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Morphogenesis of age groups of marandu palisadegrass tillers during the stockpiling period

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ABSTRACT. The stockpiled forage canopy consists of tillers at different ages, which have specific development patterns. The objective was to understand the development of *Urochloa brizantha* cv. Marandu during the stockpiling period, by the morphogenic evaluation of tillers at different ages. The experiment was conducted in a completely randomized design, in a split plot scheme, with four replications. Three tillers ages (young, mature and old) and two periods of stockpiling (initial and final) were evaluated. The leaf appearance and elongation rates were higher in young tillers (0.05 tiller^{-1} day^{-1} and 0.62 cm tiller^{-1} day^{-1}, respectively), compared to old tillers (0.02 tiller leaf^{-1} day^{-1} and 0.20 cm tiller^{-1} day^{-1}, respectively). The final leaf length of the tillers' age groups was the same in the beginning of stockpiling. The number of live leaves was lower in the old tillers (2.4), compared to the young (3.6) and mature (4.1) ones, contrary to the stem length. The number of old tillers (800 tillers m^{-2}) was higher than the young (299 tillers m^{-2}) and mature ones (358 tillers m^{-2}). The participation of different age groups of tillers in the canopy influences the development and structure of marandu palisadegrass.

Keywords: pasture structure; stockpiled pasture; tiller number; *Urochloa brizantha*.

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Introduction

The seasonality of production of tropical forage grasses can create problems for the production of animals on pasture, if the rancher does not carry out adequate forage planning and does not program management strategies to provide food to the herd during the winter months in the Southeast and Midwest of Brazilian regions. In this sense, stockpiling pasture is a relatively simple and low-cost alternative, capable of guaranteeing pasture in quantity to meet the demand of herd during the winter (Nave, Rondineli, Chris, Michael, & Gary, 2016).

The stockpiling pasture consists of selecting a pasture area in the property and excluding it from grazing, usually in late summer and, or, in early autumn in the Southeast and Midwest regions of Brazil. Thus, it is possible to obtain forage production to be grazed during the period of low growth rate of forage plants (Schio et al., 2011).

Stockpiled pasture consists of a diverse population of tillers, which are the growth units of forage grasses (Santos & Fonseca, 2016). Thus, changes in tiller population densities cause changes in the characteristics of the stockpiled pasture. In this sense, during the stockpiling period, changes in population densities of tillers age groups occur in the pasture, as a consequence of changes in climatic conditions, the microclimate inside the canopy and the phenology of the forage plant itself (Alves et al., 2019).

Considering that each age group of tillers has specific developmental characteristic (Paiva et al., 2012; Alves et al., 2019), morphology (Paiva et al., 2011) and nutritional value (Santos, Corsi, Pedreira, & Lima, 2006), understanding how variations in the numbers of young, mature and old tillers occur during the stockpiling period is essential to understand the effects of this period on persistence, forage production and the pasture structure.

The objective of this work was to understand how different age groups of tillers develop during the stockpiling period of *Urochloa brizantha* cv. Marandu pasture.

Material e methods

The experiment was conducted in the field under cutting conditions (without grazing) at the Experimental Farm Capim Branco, belonging to the Federal University of Uberlândia (UFU), Uberlândia, MG (18°53'19” S, 48°20'57” W and 863 meters altitude) from October 2014 to July 2015. The climate is tropical savanna (Aw, according to the Köppen classification), with well-defined dry and rainy seasons (Alvares, Stape, Sentelhas, Gonçalves, & Sparovek, 2013), with average annual temperature and precipitation of 22.3°C and 1584 mm. Climatic data during the experimental period were obtained from a meteorological station located 200 m from the experimental area (Figure 1).

