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Morphogenesis of stockpiled Marandu, Piatã, Xaraés and Paiaguás brachiariagrass cultivars

[*Morfogênese de cultivares de capins marandu piatã, xaraés e paiaguás diferidos*]

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ABSTRACT

The objective this study was to identify differences in the morphogenic patterns of four *Urochloa brizantha* cultivars (marandu, piatã, xaraés and paiaguás grasses) during the stockpiling period. A completely randomized design was used, with three replications, in experimental plots of 9m². The evaluations took place over 2 years. The grasses were stockpiled for 92 (Year 1) and 95 (Year 2) days. The leaf appearance rate of paiaguás grass was higher, compared to other grasses. In Year 1, the stem elongation rate of xaraés grass was higher than other grasses. At the end of stockpiling period of Year 1, the tiller population density (TPD) was higher in the paiaguás grass, intermediate in the xaraés and marandu grasses and lower in the piatã grass. At the end of the stockpiling period in Year 2, TPD was higher in the paiaguás grass canopy, intermediate in the marandu and piatã grasses canopies, and lower in the xaraés grass canopy. Paiaguás grass has greater leaf growth during the stockpiling period and is therefore suitable for use under stockpiled grazing. Xaraés grass has high stem elongation during the stockpiling period, which is why its use under stockpiled grazing must be accompanied by adjustments in pasture management.

Keywords: leaf growth, senescence, stem elongation, stockpiling period, *Urochloa brizantha*

RESUMO

O objetivo deste estudo foi identificar diferenças nos padrões morfogênicos de quatro cultivares de Urochloa brizantha *(marandu, piatã, xaraés e paiaguás) durante o período de diferimento. Foi utilizado o delineamento inteiramente ao acaso, com três repetições, em parcelas experimentais de 9m². As avaliações ocorreram por dois anos. Os capins foram diferidos por 92 (Ano 1) e 95 (Ano 2) dias. A taxa de aparecimento foliar do capim-paiaguás foi maior, em comparação aos demais capins. No Ano 1, a taxa de alongamento do colmo do capim-xaraés foi superior aos demais capins. No final do diferimento do Ano 1, a densidade populacional de perfilho (DPP) foi maior no capim-paiaguás, intermediária nos capins xaraés e marandu e inferior no capim-piatã. No fim do período de diferimento do Ano 2, a DPP foi superior no dossel de capim-paiaguás, intermediária nos dosséis dos capins marandu e piatã, e menor no dossel de capim-xaraés. O capim-paiaguás tem maior crescimento foliar durante o período de diferimento, sendo, portanto, apropriado para uso sob pastejo diferido. O capim-xaraés apresenta elevado alongamento de colmo durante o período de diferimento, razão pela qual seu uso sob pastejo diferido deve vir acompanhado de ajustes no manejo da pastagem.*

Palavras-chaves: alongamento de colmo, crescimento foliar, período de diferimento, senescência, Urochloa brizantha

INTRODUCTION

Stockpiling pasture consists of selecting a specific pasture area and excluding it from grazing, usually in late summer and/or, in autumn in the Southeast and Midwest regions of Brazil. In this way, it is possible to guarantee forage production to be grazed during the period of its scarcity and,

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with this, to minimize the negative effects of the seasonality of production of tropical forage grasses (Santos *et al*., 2009).

Forage grasses with thin stem and with high forage accumulation potential during autumn are recommended to use in stockpiling grazing. In addition, it is appropriate that grasses for stockpling do not flower intensely during the stockpling period, as flowering increases the stem elongation, which impairs the morphology and nutritional value of pasture (Santos *et al*., 2010). In general, many of these characteristics are present in *Urochloa brizantha* cultivars, such as marandu, piatã, xaraés and paiaguás grasses.

The piatã and paiaguás grasses have early flowering, in the months of December and January (Euclides *et al*., 2008; Valle *et al*., 2013). This characteristic makes these grasses suitable for stockpiling, as the concentration of their flowering occurs before the stockpiling period, normally started in March in the Southeast and Midwest regions of Brazil (Santos *et al*., 2009; Silva *et al*., 2016). In addition, paiaguás grass also has good forage production capacity during the dry season, compared to other *U. brizantha* cultivars (Veras *et al*., 2020). On the other hand, the xaraés grass has late flowering, concentrated in April and May (Valle *et al*., 2004), months in which the stockpiling period usually occurs in many regions of Brazil. This fact would make the xaraés grass inappropriate for stockpiling grazing. However, xaraés grass has the advantage of its high productive potential (Carloto *et al*., 2011, Cunha *et al*., 2012), which can increase the production of forage in stockpiled pasture.

