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The strategy of pasture lowering before stockpiling modifies the efficiency of sheep grazing in winter

A estratégia de rebaixamento do pasto antes do diferimento modifica a eficiência de pastejo de ovinos no inverno

Jhonatan Gonçalves Silva[1]*; Gabriel de Oliveira Rocha[2]; Laura Andrade Reis[3]; Dallety Haloma Alves Miler de Oliveira[1]; Simone Pedro da Silva[4]; Manoel Eduardo Rozalino Santos[4]; Natascha Almeida Marques da Silva[4]; Gilberto de Lima Macedo Junior[4]

Highlights

Lowering grass at the beginning stockpiling period improves grazing efficiency.
Sheep have greater intake stockpiling pasture beginning the grazing period.
Stockpiling Marandu grass maintains the body weight of adult sheep during the winter.
DM, CP intake and NDF digestibility are lower the middle winter grazing period.

Abstract

The aim of this study was to determine whether the lowering strategies (LSs) of *Urochloa brizantha* cv. Marandu (Marandu grass) before stockpiling would result in better stockpiled pasture structure and sheep performance in winter. The three LSs evaluated were: 1) maintenance of Marandu grass at 15 cm for 5 months before the start of stockpiling (15 cm); 2) maintenance of Marandu grass at 25 cm for 5 months before the start of stockpiling, when the pasture was lowered to 15 cm (25/15 cm); and 3) maintenance of Marandu grass at 35 cm for 5 months before the start of stockpiling, when the pasture was lowered to 18 cm (35/18 cm). Eighteen adult crossbreed sheep (Dorper × Santa Inês) were used, allocated in pairs in nine paddocks. Assessments on animals and pastures were carried out every 45 days during the period of stockpiling for pasture use, with measurements at the beginning (first week), middle (45th day) and end (90th day) of the grazing period. The average daily gain (ADG), intake and chemical composition of samples collected by simulated grazing were measured. The experiment was conducted in a completely randomized design, with repeated measurements over time. Pastures

[1] Doctoral Students of the Postgraduate Program in Veterinary Sciences, Universidade Federal de Uberlândia, UFU, Uberlândia, MG, Brazil. E-mail: jhonatan.zootec@hotmail.com; dalletymileroli@gmail.com
[2] PhD in Veterinary Sciences, UFU, Uberlândia, MG, Brazil. E-mail: gabriel.o.rocha@hotmail.com.br
[3] Zootechnist, UFU, Uberlândia, MG, Brazil. E-mail: lauraandradereis@gmail.com
[4] Profs. Drs., Faculty of Veterinary Medicine and Animal Science, UFU, Uberlândia, MG, Brazil. E-mail: simone.psilva@hotmail.com; manoel.rozalino@gmail.com; natascha@ufu.br; gilberto.macedo@ufu.br
* Author for correspondence

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under 15 cm had a higher percentage of live stems and a lower percentage of dead stems (P<0.10). Forage mass, percentage of live leaves, intake and nutrient digestibility by sheep were not affected by the LS (P>0.10). However, dry matter (DM) and crude protein (CP) intake and neutral detergent fiber (NDF) digestibility were lower in the middle compared to the beginning and end of the grazing period (P<0.10). The grazing time was shorter and the sheep's grazing efficiency was greater on the 35/18 cm pasture than on the 15 and 25/15 cm pastures (P<0.10). Animal performance was not influenced by the LS (P>0.10) but decreased from the beginning to the end of the grazing period. The abrupt lowering of Marandu grass from 35 to 18 cm before deferral resulted in greater grazing efficiency by sheep, characterizing a pastoral environment suitable for grazing in winter.
Key words: Animal performance. Canopy structure. Forage intake. Marandu grass. Nutritive value.

