumulation after N fertilization allows the higher stocking rate. The appearance rate of basal tillers (Figure 3) was 10.5% higher than in the absence of N fertilization, leading to greater population density of these tillers regarding the use of 150 and 300kg ha$^{-1}$ N (Figure 1). The highest density of leaf blades resulting from N use probably increased light interception in the top of the sward, indicating a strong competition for light at the lower stratum, a factor that interferes negatively with the basal tiller emergence (Hernàndez-Garay *et al.,* 1999). According to Morais *et al.* (2006), one of the causes of reduced tiller number is the negative energy balance, resulting from competition for light.

The development of new axillary tillers was favored by N fertilization (Figure 1). This production can be a plant strategy to rapidly increase the leaf area index after defoliation (Giacomini *et al.*, 2009), which is consistent with the higher stocking rate resulting from the use of N. Still, stems of grazed basal tillers taken by grazing are substrate for the formation of axillary tillers (Sbrissia *et al.,* 2010). N stimulates the formation of new tillers not only by increasing the number of buds, but also by activating the development of dormant buds (Matthew *et al.,* 2000; Roma *et al.*, 2012).

The Alexandergrass has a decumbent growth habit, characterized by an initial stoloniferous growth, then erect. The number of tillers increases initially, constituting the first generation, to reduce the distance between plants and increase the occupation of the area before investing in height growth (Hernàndez-Garay *et al.*, 1999). With the increase of one degree in the accumulated thermal sum during the pasture use, there was a decrease of 0.0001 tillers tiller$^{-1}$ m$^{-2}$ in appearance rate of basal tillers (Table 1). The reduced number of basal tillers in the last cycle (March/April) and increased density of axillary tillers (Figure 2) in the course of evaluation cycles of the pasture was probably due to the annual cycle of Alexandergrass and greater aerial tillering has worked as a strategy to ensure its persistence.

Mortality and survival rates of basal tillers were not influenced by N fertilization (Figure 3) and their values are consistent with those observed in the literature. Roma *et al.* (2012) in Panicum maximum cv Tanzânia under N levels (0, 100, 200 and 300kg ha$^{-1}$) found values of 0.06 tiller tiller$^{-1}$ m² tiller for mortality rate and 0.94 tiller tiller$^{-1}$ m² for tiller survival rate. The population stability index of the basal tillers (Figure 3) remained above 1.0, indicating that the survival coupled to the appearance of new tillers is sufficient to compensate for mortality rates, ensuring the persistence of the plant (Bahmani *et al,* 2003).

In turn, the mortality rate of axillary tillers (Figure 4) was 54% higher at the highest N level (0.06 tiller tiller$^{-1}$ m$^{-2}$). According to Braz *et al.* (2012), N deficiency leads tillers to reduce mortality as a survival strategy. Thus, under limiting conditions of growth, plants reduce the emergence of new tillers to maintain growth of existing tillers. This is confirmed by an appearance rate 30% lower (Figure 4) in the absence of N, since N is the nutrient with the greatest impact on the velocity of plant growth processes (Caminha *et al.*, 2010).

The highest mortality of aerial tillers at the highest level of N may be associated with a possible higher frequency of defoliation due to a higher stocking rate. With increasing N level, stocking rate was increased to maintain the target height of the canopy. Due to the highest level of insertion of aerial tillers, there is a high possibility of removing the meristems thereof. The highest stocking rate at the highest level of N probably contributed to values of tiller mortality observed since not only senescent tillers are used to determine the mortality rate, but also the tillers not found in the next assessment, which may have been consumed (Braz *et al.,* 2012). Higher rates of appearance and mortality, a condition found with the use of 300kg ha$^{-1}$ N, generate higher tiller turnover, which favors a canopy with a higher proportion of young tillers, condition favorable to increases in productivity, once the stability of the tiller population is not compromised (Caminha *et al.*, 2010).

Axillary tillers survived 6.2% more at levels Zero and 150kg ha$^{-1}$ N than at 300kg ha$^{-1}$ N (Figure 4). This was probably due to compensatory mechanism of plants to ensure the persistence in the area, by increasing their survival to compensate for the lower rates of tiller appearance (Carvalho *et al.*, 2000).

The population stability index of axillary tillers (Table 1) fitted to a negative linear regression model, indicating that with the increase of one degree in the thermal sum during the pasture use, there was a decrease in 0.0009 points in the population stability index of these tillers. This index, however, remained above 1.0 until the end of the experimental period. The stability index above 1.0 in the reproductive stage is a persistence mechanism denominated "reproductive mechanism" by Matthew *et al.* (2000).

The site filling of basal tillers was not affected by N levels, while the site filling of axillary tillers was 59% higher at the highest level of N in relation to levels Zero and 150kg ha$^{-1}$ N. This is because the N promotes development of potential buds, increasing the site filling (Matthew *et al.*, 2000). The site filling of basal tillers fitted to a negative linear regression model (Table 1), reducing 0.00009 to each degree of increase in the thermal sum accumulated during pasture use. With the progress in the development cycle of the annual pasture, as Alexandergrass, the leaf appearance tends to decrease, which are associated with a lower appearance of tillers and consequent lower site filling.

## CONCLUSION

Nitrogen fertilization in Alexandergrass is a management practice that favors the replacement of axillary tillers without compromising the stability of the tiller population. This practice enables an increase in the period of Alexandergrass pasture use by increasing the production of axillary tillers when the emergence of basal tillers is declining.

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