Marandu grass has intermediate flowering to the other cultivars of *U. brizantha* previously mentioned, generally occurring in February and March (Calvano *et al*., 2011). Thus, if the stockpiling period starts at the end of March, this forage plant also becomes a good option for use under stockpiling grazing. Another advantage of using marandu grass to stockpiling is the fact that this forage grass is already established in most pastures in the Southeast, Midwest and North regions of Brazil.

Differences in developmental and morphological patterns among forage grasses for use under stockpiling can be adequately understood through the study of morphogenesis. Morphogenesis can be defined as the dynamics of generation (*genesis*) and expansion of plant shape (*morphos*) in space (Chapman and Lemaire, 1993).

For Marandu and Piatã grasses, there are scientific studies that allow us to understand the effects of stockpiled pasture management strategies on the the morphogenesis and structure of stockpiled canopies (Alves *et al*., 2019; Gouveia *et al*., 2017; Nogueira *et al*., 2020; Rocha *et al*., 2020; Sousa *et al*., 2019). However, for the Xaraés and Paiaguás grasses, there is still no scientific information about the morphogenesis of these grasses under stockpiling. Furthermore, although the importance of the adequate choice of forage plant for use in stockpiled pastures is recognized (Silva *et al*., 2016), comparative studies of the morphogenesis of Marandu, Piatã, Xaraés and Paiaguás cultivars submitted to stockpiling do not yet exist in the scientific literature. As a result, the possible differences between Marandu, Piatã, Xaraés and Paiaguás cultivars regarding leaf appearance, elongation and senescence rates, leaf life span, stem elongation rate, number of live leaves per tiller and tiller number of stockpiled cnopies are still unknown.

Due to the production and flowering season differences between the cultivars of *U. brizantha*, it is hypothesized that: (i) the xaraés and paiaguás grasses present a higher rate of leaf elongation than the piatã and marandu grasses during stockpiling period; and (ii) Xaraés grass also has a high rate of stem elongation during stockpiling period, compared to other *U. brizantha* cultivars. This work was carried out in order to identify differences in the morphogenic patterns of marandu, piatã, xaraés and paiaguás grasses during the stockpiling period and, thus, make recommendations on which of these grasses are most appropriate for stockpiling.

MATERIAL AND METHODS

This work was carried out from October 2016 to June 2018, during which the same experiment was repeated twice. The work took place at the Capim-branco Experimental Farm, belonging to the Faculty of Veterinary Medicine of the Federal University of Uberlândia, in Uberlândia, MG. The geographic coordinates of the site are 18° 30'south latitude and 47° 50' west longitude of Greenwich, and its altitude is 776m. The climate of the Uberlândia region, according to the Köppen classification (1948), is Aw, a tropical savanna with a dry winter season. The average annual temperature is 22.3ºC. The average annual rainfall is 1,584 mm.

During the experimental period, climatic conditions were monitored in a meteorological station about 200 m from the experimental area (Fig. 1).

The relief of the experimental area is flat, and the soil was classified as Dystrophic Dark Red Latosol (Santos *et al*., 2018). In January 2017, soil samples were taken in the 0 to 20cm layer to analyze the level of fertility, and the results were: pH in H_2O: 5.4; P: 1.3 (Mehlich-1); K: 123mg dm^{-3}; Ca^{2+}: 2.6; Mg^{2+}: 0.6 and Al^{3+}: 0.0 $cmol_c$ dm^{-3}. Based on these results, liming and potassium fertilization were not necessary (Cantarutti *et al*., 1999). Phosphate and nitrogen fertilizations were carried out in January 2017 and 2018, with the application of 50kg ha^{-1} of N and 50kg ha^{-1} of P_2O_5. In February 2017 and 2018, another 50kg ha^{-1} of N was also applied. Urea and simple superphosphate were used as fertilizer sources. Fertilizations were carried out in the evening and under cover.