Resumo

O objetivo foi avaliar o efeito de estratégias de rebaixamento (ER) do pasto de *Urochloa brizantha* cv. Marandu (capim-marandu) antes do diferimento sobre a estrutura do pasto diferido e o desempenho de ovinos no inverno. As três ER avaliadas foram: 1) manutenção do capim com 15 cm durante cinco meses antes do início do diferimento (15 cm); 2) manutenção do capim-marandu com 25 cm durante cinco meses antes do início do diferimento, quando o pasto foi rebaixado para 15 cm (25/15 cm); e 3) manutenção do capim com 35 cm, durante cinco meses antes do início do diferimento, quando o pasto foi rebaixado para 18 cm (35/18 cm). Foram utilizadas 18 ovelhas adultas mestiças (Dorper x Santa Inês), alocadas em pares em nove piquetes. As avaliações nos animais e nos pastos foram realizadas a cada 45 dias durante o período de utilização dos pastos diferidos, com mensurações no início (primeira semana), meio (45º dia) e final (90º dia) do período de pastejo. Foram mensurados o GMD, consumo e a composição química de amostras de forragem colhidas por pastejo simulado. O experimento foi conduzido em delineamento inteiramente casualizado com medidas repetidas no tempo. Os pastos mantidos a 15 cm apresentaram maior percentagem de colmo vivo e menor de colmo morto (P<0,10). A massa de forragem, a percentagem de folha viva, o consumo e a digestibilidade dos nutrientes pelos ovinos não foram afetados pelas ER (P>0,10). Entretanto, o consumo de matéria seca (MS), proteína bruta (PB) e a digestibilidade da FDN foram menores no meio em comparação ao início e final do período de pastejo (P<0,10). O tempo em pastejo foi menor e a eficiência de pastejo dos ovinos foi maior no pasto 35/18 cm do que nos 15 e 25/15 cm (P<0,10). O desempenho animal não foi influenciado pelas ER (P>0,10), mas diminuiu do início para o final do período de pastejo. O rebaixamento abrupto do capim-marandu de 35 para 18 cm antes do diferimento resultou em maior eficiência de pastejo pelos ovinos, caracterizando ambiente pastoril adequado para o pastejo no inverno.
Palavras-chave: Capim-marandu. Consumo de pasto. Desempenho animal. Estrutura do pasto. Valor nutritivo.

Introduction

In pasture sheep production systems, one of the main limitations is the lack of forage planning, which results in a forage shortage in the winter. In this context, a relatively easy strategy that guarantees the stock of forage mass in winter is stockpiling, which consists of selecting certain areas of pasture and excluding them from grazing to provide forage accumulation to be offered under grazing in the period of scarcity (J. G. Silva et al., 2021).

However, for a long time, stockpiling grazing was characterized by a high percentage of dead forage and a low percentage of live leaves, which limits animal performance (M. E. R. Santos et al., 2013). A strategy to improve the nutritive value of deferred pasture is to carry out intense grazing before the start of stockpiling to remove part of the forage with the worst nutritional value, allowing greater regrowth through the appearance of younger tillers with better nutritional value (P. M. Santos et al., 2006). In this regard, in the Cerrado region of Brazil, Afonso et al. (2018) concluded that pasture with Marandu grass should be lowered to 15 cm at the beginning of the stockpiling period to obtain stockpiled pasture with a better morphological composition.