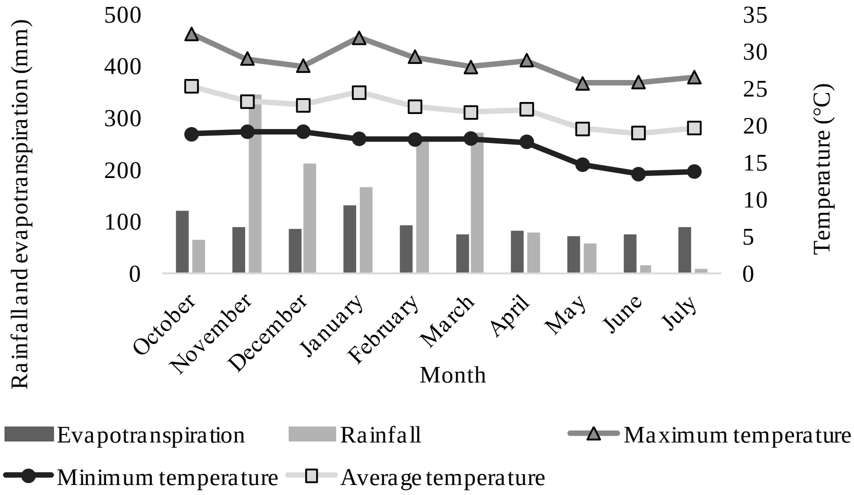

Figure 1. Rainfall, evapotranspiration and monthly average temperatures during the experimental period from October 2014 to July 2015.

The experimental area consisted of a pasture established in 2000 with *Urochloa brizantha* cv. Marandu (marandu palisadegrass) with soil 100% covered with the forage plant and without the presence of weeds, in which four experimental plots, each with 9 m^2, were demarcated. Before the experiment, this pasture was managed in continuous stocking with cattle and the pasture was maintained at a height of 15 to 25 cm. The soil of the experimental area was classified as dystrophic dark red latosol. In October 2014, 20 simple soil samples were taken, in the 0-10 cm layer, to analyze the level of fertility, the results of which were: pH in H_2O: 6.0, P: 5.2 (Mehlich^{-1}) and K: 156 mg dm^{-3}, Ca^{2+}: 5.4, Mg^{2+}: 2.0 and Al^{3+}: 0.0 cmol$_c$ dm^{-3} (KCl 1 mol L^{-1}). With these results and in accordance with the recommendations of Cantarutti et al. (1999) for a system of medium technological level, it wasn’t necessary to make liming and potassium fertilization. Nitrogen fertilization was carried out in November 2014 (70 kg ha^{-1} of N) and in January 2015 (70 kg ha^{-1} of N) under cover, using urea as an N source.

The experiment was conducted in a completely randomized design, in a split plot scheme, with four replications. Three tiller age groups (young, mature and old), corresponding to the primary factor (parcel), and two periods of stockpiling (initial and final), referring to the secondary factor (subplot), were evaluated. The young tillers corresponded to those with less than two months old, the mature ones are between two and four months old, and the old ones are older than four months (Paiva, Pereira, Silva, Dias, & Raphael, 2015). The initial period of pasture stockpiling was from 1 to 45 days, while the final period, from 46 to 90 days.

During the period prior to stockpiling, since October 2014, the plants were kept with 15 cm by weekly cuts, with the help of pruning shears. After weekly cuts, the excess cut forage that remained on the plants was removed. From November 2014, that is, 30 days after the beginning of weekly cuts to maintain canopy height at 15 cm, the tillering dynamics was also evaluated. For this, two areas of 0.07 m^2 per experimental unit were demarcated, using a 30 cm diameter PVC ring, fixed to the ground by means of wire clamps. Every 30 days, all tillers were counted and marked with smooth wire covered with plastic with different colors, to identify each generation of tillers. With these data, it was possible, during the stockpiling period, to identify and quantify the age groups of tillers within the rings of assessment of tillering dynamics.