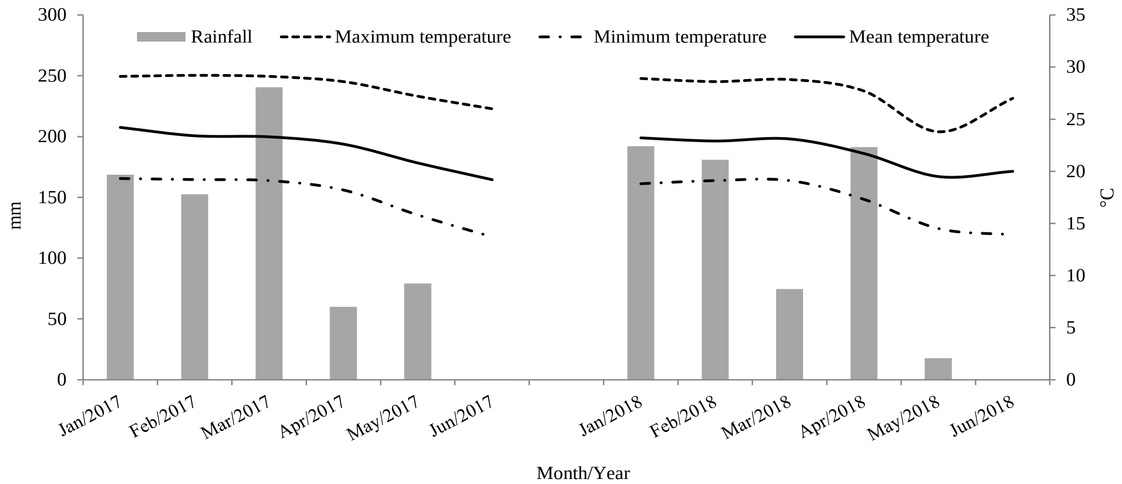

Figure 1. Values of rainfall and minimum, average and maximum temperatures during the experimental period in two years of evaluation.

The experimental area consisted of 12 experimental plots (experimental units), of 9 m². In November 2015, four cultivars of *Urochloa brizantha* (marandu, xaraés, piatã and paiaguás grasses) have been established in these plots. These *U. brizantha* cultivars corresponded to the experimental treatments. The experiment was conducted in a completely randomized design, with three replications.

In October 2016, a uniform cut at 5 cm from the ground was carried out. From then on, all plants grew and were maintained at 30 cm height (Paula *et al*., 2012; Nantes *et al*., 2013; Euclides *et al*., 2016), through weekly cuts, with pruning shears. After the cuts, the excess forage cut and remaining on the plants was removed with the use of rakes. The stockpiling period was from March 13 to June 13, 2017 (92 days) and, in this period, the cuts ceased, and the plants remained in free growth. This stockpiling period, in 2017, corresponded to the first experiment, called Year 1.

The second experiment, called Year 2, started in October 2017, with a new cut to standardize all plants 5cm from the soil surface. Afterwards, the plants were not cut until they reached 25cm in height. This height was maintained for all plants, in a similar manner to that described for the first year, until March 15, 2018, when the stockpiling period began. This period lasted 95 days, ending on June 18, 2018.

In the two experimental years, morphogenesis was evaluated. In Year 1, this assessment took place in two periods throughout the stockpiling period. The first period was between March 13 and April 20, 2017, totaling 38 days (beginning of the stockpiling period). The second period of morphogenic evaluation was 46 days, from April

28 to June 13, 2017 (end of stockpiling period). On the other hand, in Year 2, the evaluation of morphogenesis occurred only in the final half of the stockpiling period, from April 24 to June 19, totaling 56 days of evaluation. In each year and in each period, ten tillers per plot were evaluated. These tillers were identified with nylon clamps and monitored once a week. In each evaluation period, different tillers were marked and evaluated.

