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HOW DOES THE CONDITION OF THE PASTURE IN LATE WINTER INFLUENCE THE PLANT AND ANIMAL RESPONSES IN THE SUBSEQUENT SEASONS?

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Abstract

This study aimed to test the hypotheses: (i) the deferred pasture with lower height in late winter has greater herbage accumulation rate (HAR) and better structure, which facilitates the animal selective grazing during the subsequent spring and summer; (ii) the mowed of high pasture in late winter improves the sward structure but decreases its HAR from the spring. Four pasture condition in late winter of *Urochloa brizantha* cv. Marandu were evaluated: low (24.1 cm and 2,420 kg.ha^{-1} of DM); low/mowed (25.2 cm and 2,198 kg.ha^{-1} of DM, mowed at 8.0 cm); high (49.0 cm and 3,837 kg.ha^{-1} of DM); and high/mowed (50.0 cm and 4,211 kg.ha^{-1} DM, mowed at 8.0 cm). The highest live leaf blade percentage (LLBP) and the lowest dead stem percentage (DSP) occurred in the mowed pastures. The live stem (LSP) and dead leaf blade percentages of the grazing simulation sample were higher in the high pasture. This same pattern of response occurred for apparent selectivity indices (ASI) of the live leaf blade and live stem. The ASI of the dead leaf blade was greater in the high pasture, intermediate in the mowed pastures, and lower in the low pasture. The ASI of the dead stem was lower in the low pasture. The HAR was higher in low pasture. Our results support the first hypothesis. The mowing of high pasture in late winter improves the sward structure and the animal selective grazing but does not decrease the HAR during spring and summer.

Keywords: *Brachiaria brizantha* syn. Hand-plucked sample. Morphological composition**.** *Urochloa brizantha*.

1. Introduction

The deferment of the pastures makes the storage of the forage mass possible for use under grazing during winter, which reduces the negative effects of low forage production in this season on pasture-based animal production systems (Silva et al. 2016; Rocha et al. 2020; Santos et al. 2020). However, deferred pastures with high forage mass and higher height in late winter may have lower herbage accumulation in spring, due to their lower tillering caused by the greatest shading at the plant's base (Carvalho et al. 2021). In this sense, Santana et al. (2014) verified that deferred pastures of *Urochloa decumbens* cv. Basilisk with more forage mass in the late winter presented a lower tiller appearance rate in early spring when compared with pastures deferred with lower forage mass in late winter.

In addition, great stem and dead forage masses, common in taller and deferred pastures in late winter, may worsen the sward structure in spring. Thus, mowing these pastures in late winter can improve sward structure in the subsequent spring by removing residual old forage. Souza et al. (2015), working with *Urochloa brizantha* cv. Marandu, founded that all the tillers were vegetative during early summer in high/mowed pasture in late winter, while in high and no mowed pasture there was great participation of dead tillers. According to these authors, the presence of vegetative and young tillers on pasture may increase the herbage accumulation, because this tiller category has higher tissue flow (Alves et al. 2019). Moreover, young tiller has better morphological composition than old tillers (Santos et al. 2019), which can improve the sward structure.

The concern to produce pastures with appropriate morphology is justified by their effects on the selective grazing activity of the animals. In this context, Afonso et al. (2018) observed that the sward structure is a determinant factor of the morphology of the apparent consumed forage by cattle. Therefore, it is important to adopt strategies for pasture management that result in sward structures coherent with the grazing animal preference (Sousa et al. 2018).

Pasture morphology also changes the microclimate within the canopy, which interferes with the forage production (Yasuoka et al. 2021). However, it is not known whether the cut forage mass above the base plants, by increasing the shading on the basal buds, would reduce the tillering and herbage accumulation during spring and summer.

This study used the marandu palisadegrass (*Brachiaria. brizantha* cv. Marandu syn. *Urochloa brizantha* cv. Marandu) to test the following hypotheses: (i) deferred and lower pasture in late winter has high forage production and pasture structure that facilitates the animal selective grazing during the spring and summer, in comparison to higher pastures; and (ii) mowing of the pasture with high forage mass in late winter also improves the pasture structure but decreases its forage production from spring. Therefore, this study was conducted to evaluate the effects of mowing and height of pasture in late winter on herbage accumulation, pasture structural characteristics, and apparent selectivity of sheep in spring and early summer.