The morphogenesis of young, mature and old tillers was evaluated in two 45-day cycles, totaling 90 days of evaluation throughout the stockpiling period, from April 15, 2015 to July 14, 2015. In each evaluation cycle, four tillers of each age were marked using identified loops, and at each new cycle, a new group of tillers was selected for evaluation. With the graduated ruler, measurements of the length of all leaf blades and stem of the tillers were taken, once a week. The measurement of the length of the expanded leaves was taken from the tip of the leaf to its ligula. In the case of expanding leaves, the same procedure was adopted, but the ligula of the last expanded leaves was considered as a measurement reference. For leaves senescent, the length corresponded to the distance from the point to which the senescence process advanced to the ligula. The stem size was measured from the soil surface to the ligula of young leaf completely expanded. According to the methodology described by Santos et al. (2011), the following variables were calculated: leaf appearance rate (LApR), leaf elongation rate (LElR), stem elongation rate (SElR), leaf senescence rate (LSeR), number of live leaves per tiller (NLL), number of dead leaves per tiller (NDL), final leaf blade length (LBL) and final stem length (SL).

The data were previously tested, ensuring that they met the basic prerogatives for analysis of variance. For this, the evaluation of the normality of the data was performed by the Kolmogorov-Smirnov test, while the Bartlett test was used to study the homogeneity of the data. The values of the SElR and LElR were transformed into a square root. For statistical analysis, the SAS® 9.0 program was used. The means were compared by using the Tukey test with a 5% probability of occurrence of the Type I error.

Results and discussion

Of the nine response variables, 67% were influenced by the age of the tiller and approximately 20% by the stockpiling period. Only the final leaf blade length was influenced by the interaction between the stockpiling period and the tiller's age. On the other hand, some characteristics were not influenced by the studied factors, namely: stem elongation rate and leaf senescence rate (Table 1), which presented average values of 0.05 and 0.55 cm tiller^{-1} day^{-1}, respectively.

Table 1. Coefficient of variation (CV) and significance for the effects of tiller age, stockpiling period and interactions for the response variables evaluated in marandu palisadegrass.

Characteristic	Variation source			
	CV	Tiller age	Stockpiling period	Tiller age x Stockpiling period
LApR	47.07	**0.0134**	0.7239	0.2387
LElR	64.91	**0.0414**	0.8615	0.9474
SElR	97.37	0.9702	0.1213	0.9296
LSeR	98.05	0.3397	0.1512	0.6461
LBL	28.47	**0.0091**	0.2880	**0.0084**
SL	35.23	**0.0086**	**0.0151**	0.2322
NLL	29.33	**0.0008**	0.4823	0.3882
NDL	48.80	0.2481	**0.0204**	0.4411
NT	54.26	**0.0001**	0.3889	0.2173

LApR: leaf appearance rate; SElR: stem elongation rate, RElL: leaf elongation rate; LSeR: leaf senescence rate, LBL: final leaf blade length; SL: final stem length; NLL: number of live leaves per tiller; NDL: number of dead leaves per tiller; NT: number of tillers.

The leaf elongation (LElR) and leaf appearance (LApR) rates were lower in old tillers, when compared to young tillers (Table 2). It is possible that the LApR and LElR of the old tillers have been compromised by the decrease in leaf tissue (leaf blade size) of these tillers (Figure 2), which may have reduced the light interception and photosynthesis of the old tillers.

These results indicate that young tillers have a higher growth rate, compared to old ones. Thus, the idealization of management strategies that result in a greater number of young tillers in stockpiled pastures could increase the forage production during the stockpiling period. For this purpose, the following management strategies can be adopted in stockpiled pastures: reducing the stockpiling period, decreasing the height of the forage canopy at the beginning of the stockpiling period, and nitrogen fertilization (Santos & Fonseca, 2016).

The nitrogen fertilization and the reduction of the height of the forage canopy at the beginning of the stockpiling period can cause a higher occurrence of young tillers in the stockpiled canopy. Nitrogen stimulates the development of basal gems in tillers (Skinner & Nelson, 1995), as long as the leaf area index of the forage canopy is not very high. In this condition, more light is focused at the base of the plants, which stimulates the development of basal gems in new tillers (Sousa et al., 2012). Furthermore, with the demotion of the pasture at the beginning of stockpiling period, many old tillers are expected to die due to the elimination of their apical meristem. In fact, the participation of this tiller age group, which has a lower growth rate (Table 2), is reduced.