With graduated ruler, measurements of leaf blade and stem lengths of marked tillers were taken once a week. The length of the leaf blades of the expanded leaves was measured from the tip of the leaf to its ligule. In the case of expanding leaves, the same procedure was adopted, but the last expanded leaf was considered as a measurement reference. For senescent leaves, the leaf blade length corresponded to the distance from the point to which the senescence process advanced to the leaf ligule. The stem size was measured as the distance from the soil surface to the young leaf leaf completely expanded. From this information, the following variables were calculated: number of live leaves per tiller (NLL): average number of leaves fully expanded per tiller, excluding leaves with more than 50% of the senescent leaf blade; leaf blade length (cm): average length of all expanded leaves of each tiller; stem length (cm): average stem length of each tiller; leaf appearance rate (tiller leaf.dia^{-1}): number of leaves per tiller divided by the number of days in the evaluation period; phyllochron (day): inverse of the leaf appearance rate; leaf elongation rate (cm tiller.dia^{-1}): sum of positive variations in leaf blade length per tiller divided by the number of days in the evaluation period; stem elongation rate (cm tiller.dia^{-1}): sum of positive variations in stem length per tiller divided by the number of days in the evaluation period; leaf life span (LLS): estimated by the equation LLS (day leaf^{-1}) = NLL x Phyllochron (Lemaire and Chapman, 1996); and leaf senescence rate (cm tiller.dia^{-1}): sum of the negative variations in leaf blade length per tiller divided by the number of days in the evaluation period.

At the end of the stockpiling period and at two points per plot, the vegetative and reproductive basal tillers were counted, using a 0.25 x 0.5m frame. Tillers with visible inflorescence were classified as reproductive, while those without visible inflorescence, as vegetative. The sum of the reproductive and vegetative tillers corresponded to the number of live tillers.

The statistical analysis of the data was performed separately for each experimental year, using the SAS® program, version 9.0. For the response variables obtained in Year 1, the variance analysis was carried out in a completely randomized design with repeated measures over time (beginning and end of the stockpiling period). For the response variables obtained in Year 2, the analysis of variance was in a completely randomized design, but the data were not analyzed with repeated measures over time, because in this year the assessments occurred only in the end of stockpiling period. Subsequently, the effects of factor levels were compared using the Tukey test. All statistical analyzes were performed at a significance level of up to 5% probability of occurrence of type I error.

RESULTS

In Year 1, all characteristics were influenced in isolation by the factors studied, except for the stem length (SL), which was influenced (P = 0.0008) by the interaction between cultivar and stockpiling period.

In Year 1, the following characteristics did not differ (P>0.05) between *U. brizantha* cultivars: leaf elongation rate (LElR), leaf senescence rate (LSeR) and number of live leaves per tillers (NLL). These showed average values of 1.17cm tiller^{-1} day^{-1}; 0.82cm tiller^{-1} dia^{-1} and 4.4 leaves tiller^{-1}, respectively. In Year 1, the NLL was also similar (P>0.05) between the beginning and the end of stockpiling period.

In Year 2, the stem elongation rate (SElR), LSeR and NLL were also similar (P>0.05) between marandu, piatã, xaraés and paiaguás grasses, with average values of 0.06cm tiller^{-1} day^{-1}; 0.67cm tiller^{-1} dia^{-1} and 3.0 leaves tiller^{-1}, respectively. In both Year 1 and Year 2, the leaf appearance rate (LApR) of the paiaguás grass was higher, compared to the other grasses. An opposite pattern of responses occurred for the phyllochron and leaf life span (LLS) in both years, as well as for leaf blade length in Year 1 (Table 1).

In Year 1, the SElR of xaraés grass was higher than the other grasses. This same response pattern occurred for leaf blade length in Year 2. In this year, the paiaguás grass expressed higher LElR than the xaraés grass, with the piatã and marandu grasses showing similar values to the others. The SL was higher in paiaguás grass, intermediate in xaraés grass and lower in piatã and marandu grasses during Year 2 (Table 1).

During Year 1, LApR and LElR were higher at the beginning, compared to the end of the deferral period, contrary to what was observed for the phylochron, SElR, LSeR, LLD and LL (Table 2).

During the beginning of the Year 1 deferral period, the SL did not vary between cultivars of *U. brizantha*. However, at the end of this period the SL of capim xaraés was greater than the SL of capand-marandu; and the piatã and paiaguás grasses presented intermediate values to the others. Only xaraés grass showed a higher SL at the end, compared to the beginning of the deferral period (Table 3).