2. Material and Methods

The study was carried out from March 2014 to February 2015, on the Experimental Capim Branco Farm, belonging to the Faculty of Veterinary Medicine of Federal University of Uberlandia, Uberlandia, MG (18º53'19 '' S; 48º20'57'' W; 776 masl). The climate in the region of Uberlândia is classified as Aw type (Tropical Savannah) by Alvares et al. (2013), with dry (April to Sept.) and rainy (October to March) seasons well defined. The climatic conditions were monitored during the experimental period at the meteorological station, located approximately 200 m from the experimental area (Figure 1).

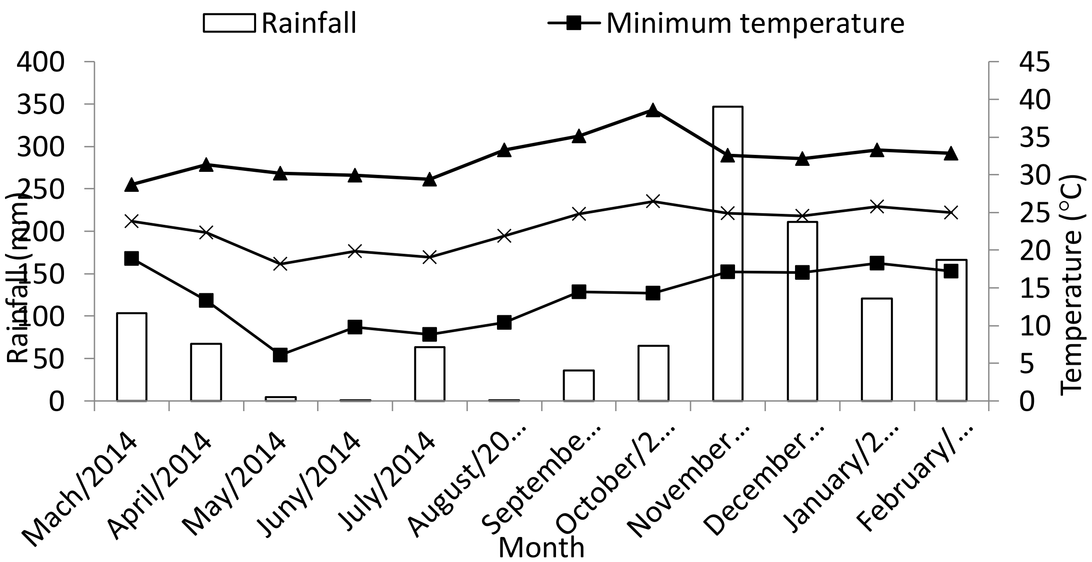

Figure 1. Monthly rainfall and average minimum (Min), mean and maximum (Max) air temperatures on the experimental site from March 2014 to February 2015.

The monthly mean temperature and rainfall were used to calculate the monthly soil water balance (Thornthwaite and Mather, 1955), considering the soil water storage capacity of 40 mm (Figure 2).

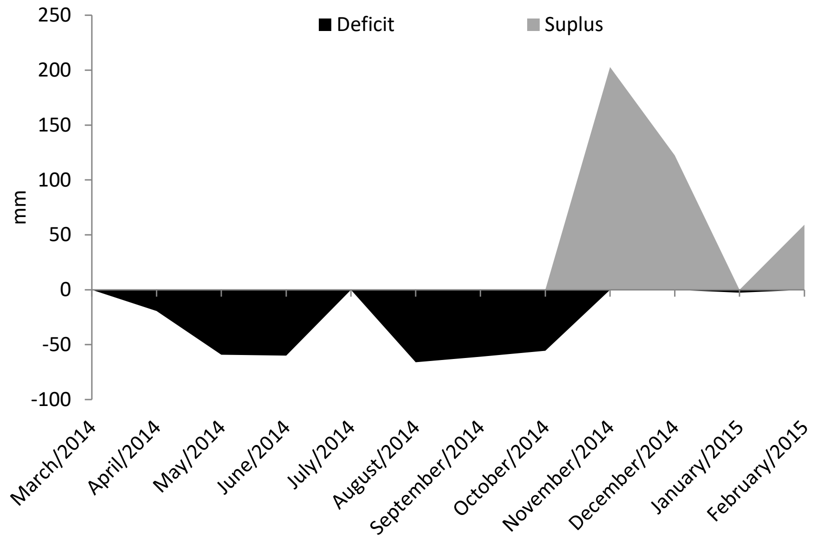

Figure 2. Monthly soil water balance on the experimental site from March 2014 to February 2015, considering a soil water storage capacity of 40 mm.