Table 2. Morphogenic and structural characteristics of three age groups of marandu palisadegrass tillers during the beginning and end of the stockpiling period.

Characteristic	Tiller age			Stockpiling period	
	Young	Mature	Old	Beginning	End
LApR	0.05 A	0.03 AB	0.02 B		
LElR	0.62 A	0.58 AB	0.20 B		
NLL	3.6 A	4.1 A	2.4 B		
NLD				1.9 A	1.2 B
LBL	18.17 B	28.51 A	29.27 A	29.31 A	21.32 B
NT	299 B	358 B	800 A		

LApR: leaf appearance rate (Leaf Tiller $^{-1}$ day^{-1}), LElR: leaf elongation rate (cm tiller^{-1} day^{-1}), NLL: number of live leaves per tiller $^{-1}$, NDL: number of dead leaves per tiller $^{-1}$, LBL: final leaf blade length; NT: number of tillers m^{-2}; For each characteristic, averages followed by the same letter, uppercase for the tiller age and lowercase for the stockpiling period, don't differ by the Tukey test ($p > 0.10$). Unfilled spaces indicate no effect ($p > 0.10$)

Old tillers occurred in greater numbers in the stockpiled canopy, when compared to young and mature ones (Table 2). When stockpiling pasture is adopted, the forage plant remains in free growth, and its development stage is not interrupted by grazing. Thus, the tillers reach older ages. In addition, if the stockpiling period is too long, there is less new tiller appearance and there is also a greater number of tiller dead in the canopy (Alves et al., 2019).

The young tiller is in an early stage of development, with a more active and intense tissue renewal, compared to the old tillers, which generally have a lower flow of tissues. This result may justify the lower numbers of live leaf (Table 2) and leaf blade length (LL) of the old tillers at the end of stockpiling (Figure 2), when compared with the other tillers evaluated.

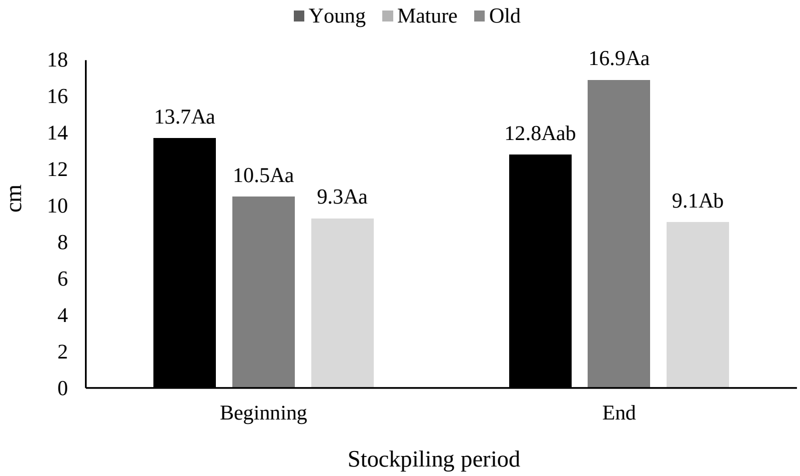

Figure 2. Final leaf length of three age groups of marandu palisadegrass tillers during the beginning and end of the stockpiling period. Lower case letters compare the age group of tillers within each stockpiling period, and upper case letters compare stockpiling periods within each age group of tillers. Means followed by the same letter don't differ by the Tukey test ($p > 0.10$).