Table 1. Morphogenic and structural characteristics of marandu, piatã, xaraés and paiaguás grasses during the stockpiling period and in two experimental years

Variable	Cultivars				P-value	SEM
	Piatã	Xaraés	Marandu	Paiaguás		
			Year 1*			
LApR	0.06b	0.05b	0.06b	0.08a	0.0141	0.007
Phyllchron	19.9a	21.5a	20.6a	15.7b	0.0437	1.72
SElR	0.24b	0.42a	0.14b	0.22b	0.1022	0.033
LLS	86a	90a	85a	59b	0.0015	3.787
LBL	18.0a	19.1a	17.41a	14.2b	0.0035	1.424
			Year 2**			
LApR	0.03b	0.02b	0.02b	0.04a	0.0030	0.005
Phyllochron	40.4a	50.0a	50.3a	27.8b	0.0120	5.300
LElR	0.380ab	0.31b	0.41ab	0.56a	0.0093	0.053
LLS	132a	140a	130a	81b	<0.0001	13.43
LBL	14.9b	18.7a	15.3b	13.6b	0.0160	1.087
SL	14.9c	18.7b	15.4c	26.4a	0.0047	2.654

* averages for the entire stockpiling period (beginning and end); ** averages corresponding only to the end of the stockpling period; LApR: leaf appearance rate (leaf tiller^{-1}.day^{-1}); LElR: leaf elongation rate (cm tiller^{-1}.day^{-1}); SElR: stem elongation rate (cm tiller^{-1}.day^{-1}); LSeR: leaf senescence rate (cm tiller^{-1}.day^{-1}); LLS: leaf life span (day); NLL: number of live leaves per tiller; LBL: leaf blade length (cm); SL: stem length (cm); SEM: standard error of the mean. Means followed by different letters differ by Tukey's test (P<0.05).

Table 2. Morphogenic and structural characteristics of marandu, piatã, xaraés and paiaguás grasses during the beginning and end of the stockpling period in the first experimental year

Variable	Stockpiling Period		P-value	SEM
	Beginning	End		
LApR	0.07a	0.05b	0.0005	0.006
Phyllochron	13.8b	25.1a	<0.0001	1.416
LElR	1.47a	0.87b	<0.0001	0.098
SElR	0.16b	0.36a	0.0028	0.034
LSeR	0.74b	0.89a	0.0185	0.136
LLS	63.8b	95.9a	0.0006	4.376
LBL	14.3b	20.1a	0.0007	0.781

LApR: leaf appearance rate (leaf tiller^{-1}.day^{-1}); LElR: leaf elongation rate (cm tiller^{-1}.day^{-1}); SElR: stem elongation rate (cm tiller^{-1}.day^{-1}); LSeR: leaf senescence rate (cm tiller^{-1}.day^{-1}); LLS: leaf life span (day); NLL: number of live leaves per tiller; LBL: leaf blade length (cm); SEM: standard error of the mean. Means followed by different letters differ by Tukey's test (P<0.05).

Table 3. Stem length (cm) of marandu, piatã, xaraés and paiaguás grasses during the beginning and end of the stockpiling period in the first experimental year

Stockpiling Period	Cultivar				SEM
	Piatã	Xaraés	Marandu	Paiaguás	
Beginning	28.7Aa	29.3Ba	27.1Aa	35.0Aa	5.293
End	46.8Aab	61.9Aa	28.7Ab	44.8Aab	

SEM: standard error of the mean; Means followed by distinct letters, lower case in the row and upper case in the column, differ by Tukey's test (P<0.05).

At the end of the stockpiling period of Year 1, the tiller population density (TPD) was higher in the paiaguás grass, intermediate in the xaraés and marandu grasses and lower in the piatã grass. In the same year, the percentage of vegetative tillers (TVEG) was higher in the canopy of paiaguás grass than in the other forage canopies, a response pattern contrary to that observed for the percentage of reproductive tillers (TREP) (Table 4).

At the end of the stockpiling period in Year 2, TPD was higher in the paiaguás grass canopy, intermediate in the marandu and piatã grasses canopies, and lower in the xaraés grass canopy. In Year 2, TVEG was higher in the paiaguás grass than in the xaraés grass, contrary to what was observed for the TREP (Table 4).