Soil samples were taken from each experimental unit to analyze the fertility level in the 0-20 cm layer, presenting, on average, the following characteristics: pH in H_2O: 6,1; P: 4.5 (Mehlich-1), and K: 118.1 mg dm^{-3} Ca^{2+}: 4.9; Mg^{2+}: 2.1, and Al^{3+}: 0 cmol$_c$ dm^{-3}. Based on these results, 50 kg.ha^{-1} of N (as urea) and P_2O_5 (as simple superphosphate) were applied in January 2014. Other 50 kg.ha^{-1} of N were applied in March of the same year. Liming was not performed.

The experimental area consisted of a pasture of *Brachiaria brizantha* syn. *Urochloa brizantha* cv. Marandu (marandu palisadegrass) divided into twelve paddocks (experimental units) of 800 m^2 each. From January 2014 until the end of the experiment, all paddocks were managed with sheep in continuous stocking and variable stocking rate, to maintain the average sward surface heights (SSH) at 30 cm (Sbrissia et al. 2020). In March 2014, the stocking rate was increased to reduce the average SSH to 15 cm in three paddocks, and to 25 cm in the other three paddocks. In addition, the stocking rate was reduced to increase the average SSH of other three paddocks to 35 cm, and to 45 cm in other three paddocks. The deferment period (92 days) started on 17 March 2014 and ended on 17 June 2014. During the occupation period (82 days), from 18 June 2014 to 7 September 2014, all pastures were managed in continuous stocking with a fixed stocking rate. Thirty-six crossbred Santa Inês × Dorper ewes were used, with an average weight of 48 kg. The allocation of the groups of animals in the paddocks was done in a random way, to maintain the same initial stocking rate (4.0 AU.ha^{-1}).

At late grazing period (September 2014), the pastures initially deferred with 15 and 25 cm presented height values of 24.1 cm and 25.2 cm, respectively; and forage mass of 2,420 and 2,198 kg.ha^{-1} of DM, respectively. Pastures deferred with 35 and 45 cm were taller and with greater forage mass (49.0 cm and 3,837 kg.ha^{-1} of DM; 50.0 cm and 4,211 kg.ha^{-1} DM, respectively). Thus, in order to cause differences in the 35 and 45 cm deferred pastures, paddocks of 45 cm were mowed to 8 cm on 7 September 2014, and the cut forage mass was not removed from the paddocks. Likewise, to create a difference between 15 and 25 cm deferred pastures, paddocks with 25 cm pasture were also mowed to 8 cm post-cut height. Thus, it was possible to obtain four pasture conditions in late winter (low, low/mowed, high, and high/mowed), which corresponded to our experimental treatments and were evaluated during the beginning, middle, and at end of the grazing period in the spring and summer.

After this period, all pastures remained without animals for 75 days, when the grazing period started. This grazing period ended on 20 February 2015. During the grazing period, all pastures were managed in continuous stocking and variable stocking rate, in order to maintain an average SSH between 30 and 35 cm

(Sbrissia et al. 2020). The animals used in this period were crossbred Santa Inês × Dorper sheep, with an average weight of 30 kg, which had unrestricted access only to mineral salt and water.

The measurements of the SSH were weekly performed, with a graded ruler on 30 points of each paddock, following a zigzag path, using as a criterion the distance from the soil surface to the apex of the live leaf located higher in the canopy. When the average SSH was below 30 cm, equilibrium animals were removed from the paddocks. The opposite happened when the pastures were with average SSH above 35 cm.

At the beginning (7th day), middle (45th day), and end (91st day) of the grazing period, all other pasture evaluations were performed. The forage mass was determined with the cut to the ground level of all tillers contained within a 0.25 m^2, in three representative areas (same SSH) in each paddock. Each sample was weighed and subdivided into two parts. One of the subsamples was weighed, placed in a paper bag, and dried in a forced ventilation oven at 65 °C to constant weight, when it was again weighed, in order to estimate the total forage mass. The total forage bulk density (kg.ha^{-1}.cm^{-1} of DM) was calculated by dividing the forage mass by the average SSH. The other sub-sample was separated into a live leaf blade, live stem, dead leaf blade, and dead stem. The inflorescence and green leaf sheath were incorporated into the live stem fraction. The part of the leaf blade that did not show signs of senescence was considered as live leaf blade. On the other hand, the parts of the stem and the leaf blade with yellowing and/or necrosis were incorporated into the fractions of dead stem and dead leaf blade, respectively. After separation, the components were weighed, dried in a forced ventilation oven at 65 °C to constant weight, and again weighed. With that, the percentages of morphological components in the forage mass were estimated.