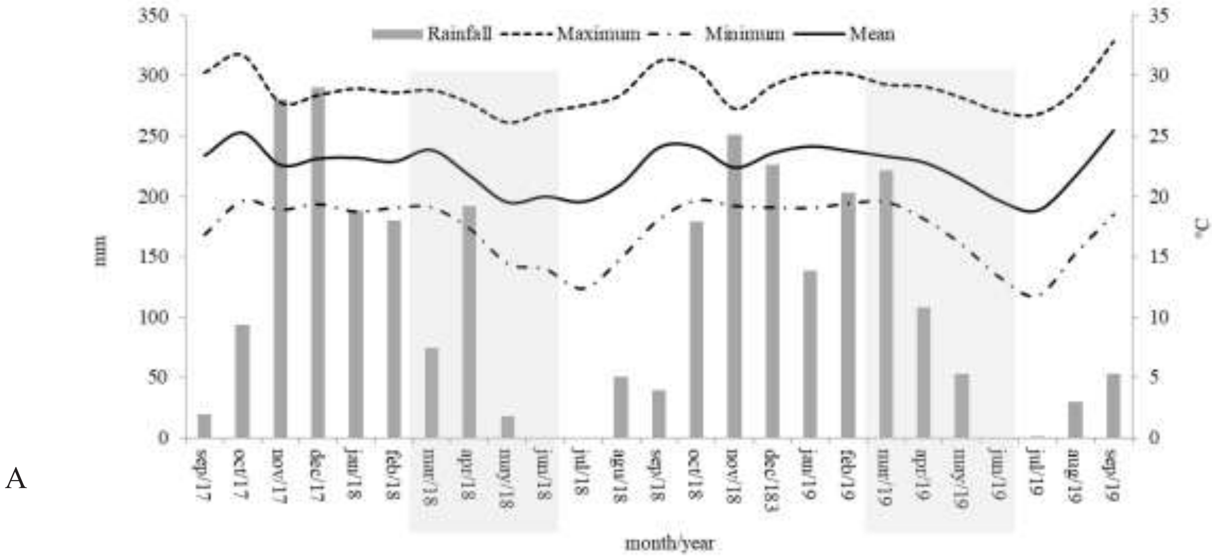
However, grass lowering for stockpiling can be carried out in different ways. Lowering a few months in advance and maintaining the pasture height until the beginning of stockpiling can promote a greater number of tillers, higher leaf area index at the beginning of the stockpiling period, and high growth rates and stem elongation in the stockpiled pasture (M. E. R. Santos et al., 2013), with benefits for the structure and nutritional value of pasture, as well as for the intake and performance of grazing animals.

Therefore, if grass lowering occurs immediately before the beginning of the stockpiling period, the upper canopy stratum, with leaves and apical meristems, should be more intensely removed (Carvalho et al., 2016). This may reduce the growth rate but would result in pastures with a better nutritional value in the winter, which would have positive effects for forage intake and animal performance.

Thus, the objective was to evaluate the effect of different forms of lowering of Marandu grass (*Urochloa brizantha* cv. Marandu) pasture before stockpiling on the structure and nutritional value of the pasture, the feeding behavior, and intake and performance of the animals during the winter (use period of stockpiled pasture).

Materials and Methods

This work was carried out from September 2017 to September 2019 and included two stockpiling periods. The first experimental year (2018) was from September 2017 to September 2018; and the second (2019) was from September 2018 to September 2019. This work was conducted in Uberlândia, Minas Gerais, Brazil (18o30′ S; 47o50′ W; 863 m a.s.l.). According to the Köppen classification, the climate of the region is type Aw, tropical savannah (Alvares et al., 2013), with two well-defined seasons: hot and rainy from October to March and dry and cold from April to September. Climatic data during the experimental period were collected at a meteorological station close to the experimental area (Figure 1).