In general, there is a positive relationship between leaf blade and stem lengths of tropical forage grasses. This is because the larger SL causes the leaf to make a greater path during development, from the apical meristem to the top of the tiller, for exposure. In this way, the leaf elongation time increases, generating longer leaves (Duru & Ducrocq, 2000). However, this pattern of response did not occur in this study, as the old tillers had a higher SL (Table 2) and a lower LBL at the end of stockpiling period (Figure 2). It is possible that, at the end of stockpiling period, many old tillers have moved from the vegetative to the reproductive stage. In this process, there may have been an elevation of the apical meristem and, consequently, the distance from the meristem to the tiller top may have been reduced (Medica, Reis, & Santos, 2017), which would be responsible for the decrease in the LBL of the old tillers (Figure 2). On the other hand, at the beginning of stockpiling period, the lower flowering and the absence of elevation of the apical meristem, could justify the fact that the LBL was the same in all categories of tillers evaluated (Figure 2).

The stem length of the reproductive tillers, in general, is greater than that of the vegetative tillers. In this sense, it is possible that some mature and old tillers have reached the reproductive stage, presenting a longer stem, compared to young tillers (Table 2).

Considering that mature tillers and, especially, old tillers, due to their older ages, tend to flourish more than young tillers, the adoption of management strategies that reduce flowering are adequate to increase the relative participation of younger tillers and, in effect, improve the structure of stockpiled pasture. In this context, again three management strategies stand out to achieve this objective: the reduction of stockpiling period, the decrease of the height of the forage canopy at the beginning of stockpiling period and the use of earlier forage grasses, whose flowering occurs before the stockpiling period. Santos et al. (2009), evaluating *Urochloa decumbens* cv. Basilisk, found that the pasture under a long stockpiling period had a higher number of reproductive tillers, while the pasture stockpiled for a short period had a higher number of vegetative tillers. In another study, Rodrigues, Alves, Souza, Santos e Silva (2015) evaluated the morphogenesis of marandu palisadegrass at different heights at the beginning of stockpiling period and found that the stockpiled pasture with an average height of 15 cm had a greater number of vegetative tillers than the stockpiled one with 45 cm.

The nutritional value of the pasture is negatively influenced by the stem elongation, as this organ has a worse nutritional value compared to the live leaf (Nave, Pedreira, & Pedreira, 2011). Higher stem growth also negatively influences grazing efficiency and pasture consumption by animals (Benvenutti, Pavetti, Poppi, Gordon, & Cangiano, 2016). For this reason, it is advantageous that the stockpiled pasture is made up of more young tillers, which have less SL, and less mature and old tillers, which have longer stem (Table 2).

Regarding the stockpiling period, it is possible that the life span of the leaves increased at the end of the stockpiling period, due to the adverse climate prevailing in this period, justifying the lower number of dead leaves per tiller at the end of the stockpiling period (Table 2). In fact, rainfall at the beginning of stockpiling period was 65.6 mm while at the end it was 15.4 mm. The minimum temperature at the beginning of the stockpiling period was an average of 14.1 and 13.6°C at the end. In conditions of unfavorable climate for plant growth, the increase in leaf life can contribute to optimizing the leaf area index, light interception and, consequently, pasture photosynthesis (Alves et al., 2019).

It is worth noting that, especially in the water period, the dead leaf is considered a source of forage loss in the pasture, as this morphological component of the pasture is rejected by grazing animals (Sousa, Santos, Fonseca, Macedo Junior, & Silva, 2018). However, in stockpiled pastures, dead material can be better used. Afonso et al. (2018), in work with *Urochloa brizantha* cv. Marandu found that the sheep grazing simulation sample showed, on average, 36% of dead tissues, indicating the consumption of this fraction by the animals.

At the beginning of the stockpiling period, the SL was greater than at the end of this period (Table 2) and the marked tillers came from a more favorable climate and temperature condition at the end of summer (Figure 1), justifying their greater SL at the beginning of the morphogenic evaluation. On the other hand, the new group of tillers marked for evaluation during the end of the stockpiling period had a smaller initial stem size, as these tillers developed under more limiting climatic conditions, typical of autumn.

Conclusion

The young tillers of *Urochloa brizantha* cv. Marandu have greater leaf growth and shorter stem length compared to mature and old tillers. Thus, the idealization of stockpiled pasture management strategies can be done with the objective of increasing the percentage of young tillers in stockpiled pasture.

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