A forage sample per paddock was also collected to simulate the morphological composition of the forage consumed by the animals (Afonso et al. 2018). Each simulated grazing sample was processed in the same way as described for the forage mass samples. The apparent selectivity index (ASI) of all morphological components of the pasture was calculated according to Afonso et al. (2018). The ASI consisted of the relation between the percentage of the specific morphological component in the forage mass and the percentage of the same morphological component in the simulated grazing sample.

Herbage accumulation rate (HAR) was measured using three exclusion cages (1 m^2) per paddock, which were rotated every 30 days. After each sampling, cages were rotated and anchored on new areas representative of sward conditions (visual assessment of herbage mass and SSH). The HAR was calculated as the difference between the forage mass under the cage at the last and the first day of exclusion, divided by the number of days between the samplings (Yasuoka et al. 2021). The forage mass, inside and outside the cage, was obtained by cutting the forage contained within a square of 0.25 m^2 at ground level.

Statistical analysis was performed using the analysis of variance in a completely randomized design, using the PROC MIXED of SAS. The covariance matrices were chosen using the Akaike criterion. The pasture condition in late winter and grazing periods and their interaction were considered as fixed effects. The days of the grazing period were considered measures repeated over time. To analyze data the means were compared by the Tukey's test ($p<0.05$).

3. Results

Among all the variables analyzed, six were influenced by the interaction between pasture condition in late winter (PCLW) and grazing period: the percentages of live stem and dead leaf blade of the pasture; percentages of the dead leaf blade and dead stem of the grazing simulation sample; mass and forage bulk density. The other response variables were influenced only by the factors isolated (Tables 1 and 2).

Table 1. Characteristics of pasture, morphological composition of grazing simulation samples, and apparent selectivity index in marandu palisadegrass pastures during spring and summer, according to the pasture condition in late winter.

Characteristic	Pasture condition at late winter*				SEM
	Low	Low/Mowed	High	High/Mowed	
SSH (cm)	35.3[a]	31.6[a]	32.6[a]	34.8[a]	0.88
LLB in the FM	32.1[b]	40.2[a]	30.8[b]	39.6[a]	2.26
DS in the FM	13.4[b]	4.4[c]	26.1[a]	5.0[c]	5.06
LS in the GS	1.1[b]	2.2[b]	6.3[a]	2.8[b]	1.12
DLB in the GS	1.5[b]	2.6[b]	5.4[a]	2.6[b]	0.83
ASI of LLB	3.9[a]	2.7[b]	3.4[a]	2.5[b]	0.32
ASI of LS	0.03[b]	0.05[b]	0.17[a]	0.06[b]	0.03
ASI of DLB	0.17[c]	0.43[b]	0.71[a]	0.44[b]	0.11
ASI of DS	0.14[b]	0.28[a]	0.21[a]	0.22[a]	0.03
HAR	82.7[a]	66.1[b]	50.8[c]	51.5[c]	7.53

*Low pasture: 24.1 cm and 2,420 kg.ha^{-1} of DM; low/mowed pasture: 25.2 cm and 2,198 kg.ha^{-1} of DM; High pasture: 49.0 cm and 3,837 kg.ha $^{-1}$ of DM; High/mowed: 50.0 cm e 4,211 kg.ha $^{-1}$ of DM. SEM: standard error mean; SSH: sward surface height (cm); LLB: live leaf blade; DLB: dead leaf blade (%); FM: forage mass; LS: live stem (%); DS: dead stem (%); GS: grazing simulation sample; DLB: dead leaf blade (%); ASI apparent selectivity index; HAR: herbage accumulation rate (kg ha $^{-1}$ day^{-1} of DM). Means followed by different letters differ by Tukey test (p<0.05).

The average SSH did not vary among the PCLW (Table 1) and was lower at the end than at the beginning and middle of the grazing period (Table 2).

Table 2. Characteristics of pasture, morphological composition of grazing simulation samples, and apparent selectivity index in marandu palisadegrass pastures, according to the time of grazing period during spring and summer.