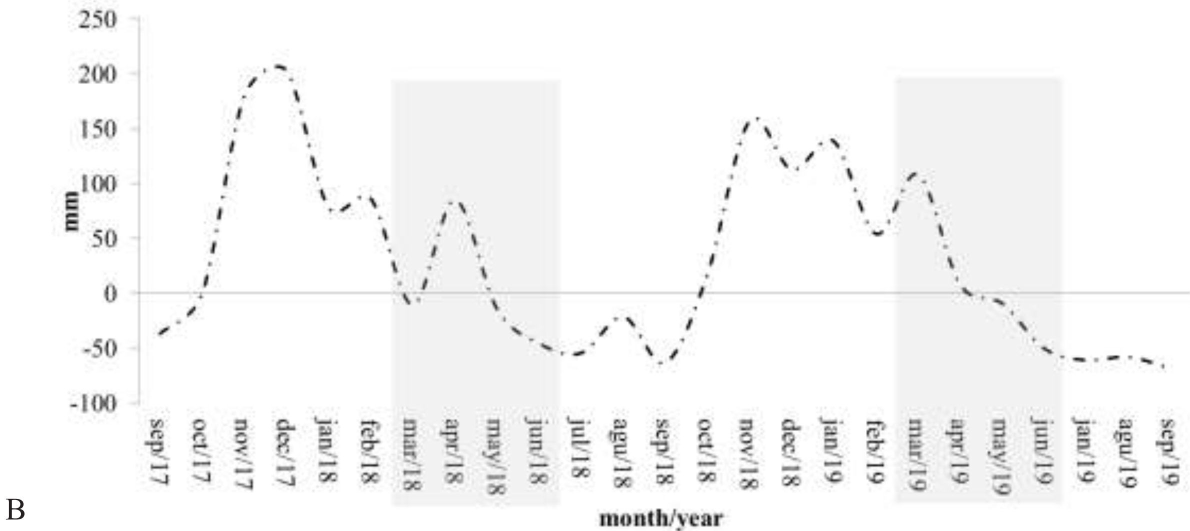


Figure 1. Monthly averages of daily temperatures (minimum, average and maximum) and monthly cumulative rainfall (mm; A), and soil water balance (B) during the experimental period in Uberlândia, MG, Brazil. The period highlighted in gray corresponds to the stockpiling period. Based on the temperature and rainfall data, the soil water balance was calculated according to the methodology of Thornthwaite and Mather (1955), considering a soil water storage capacity equal to 50 mm.

The soil in the experimental area was classified as Dark Red Latosol with a clayey texture. Soil analysis in September 2017 in the 0-20 cm layer showed the following: pH (H_2O), 5.54; P, 8.06 mg dm^{-3} (Meh-1); K, 146 mg dm^{-3}; Ca^{2+}, 3.89 cmol/dm^{-3}; Mg^{2+}, 1.83 $cmol_c$ dm^{-3}; Al^{3+}, 0 $cmol_c$ dm^{-3} (KCl 1 mol L^{-1}); e V, 60%. Soil analysis in 2018 showed the following: pH (H_2O), 5.34; P, 6.74 mg dm^{-3} (Meh-1); K, 240 mg dm^{-3}; Ca^{2+}, 4.23 $cmol_c$ dm^{-3}; Mg^{2+}, 1.54 $cmol_c$ dm^{-3}; Al^{3+}, 0 $cmol_c$ dm^{-3} (KCl 1 mol L^{-1}); e V, 58%. Based on these results, liming and potassium fertilization were not necessary. Nitrogen fertilization was performed with urea (70, 50, 50 and 30 kg ha^{-1} of N) on four application dates 03/10/17, 04/11/17, 09/01/18 and 06/03/18 in the first year and 10/10/18, 12/11/18, 08/01/19 and 10/03/19 in the second year. Phosphate fertilization with 50 kg ha^{-1} of P_2O_5, in the form of simple superphosphate, was carried out with the second installment of nitrogen in each experimental year.

The experimental area consisted of a pasture with *Urochloa brizantha* cv. Marandu (Marandu grass) divided into nine paddocks (experimental units) of 800 m^2 each, in addition to four reserve paddocks. The treatments were three grass-lowering strategies for stockpiling: (i) pasture with an average height of 15 cm from October until the beginning of the deferral period (15 cm); (ii) pasture with an average height of 25 cm from October until the beginning of the deferral period, when it was reduced to 15 cm (25/15 cm); and (iii) pasture with an average height of 35 cm from October until the beginning of the deferral period, when it was reduced to 18 cm (35/18 cm). The experimental design was completely randomized, with three replications.

In each experimental year, from October to mid-March, all pastures were managed with continuous stocking and a variable stocking rate to maintain the height targets, using sheep as grazing animals. Mean pasture heights were monitored twice a week by measuring the distance from the soil surface to the highest living leaf in the canopy at 30 points per paddock. Grass lowering for the 25/15 and 35/18 cm treatments occurred 5 days prior to the beginning of the deferral period, being carried out by increasing the stocking rate in the paddocks with sheep. Pastures managed under 35/15 cm did not have their height reduced to 15 cm, but the sheep were able to lower them to 18 cm.