Table 4. Population density of live tillers and percentages of vegetative and reproductive tillers of marandu, piatã, xaraés and paiaguás grasses at the end of the two-year stockpiling period

Variable	Cultivar				P-value	SEM
	Piatã	Xaraés	Marandu	Paiaguás		
			Year 1			
TPD	787c	912b	950b	1236a	0.0071	94.870
TVEG (%)	86.7b	77.7c	82.8ab	99.1a	0.0104	4.556
TREP (%)	13.3b	22.3a	17.2ab	0.9c	0.0104	4.556
			Year 2			
TPD	664b	486c	679b	844a	0.0090	73.165
TVEG (%)	91.6ab	85.4b	90.7ab	97.3a	0.0285	2.433
TREP (%)	8.4ab	14.6a	9.3ab	2.7b	0.0285	2.433

TPD: population density of live tillers m^{-2}; TVEG (%): percentage of vegetative tillers; TERP (%): percentage of reproductive tillers. SEM: standard error of the mean. Means followed by different letters differ by Tukey's test (P<0.05).

DISCUSSION

The highest LApR in the two experimental years, as well as the higher LElR in Year 2 (Table 1), demonstrate that the paiaguás grass was the cultivar of *U. brizantha* with the highest leaf growth during the stockpiling period, from March to June (autumn). These results are in line with those obtained by Euclides *et al*. (2008), who observed that paiaguás grass showed a higher forage accumulation rate and live leaf percentage in the forage mass during autumn and winter, compared to piatã grass.

The paiaguás grass also had the lowest LLS in the two experimental years, in addition to the lowest LBL in Year 1 (Table 1). This result is consistent with the higher LElR of paiaguás grass. In this context, Santos *et al*. (2012) also found a negative relationship between LElR and LLD in pastures of *Urochloa decumbens* cv. Basilisk under continuous stocking. Considering that the number of live leaves per tiller is a relatively stable characteristic, any increase in leaf appearance is accompanied by greater senescence of older leaves, which, therefore, express less longevity.

Another characteristic observed in the paiaguás grass at the end of stockpiling period was its higher TPD in both experimental years, in comparison to the other cultivars evaluated (Table 1). This result indicates that the paiaguás grass has greater potential to promote soil cover and to form a denser forage canopy, in comparison to the marandu, piatã and xaraés cultivars.

In addition, the paiaguás grass also showed higher TVEG and lower TREP at the end of stockpiling of the two experimental years (Table 4). As the paiaguás grass has an early flowering, its flowering occurred before the stockpiling period, when the plants were frequently being cut. Thus, during the stockpiling period, the paiaguás grass had no stimulus to flowering, which reduced its TREP and, on the other hand, kept the canopy with high TVEG.

On the other hand, the Xaraés grass canopy had higher TREP and lower TVEG at the end of stockpiling period, both in Year 1 and Year 2 (Table 4). This result is because the Xaraés grass concentrates its flowering in May and June (Flores *et al*., 2008), a time when the canopy was in stockpiling (free growth). With flowering, it is natural to elongate the tillers stem. Therefore, in this work, the SElR (Table 1) and SL at the end of stockpiling period of Year 1 (Table 2) and Year 2 (Table 1) were high in Xaraés grass. In this sense, the paiaguás grass also showed high SL (Tab. 1 and 3), even though it consists of few tillers in the reproductive stage (Table 4). This may have happened, due to the higher growth rate of the paiaguás grass during the autumn.

It was expected that TREP of piatã grass in the stockpiled canopy to be low, due to its earlier flowering season, in January and February (Nantes *et al*., 2013), however this did not occur in this work.

The high TREP of stockpiled marandu grass was due to its accentuated flowering during autumn, the season in which the canopy remained without defoliation. Indeed, Paula *et al*. (2012) and Calvano *et al*. (2011) evaluated the marandu grass managed with three average heights in continuous stocking and also observed that the number of reproductive tillers was higher in autumn, compared to other seasons.