Characteristics	Grazing period			SEM
	Beginning	Middle	End	
SSH (cm)	37.8[a]	34.2[a]	28.8[b]	0.16
LLB in the FM	47.2[a]	40.7[a]	19.2[b]	0.76
DS in the FM	6.7[b]	8.3[b]	21.7[a]	0.38
LS in the GS	1.9[b]	4.9[a]	2.6[b]	0.60
DLB in the GS	0.1[c]	6.5[a]	2.4[b]	1.35
ASI of LLB	2.1[b]	2.1[b]	5.2[a]	0.34
ASI of LS	0.04[b]	0.12[a]	0.06[b]	0.69
ASI of DLB	0.05[c]	1.06[a]	0.19[b]	2.88
ASI of DS	0.13[b]	0.40[a]	0.10[b]	1.65
HAR	69.9[a]	60.1[b]	58.3[b]	0.11

*Low pasture: 24.1 cm and 2,420 kg.ha^{-1} of DM; low/mowed pasture: 25.2 cm and 2,198 kg.ha^{-1} of DM and lowered to 8 cm; High pasture: 49.0 cm and 3,837 kg.ha^{-1} of DM; High/mowed: 50.0 cm e 4,211 kg.ha^{-1} of DM and lowered to 8 cm. SEM: standard error mean; SSH: sward surface height (cm); LLB: live leaf blade (%); FM: forage mass; LS: live stem (%); DS: dead stem (%); GS: grazing simulation sample; DLB: dead leaf blade (%); ASI: apparent selectivity index; HAR: herbage accumulation rate (kg ha^{-1} day^{-1} of DM). Means followed by different letters differ by Tukey test (p <0.05).

The greatest live leaf blade percentage occurred in the mowed pastures, in relation to the non-mowed pastures. On the other hand, the dead stem percentage was lower in the mowed pastures, intermediate in the low pastures, and greater in the high pasture (Table 1). Regarding the grazing period, the live leaf blade percentage was smaller in the end, compared to the beginning and middle of this period. A contrary pattern of response was observed for the dead stem percentage (Table 2).

The live stem and dead leaf blade percentages of the grazing simulation samples were greater in the high pasture, in comparison to the others. This same pattern of response occurred for apparent selectivity indices (ASI) of the live leaf blade and live stems (Table 1). The ASI of the dead leaf blade was greater in the high pasture, intermediate in the mowed pastures, and lower in the low pasture. In addition, the ASI of the dead stem was lower in the low pastures, when compared to the others (Table 1).

The live stem percentage in the grazing simulation sample, as well as the ASI of live stem and dead stem, were greater in the middle compared to the beginning and end of the grazing period. The dead leaf blade percentage in the grazing simulation sample and its ASI were greater in the middle of the grazing period and lower at the beginning of it. The ASI of the live leaf blade was greater at the end than at the beginning and middle of the grazing period (Table 2).

The herbage accumulation rate was lower in the high and high/mowed pastures, intermediate in low/mowed pastures, and greater in low pasture (Table 1). At the beginning of the grazing period, the herbage accumulation rate was greater than in the middle and end of this period (Table 2).

The forage mass was greater in the high pasture than in the others during the beginning and middle of the grazing period (Table 3). At the end of this period, forage mass did not vary among PCLW. The forage mass also did not vary among grazing periods in low and low/mowed pastures. However, in the high pasture, the forage mass was lower at the end than at the beginning and middle of the grazing period. A contrary pattern of response was observed in high/mowed pasture (Table 3).

Table 3. Characteristics of pasture and morphological composition of grazing simulation samples during spring and summer, according to pasture condition in late winter and days of grazing period.