After an 88-day deferral period, from March 23 to June 19 in both experimental years, the period of use of deferred pastures began, which were managed with continuous stocking and a fixed stocking rate, using 18 crossbred females (½ Dorper + ½ Santa Inês) that were not pregnant and had an average initial body weight of 57.5 kg. To adjust the stocking rate (Allen et al., 2011) during this period, the following formula was used:

$$SR = {}^{LM}/_{(I/GE) * P} \qquad (1)$$

where SR is the stocking rate (animal ha^{-1}); LM is the mass of leaves (live + dead), in kg ha^{-1} of dry matter (DM); I is the daily intake per animal, in kg for $animal^{-1}$ day^{-1} of DM; GE is the grazing efficiency, in %; and P is period of deferred pasture use, in days.

In this study, a daily forage intake per animal of 1.8% BW, a grazing efficiency of 50% and a period of use for the deferred pasture of 90 days were considered.

The sheep remained in the pastures during the day and at night, where they received, in 2018, protein salt with the following composition: white salt (62.5%), mineral salt (12.5%), corn meal (10%), urea (7.5%) and soybean meal (7.5%). The protein supplement was formulated to allow a consumption level of 0.1% BW. In 2019, sheep had unrestricted access to mineral salt only.

All evaluations were carried out every 45 days during the use period of deferred pastures, with measurements taken at the beginning (first week), middle (45th day) and end (90th day) of the grazing period. The nutritive value of pasture and the animal variables were only evaluated in the first experimental year.

The mean pasture height (PH) was monitored by measuring the distance from the soil surface to the highest living leaf in the canopy at 30 points per paddock. Immediately after measuring the height of the sward, the height of the extended plant (HEP) was measured at 30 points per paddock, considering the distance from the soil surface to the extended tiller in the vertical direction. The tipping index was calculated by dividing the HEP by the PH.

Three forage samples were collected per paddock at points whose plants were at the same average height as the pasture using a 0.25 m^2. Each sample was placed in a plastic bag, weighed and separated into two subsamples. One of them was completely placed in a paper bag, weighed, placed in a forced ventilation oven for 72 h at 55°C, and weighed again. The other subsample was separated into live leaves, dead leaves, live stems and dead stems. Each morphological component was placed in labeled paper bags, dried in a forced ventilation oven for 72 h at 55°C and weighed. Using these data, the masses and percentages of the morphological components of the forage were determined.

The falling index (FI) at the end of the stockpiling period was calculated by dividing the extended plant height (EPH) by the average PH. The PH and EPH were measured at 30 points per paddock using a graduated ruler. The PH was measured according to the same criterion previously described in an attempt to cause minimal disturbance to the plants. The EPH measurement corresponded to the distance from the soil surface to the tip of the tiller, extended in the vertical direction.

Simulated grazing (SG) was carried out by collecting a forage sample per paddock to simulate the morphological composition of forage consumed by sheep during grazing (Sollenberger & Cherney, 1995). Sampling was carried out by observing the forage consumption of two animals present in the paddock.

To determine the average daily gain (ADG), after fasting for 16 h, the animals were weighed before being distributed in experimental units. Afterwards, they were weighed after fasting every 30 days and at the end of the grazing period. The weights were determined using a mechanical digital scale with a precision of 10 g. The ADG at the beginning, middle and end of grazing period was calculated by the difference in weight of the animals at the end and beginning of each period, divided by the number of days between these two weigh ins.