In canopies with greater predisposition to flowering during the stockpiling period, such as the Xaraés and Marandu grasses in this work (Table 4), the reduction of the stockpiling period (Santos *et al*., 2009) and the decrease in the pasture height (Sousa *et al*., 2012) at the beginning of the stockpiling period can be management strategies capable of minimizing the flowering. This is relevant, because the higher occurrence of reproductive tillers affects the structure of the stockpiled pasture. With the flowering of the tropical grass, there is intense elongation of the stem, and, in addition, the leaf appearance ceases after the inflorescence emission, which contributes to the decrease of the live leaf/live stem ratio of pasture (Euclides *et al*., 2008). In addition, after the tiller has flowered, it usually dies. This process also contributes to increase the percentage of dead stem and dead leaf in the forage canopy.

It is also worth noting that the lower TPD in the stockpiled canopy of xaraés grass in Year 2 was expected, because in general naturally taller forage canopies present greater shading at the plants base, which reduces the tiller appearance, as well as increases the mortality of small tillers (Sbrissia and Silva, 2008; Calvano *et al*., 2011). These processes may have occurred in the stockpiled canopy of xaraés grass, considering its greater natural height, in comparison to the other evaluated cultivars. The larger size of xaraés grass may also have been responsible for its largest LBL in Year 2 (Table 1).

Due to its greater forage production potential (Euclides *et al*., 2008), it was expected that xaraés grass would show high rates of leaf growth (higher LApR and LElR) during the stockpiling period, which did not occur (Table 1). Probably, the growth of xaraés grass is optimized during the period of good climatic conditions (high temperatures and rainfall). However, the beginning of water restriction in the autumn (Fig. 1) may have limited the growth of xaraés grass.

Regarding the periods of stockpiling, the greatest leaf growth (higher LApR and LElR) occurred at the beginning of that period (Table 2), a consequence of the greater amount of rainfall (Fig. 1) at the beginning, compared to the end of the stockpiling period. The most adverse climate at the end of the stockpiling period was also responsible for the largest phyllochron and, consequently, for the longest life leaf span of the new leaves that appeared in this period (Table 2). Additionally, LSeR was high at the end, in relation to the beginning of stockpiling period (Table 2), due to the higher mortality of older leaves, caused by water stress and greater self-shading inside the canopy, which was more developed (highest) at the end of the stockpiling period.

The highest stage of canopy development at the end of stockpiling period, in which many tillers reached the reproductive stage, also justifies the highest LBL and, above all, the highest SElR at the end, in relation to the beginning of stockpiling period (Table 2).

The results of work demonstrate that hypotheses have been partially proven. In fact, the paiaguás grass showed a higher leaf growth rate during stockpiling period (autumn) than the xaraés, piatã and marandu grasses. Thus, the results demonstrate that paiaguás grass is suitable for use during the dry season of the year, as previously reported by Valle *et al*. (2013) and Euclides *et al*. (2016). It is worth noting, however, that, due to its susceptibility to spittlebugs (Valle *et al*., 2013), the use of paiaguás grass to stockpiling is not recommended for regions with a history of incidence of this insect prague.

The expectation that the xaraés grass, due to its high genetic potential for forage production (Euclides *et al*., 2008), would also show high leaf growth during stockpiling period has not been proven. However, the other hypothesis about xaraés grass, that it has high SElR during stockpiling period, was duly proven, which is related to its late flowering. Thus, for the use of xaraés grass under stockpiled grazing, some adjustments should be adopted in the management of stockpiling, such as reducing the stockpiling period and the height of the pasture at the beginning of this period. These adjustments prevent the excessive production of stem, which would damage the structure of the stockpiled pasture. In general, marandu and paiaguás grasses presented intermediate morphogenic patterns to xaraés and paiaguás grasses and can be considered suitable forage grass options for stockpiling.

Our results demonstrate that there are differences in morphogenic and structural characteristics during the stockpiling period. These specificities are relevant and should be considered when designing management strategies for stockpiled pastures.

CONCLUSION

When stockpiled, marandu, piatã, xaraés and piatã grasses have distinct morphogenic characteristics. Paiaguás grass has higher leaf appearance rate during the stockpiling period than piatã, marandu and xaraés grasses. Xaraés grass presents high stem elongation during the stockpiling period, in adittion to presenting a high number of reproductive tillers during this period.

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