Grazing period	Pasture condition at late winter *				SEM
	Low	Low/mowed	High	High/mowed	
	Forage mass (kg ha $^{-1}$ of DM)				
Beginning	2,953^{bA}	2,471^{bA}	4,091^{aA}	2,299^{bB}	
Middle	2,897^{bA}	2,267^{bA}	3,834^{aA}	2,312^{bB}	157.5
End	3,069^{aA}	2,552^{aA}	3,067^{aB}	3,474^{aA}	
	Bull density of forage mass (kg ha $^{-1}$ cm^{-1} of DM)				
Beginning	73^{bB}	71^{bB}	105^{aA}	62^{bB}	
Middle	79^{bB}	70^{bB}	124^{aA}	63^{bB}	6.3
End	106^{aA}	93^{aA}	110^{aA}	112^{aA}	
	Live stem (%) in the forage mass				
Beginning	40.8^{aC}	43.3^{aB}	35.9^{bA}	45^{aA}	
Middle	45.6^{aB}	45^{aB}	38.5^{bA}	49.6^{aA}	1.9
End	51.4^{aA}	54.2^{aA}	31.6^{bA}	49.3^{aA}	
	Dead leaf blade (%) in the forage mass				
Beginning	7.1^{aA}	3^{bB}	5^{abB}	4^{bB}	
Middle	8.5^{aA}	4.8^{bB}	7.5^{aB}	4.4^{bB}	1.1
End	10.1^{bA}	15.3^{aA}	10.7^{bA}	13.4^{aA}	
	Live leaf blade (%) in the grazing simulation sample				
Beginning	97.4^{aA}	99^{aA}	93.9^{aA}	98.4^{aA}	
Middle	97^{aA}	88.8^{bB}	65.4^{cB}	89.5^{bB}	2.6
End	94^{aA}	93^{aB}	93.4^{aA}	93.3^{aB}	
	Dead stem (%) in the grazing simulation sample				
Beginning	1.1^{aA}	0.3^{bB}	2.0^{aB}	0.2^{bB}	
Middle	1.5^{bA}	1.3^{bA}	8.9^{aA}	1.1^{bA}	0.7
End	1.7^{aA}	1.4^{aA}	1.5^{aA}	1.5^{aA}	

*Low pasture: 24.1 cm and 2,420 kg.ha^{-1} of DM; low/mowed pasture: 25.2 cm and 2,198 kg.ha^{-1} of DM and lowered to 8 cm; High pasture: 49.0 cm and 3,837 kg.ha $^{-1}$ of DM; High/mowed: 50.0 cm e 4,211 kg.ha $^{-1}$ of DM and lowered to 8 cm. SEM: standard error mean. Means followed by different letters, lowercase on row and uppercase on column, differ by Tukey test ($p < 0.05$).

At the beginning and middle of the grazing period, the bulk density of the forage (BDF) was greater in the high pasture when compared to the others, but it did not vary among pastures at the end of the grazing period. The BDF was also similar among grazing periods in high pasture. However, in the others, this characteristic was greater at the end than at the beginning and middle of the grazing period (Table 3).

The live stem percentage was lower in the high pasture, in relation to the others. The live stem percentage was similar in all grazing periods in high and high/mowed pastures. However, in low and low/mowed pastures, the live stem percentage was greater at the end than at the beginning of the grazing period (Table 3).

Except for the low pasture, the dead leaf blade percentage (DLBP) was greater at the end than at the beginning and middle of the grazing period. At the beginning of the grazing period, the percentage was greater in the low pasture, in relation to the mowed pastures. The mowed pastures also presented lower DLBP than non-mowed pastures during the middle of the grazing period. A contrary pattern of response was verified at the end of this period (Table 3).

At the beginning and at the end of the grazing period, the live leaf blade percentage (LLBP) in the grazing simulation sample (GS) did not vary among pastures. However, in the middle of the grazing period, the LLBP in the GS was greater in the low pasture, intermediate in the mowed pastures, and lower in the high pasture. In the high pasture, the LLBP in the GS was lower in the middle than at the beginning and at the end of the grazing period. In the low pasture, the LLBP in the GS did not vary among grazing periods. However, in the mowed pastures this characteristic was greater at the beginning than in the middle and end of the grazing period (Table 3).

Regarding the dead stem percentage (DSP) in the GS, their values were lower than in the middle and end of the grazing period in the low/mowed, high, and high/mowed pastures. In the low pasture, the DSP in the GS did not vary among grazing periods. At the beginning of the grazing period, this characteristic was lower in mowed pastures than in non-mowed pastures. In the middle of the grazing period, the DSP in the GS was greater in the high pasture than in the others, but at the end of the grazing period, this characteristic was similar among pastures (Table 3).

4. Discussion

The average SSH was similar among the pastures (Table 1) because the criterion for grazing management consisted of the maintenance of all pastures between 30 and 35 cm, which are values within the range recommended for the marandu palisadegrass managed in continuous stocking (Sbrissia et al. 2020). The SSH decreased at the end of the grazing period because the forage production rate also decreased in the middle and at the end of this period (Table 2). Even so, it was necessary to maintain at least two animals per paddock, to maintain the continuous stocking condition, which made the SSH decrease at the end of the grazing period.