To estimate fecal excretion, purified and enriched lignin (LIPE®) was determined through the relationship between dose and fecal concentration of the external indicator. LIPE® was administered through an esophageal tube at a daily dose of 0.5 g animal⁻¹ day⁻¹ in capsules provided in the morning, once a day, for 6 days, with 2 days of adaptation and 4 days of collection. At the end of the collection period, a composite sample of feces was collected for each animal. The samples were dried and ground to 1 mm for later analysis of the LIPE® concentration. This was determined using infrared spectroscopy with a Watson Galaxy model device, FT-IR 3000 series. Fecal production was calculated as described by Saliba et al. (2015). Feces was collected after the third day, after the supply of the LIPE® for four days, and at the same time as the supply of capsules. Indigestible neutral detergent fiber (iNDF) was used as an internal indicator to estimate forage intake. The iNDF concentration in simulated grazing and feces samples was determined by incubation in TNT bags in the bovine rumen for 240 h (Valente et al., 2011). Pasture DM intake was estimated as follows:

$$\text{Dry Matter Intake} = {(FE * CiNDFFc)}/{CiNDFFo} + ISup \quad (2)$$

where Dry Matter Intake = total intake dry matter (g day^{-1}); FE = fecal excretion (g day^{-1}); CiNDFF = concentration of iNDF in feces (g.g^{-1}); CiNDFFor = concentration of iNDF in forage (g.g^{-1}); and ISup = dry matter intake of supplement (g day^{-1}).

The estimate of individual supplement consumption in 2018 was obtained by dividing the total amount of supplement offered by the animal's number. The apparent digestibility of DM and other nutrients was obtained as follows:

$$AD = {(NI - NE)}/{NI} \quad (3)$$

where AD = apparent digestibility; NI = nutrient intake (g day^{-1}); and NE = nutrient excretion (g day^{-1}).

Potentially digestible dry matter (DMpd) was calculated using the following formula (Paulino et al., 2008):

$$DMpd = [0.98 * (100 - NDF) + (NDF - iNDF) \quad (4)$$

where NDF = neutral detergent fiber; and iFDN = indigestible neutral detergent fiber.

Samples of pasture, simulated grazing, feces and supplement ingredients were ground in a knife mill (1 mm) and placed in plastic pots; subsequently, the contents of dry matter, mineral matter, crude protein and insoluble fiber in neutral detergent were determined by methods proposed by INCT-CA (Detmann, 2012).

To evaluate the feeding behavior, observations were made every 10 minutes, during a 12-h day, to identify the time destined for grazing, rumination and other activities (R. R. Silva et al., 2008). The animals were visually evaluated by two trained observers for each treatment, who were strategically positioned so as not to disturb the animals. Grazing efficiency was calculated by dividing the total daily consumption of pasture by the daily grazing time.

Pasture-related response variables were analyzed in a completely randomized design, with repeated measurements over time during the grazing period and experimental years. The animal variables were analyzed in repeated measurements over time only during the grazing period. For the inferential analysis of the data, all variables were analyzed in terms of assumptions of normality and evaluated using analysis of variance, followed by the test of means (Least Square Difference (LSD) using a Fisher test) at a 10% probability level for type I error.

Results and Discussion

The LSs had no impact on the forage mass (FM) of the pastures after the period of stockpiling, resulting in an average of 10.639 kg ha^{-1} of DM. However, the pasture under 15 cm exhibited higher percentages of live stem and FI and a lower percentage of dead stems (DSs) compared to the pasture under 35/18 cm. The pasture under treatment 25/15 cm presented intermediate values for these structural characteristics (Table 1). Pastures maintained at a higher height (25 and 35 cm) and later lowered to 15 cm required a longer adaptation period, characterized by a greater height and leaf area index (LAI) and high competition for light among tillers, triggering increased stalk development and greater tiller senescence. Conversely, pastures kept at a lower height (15 cm) exhibited the lowest LAI, with reduced competition leading to a greater stimulus for tiller renewal. Senescent tillers from pastures at 25 and 35 cm were responsible for the reduced live stems in these treatments.

Table 1
Structural characteristics of *Urochloa brizantha* cv. Marandu subjected to lowering strategies before deferral grazed by sheep in 2018 and 2019

Variable	Lowering Strategies			Year		Grazing Period		
	15	25/15	35/15	2018	2019	Beginning	Middle	End
FM	1061.6	1046.8	1083.5	1043.5	1084.4	1310.7a	1129.3b	7519c
LSt	39.79a	32.34b	29.93b	30.71b	37.33a	41.17a	36.38b	24.51c
DS	20.32c	33.60b	38.36a	34.53a	26.99b	16.03c	30.29b	45.96a
PH	102.2	101.3	103.5	101.3b	103.4a	114.4a	106.1b	86.46c
FI	1.52a	1.40ab	1.31b	1.47	1.34	1.26b	1.49ab	1.47a

FM: forage mass; LSt: percentage of live stem; DS: percentage of dead stem; PH: pasture height; FI: falling index. For each variable and in each factor, means followed by different letters differ by the Least Square Difference (LSD, $P<0.10$).

The highest percentage of dead stems in the pasture under 35/18 cm occurred due to abrupt lowering of the plants prior to stockpiling, which eliminated the apical meristems of basal tillers, causing them to die. Furthermore, the abrupt lowering resulted in the control of live stem elongation due to greater light penetration inside the canopy, resulting in lower participation of live stems in the forage mass (Table 1).

The experimental year did not influence FM (10.639 kg ha^{-1} DM) or FI (1.40). In 2018, stockpiled pastures had a lower pasture height (101.3 cm) and percentage of live stems (30.71%) but a higher percentage of DS (34.53%) compared to 2019 (103.4 cm in height, 37.33% DS, and 26.99% LSt) (Table 1). The first experimental year (2018) had more irregular rainfall and a negative water balance at the beginning of the stockpiling period (Figure 1). This resulted in worse growth conditions for the forage plant. Therefore, a lower pasture height and percentage of live stems but a higher percentage of DSs were observed in the stockpiled canopies in 2018 (Tables 1-3). The FM, PH and LSt percentage decreased from the beginning to the end of the grazing period. An opposite response pattern occurred with DS and FI percentages (Table 1).

The FI can be understood as the inability of the stem to support the weight of the tiller. The fall of the plant is related to stem etiolation during the stockpiling period due to competition for light between tillers. FI has a strong positive correlation with the number of reproductive and dead tillers in the canopy but has a negative correlation with the number of live tillers (M. E. R. Santos et al., 2010). Thus, a high FI is characteristic of a stockpiled canopy with a worse structure and nutritional value (M. E. R. Santos et al., 2010). Additionally, during grazing, the displacement of animals can cause tipped plants, with greater intensity in pastures with greater canopy height, resulting in greater forage loss.

The percentage of live leaves (LLs) in the pasture was influenced by the interaction between treatments, experimental years and grazing periods (Table 2). In the two experimental years, LL was higher in the beginning than in the middle and end of the grazing period for all treatments. However, this reduction occurred with greater intensity in 2018 than in 2019. In fact, in 2018, the LL in the middle was similar to the end of the grazing period, while in 2019, the intermediate period of grazing presented higher LL values compared to the final period but lower than those at the beginning of grazing. As for live and dead leaves in the canopy, components preferred by animals and with better nutritional value compared to the stem (M. E. R. Santos et al., 2016) had similar values at the beginning of the grazing period among the SL treatments. Therefore, the structure of stockpiled pastures was determined by the stem and how it was distributed in the vertical profile of the canopy. There was a greater proportion of DSs in the stratum below 18 cm in the pasture under 35/18 cm. A greater number of reproductive tillers in pastures under 35/18 cm probably occurred due to their tillers being older and tending to flower more.

Table 2
Percentage of live and dead leaves and pasture height of *Urochloa brizantha* cv. Marandu submitted to lowering strategies before deferral and grazed by sheep in 2018 and 2019

Year	Period	Lowering Strategies			*P*-value
		15	25/15	35/18	
		Pasture height (cm)			
2018	-	102.41Aa	101.78Aa	99.70Ba	0.077
2019	-	102.02Ab	100.82Ab	107.26Aa	
		Live leaf (%)			
2018	Beginning	19.81 Aa	17.83 Aa	18.78 Aa	0.047
	Middle	1.86 Ba	2.56 Ba	3.06 Ba	
	End	1.60 Ba	2.44 Ba	2.13 Ba	
2019	Beginning	29.18 Aa	30.11 Aa	30.29 Aa	
	Middle	4.92 Ba	0.79 Bb	5.36 Ba	
	End	1.61 Ca	0.10 Cb	1.34 Ca	
		Dead leaf (%)			
-	Beginning	18.79 Ba	20.11 Ba	16.48 Ba	<0.001
-	Middle	34.07 Aa	31.30 Aa	25.31 Ab	
-	End	37.29 Aa	23.81 Bb	22.87 Ab	

For each variable, means followed by different uppercase letters in the column and lowercase letters in the row differ by the Least Square Difference (LSD, P<0.10).