The lowest herbage accumulation rate at the end of the grazing period (Table 2) occurred as a function of the decrease in rainfall in this period (Figure 1). In addition, in early spring, many young tillers appear in the pastures, which will develop and become more mature during the grazing period. It is known that young tillers present a greater growth rate compared to old tillers (Alves et al. 2019). These factors may also justify the greater herbage accumulation rate at the beginning than in the middle and at the end of the grazing period.

The increase in the mean age of the tillers in the pastures during the grazing period could also justify the worse morphological composition (more dead stems and fewer live leaf blades) of the pastures at the end, in relation to the beginning and middle of the grazing period (Table 2). In line with these results, Sbrissia and Da Silva (2008) also related that the tiller morphology got worse from early spring to late spring on *U. brizantha* cv. Marandu pastures under stocking rate. In this study, the tiller leaf:stem ratio decreased in this period.

The increase in the mean age of the tillers may also have been responsible for the greater stem live percentage at the end than at the beginning and middle of the grazing period of low and low/mowed pastures, as well as by the greater dead leaf blade percentage at the end than at the beginning and middle of the grazing period of low/mowed, high, and high/mowed pastures (Table 3). In studies conducted with marandu palisadegrass, it was verified that the young tiller percentage was high, but the participation of mature tillers increased during the rainy season (Paiva et al. 2011). These mature tillers usually have longer stems, fewer live leaves, and more senescent leaves than young tillers (Carvalho et al. 2019).

The mowed pastures in late winter presented better morphological composition in subsequent spring and summer. The mowing promoted the elimination of dead and old pasture tillers, and, after regrowth, the pasture has predominantly vegetative and younger tillers (Souza et al. 2015), which are of better morphological composition, when compared to the old tiller (Santos et al. 2019). This may explain the greater live leaf blade percentage, as well as the lower dead stem percentage in the mowed pastures compared to the non-mowed ones (Table 1). This explanation also allows understanding the lower dead leaf blade percentage during the beginning and middle of the grazing period in the mowed pastures, compared to those not mowed (Table 3). Consequently, the mowed pastures also resulted in a lower dead stem percentage in the grazing simulation sample, obtained at the beginning of the grazing period, when compared to the non-mowed pastures.

High pasture in late winter had the greatest dead stem percentage during spring and summer (Table 1). In this pasture, many dead tillers from the winter remained in the pasture, mixed with the new tillers that emerged from spring. This fact may have been responsible for the greater masses and bulk density of the high pasture, in relation to the others, during the beginning and middle of the grazing period (Table 3). However, at the end of the grazing period, due to the long time (90 days) in which pastures were submitted to the same grazing management, i.e., the same average SSH (30 to 35 cm), there was no difference between the values of mass and bulk density of forage among pastures (Table 3).

The high dead stem percentage in the high pasture (Table 1) may also have proportionally reduced the relative participation of live stem in forage mass throughout the grazing period (Table 3). In addition, the high dead stem percentage in the high pasture was determinant for this same pattern of response to occur in the grazing simulation sample during the middle of the grazing period. It is likely that most of the dead tillers in the high pasture have been detached from the plants and thus, have become litter. This may have been the cause of the lower forage mass at the end, than at the beginning and middle of the grazing period on the high pastures (Table 3).

With the improvement of the weather conditions from spring (Figures 1 and 2), it is common that the number of tillers increases in tropical pastures during the rainy season (Sbrissia and da Silva 2008). This probably occurred in the present study and resulted in greater forage bulk density at the end of the grazing period of low, low/mowed, and high/mowed pastures (Table 3). This same factor also explains the greater forage mass at the end than at the beginning and middle of the grazing period (Table 3).

The greatest forage mass in early spring on the high pasture (Table 3) may have increased shading at the base of the plants, inhibiting tillering (Santana et al. 2014), and thus reducing the herbage accumulation rate (HAR) in this pasture (Table 1). The high/mowed pasture also presented low HAR (Table 1), possibly because the cut forage deposited on the base of the plants also prevented the light incidence on the basal buds, limiting tillering. This same process may have occurred in the low pastures, but with less intensity, since the amount of cut forage and deposited on the base of the plants was lower in the low pasture, compared to the high pasture. Therefore, the HAR was greater in the low/mowed pastures than in the high and high/mowed pastures (Table. 1). On the other hand, in the low pastures probably more light reached the basal buds, which stimulated the tillering and increased the HAR (Table 1). In this sense, Costa et al. (2016) also found that the lower marandu palisadegrass canopy (15 cm) during winter presented a greater number of tillers when compared to the highest canopy in winter (45 cm), which can ensure high forage product during the spring and summer.

As a consequence of the worst morphology of the high pasture (Table 1), the grazing simulation sample obtained from these pastures also presented high live stem and dead leaf blade percentages (Table 1).

At the beginning of the grazing period, the live leaf blade percentage (LLBP) in the grazing simulation sample (GS) did not vary among pastures conditions. As all pastures were not grazed for 75 days, there was the formation of an upper stratum with a high LLBP, a result of the pastures regrowth in early spring. This stratum was consumed by sheep at the beginning of the grazing period, which is why there was no variation in the LLBP in the GS in this period. However, in the middle of the grazing period, the LLBP in the GS was lower in the high pastures than in the others, a consequence of the worst morphology of this pasture (Table 1). At the end of the grazing period, LLBP in the GS again did not vary among pastures conditions, probably due to the long time that these pastures remained under the same criterion of grazing management.

In the mowed pastures, the lowest LLBP in the GS in the middle and at the end of the grazing period than the beginning of this period was also due to the consumption of the upper stratum with a high LLBP in the pastures, formed during regrowth in early spring.

The apparent selectivity index (ASI) of less than one indicates that the morphological component is rejected by the animal (Santos et al. 2016), as occurred for dead leaf blade and live and dead stems (Table 1). On the other hand, ASI greater than one indicates the animal preference for the morphological component (Santos et al. 2016), as verified for live leaf blade (Table 1). In addition, the closer to one is the ASI, it can be inferred that the lower the selectivity exerted by the animals (Santos et al. 2016). In this context, it was observed that the mowed pastures resulted in lower ASI of the LLB, compared to the non-mowed pastures (Table 1). This result shows that the sheep were less selective for LLB in the mowed pastures, which can be considered advantageous. A pasture with a high LLBP, such as mowed, presents morphology closer to that the grazing animal prefers, making it unnecessary for the animal to exercise its selectivity markedly to eat a diet with better nutritional value. However, in the high pasture, the ASI of the morphological components of low nutritive value (dead leaf blade and live stem) was greater in relation to the other pastures. The ASI of the dead stem was also greater in the high pasture when compared to the low pasture (Table 1). These results allow inferring that the high pasture presented morphology that made the rejection difficult by the grazing animals of these morphological components, which can impair the consumption and the animal performance. In this sense, Sousa et al. (2018) concluded that, compared to the low pasture (15.1cm and 4,600 kg ha^{-1} DM), deferred and high pasture (31.4cm and 7,640 kg ha^{-1} DM) in late winter show better structure and greater sheep performance during spring and early summer.

As previously described, it is possible that after consumption of the upper stratum of the pastures at the beginning of the grazing period, the availability of live leaf blades has been markedly reduced. Indeed, in the middle of the grazing period, the pasture morphology made it difficult for the sheep to reject less preferred morphological components. For that reason, the live stem and dead leaf blade percentages in the grazing simulation sample were greater in the middle than at the beginning and end of the grazing period (Table 2). This fact may have also been the cause of the greater selectivity indexes of morphological components of lower nutritive value in the middle than at the beginning and end of the grazing period (Table 2).

Our results demonstrate that the pasture management adopted in one season (winter) has effects on the following seasons (spring and summer). Additionally, our results support the first hypothesis, because deferred pasture with lower height in late winter has greater HAR and better structure, which facilitates the animal selective grazing during the subsequent spring and summer, in comparison to higher pasture. However, the second hypothesis was partially supported, because mowing of high pasture in late winter improves the sward structure and the animal selective grazing but does not decrease the HAR during spring and summer.

5. Conclusions

Low sward of marandu palisadegrass in late winter has greater herbage accumulation, better sward structure, and facilitates the animal selective grazing during subsequent spring and summer, in comparison to higher sward. The mowing of high or low marandu palisadegrass swards in late winter also improves the sward structure and the animal selective grazing in spring and summer. The mowing decreases the herbage accumulation during the spring and summer when marandu palisadegrass is low in late winter, but if marandu palisadegrass is high in late winter, the mowing does not decrease the herbage accumulation during spring and summer.

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