The PH was similar between the SLs in 2018, but in 2019, the pasture submitted to 35/18 cm presented a greater canopy height compared to the pastures. The PH under 15 cm and 25/15 cm was similar between the experimental years (mean 102.2 and 101.3 cm, respectively), but the pasture under 35/18 cm had a higher value in 2019 (107.26 cm) than in 2018 (99.70 cm) (Table 2).

In 2018, LL within each grazing period did not vary between LSs. However, in 2019, the pasture managed with 25/15 cm had a lower LL than the other treatments in the middle and end of the grazing period (Table 2).

The percentage of dead leaves (DLs) was influenced by the interaction between LSs and the grazing period (Table 2) and by the interaction between the grazing period and year (Table 3). The DL was higher in the middle and end compared to the beginning of the grazing period in all LSs except 25/15 cm. In this LS, the DL was higher only in the middle of the grazing period. Throughout the grazing period, DL was similar between the LSs at the beginning, lower in the 35/18 cm LS during the middle and higher in the 15 cm LS at the end (Table 2). The DL did not vary between the experimental years in the middle or end of the grazing period, but at the beginning of this period, DL was higher in 2018 than in 2019. The initial grazing period had the lowest DL in both experimental years (Table 3).

Table 3
Dead leaf percentage of Urochloa brizantha cv. Marandu in the stockpiling period after sheep grazing in 2018 and 2019

Year	Grazing Period			*P*-value
	Beginning	Middle	End	
2018	22.97 Ab	28.82 Aa	29.10 Aa	<0.001
2019	13.96 Bc	31.63 Aa	26.87 Ab	

Means followed by different uppercase letters in the column and lowercase letters in the row differ by the Least Square Difference (LSD, P<0.10).

Regarding the grazing period, FM and PH decreased from the beginning to the end of the grazing period (Table 1) due to the adverse conditions of the dry period, such as less water availability and lower temperatures, which increased during the grazing period (Figure 1) and caused the death of LSt and increased DS, linked to the pasture intake by animals. Afonso et al. (2018) also found a reduction in FM over the grazing period in stockpiled Marandu grass pasture.

The NDF content of the forage sample obtained with simulated grazing was higher in the intermediate period compared to the beginning and end of the grazing period, in contrast to what occurred for the CP content. The iNDF content was similar between the grazing periods, with an average of 24.5%. However, the DMpd concentration was lower in the middle of the grazing period (Table 4). The NDF and iNDF contents were higher in the simulated grazing sample in the middle of the grazing period (Table 4), which can be explained by the large amount of dead leaves (Tables 1 and 3) and dead stems in the pastures during this period (Table 4). During grazing, the animals selected live leaves and rejected dead stems, which had higher NDF and iNDF contents. In this context, in a study carried out with cattle grazing stockpiled signalgrass at four evaluation times (1, 31, 57 and 88 days of grazing), Nogueira et al. (2020) found increasing levels of NDF with increasing grazing time, demonstrating the worsening of the pasture's nutritional value.

Table 4

Effect of grazing period on chemical composition of simulated grazing sample and intake and digestibility of nutrients in sheep grazing Urochloa brizantha cv. Marandu stockpiled with different lowering strategies before deferral in 2018

	Grazing Period			*P*-value
	Beginning	Middle	End	
Crude Protein (%)	9.14 a	5.90 b	10.06 a	<0.001
NDF (%)	68.13 b	73.50 a	68.55 b	<0.011
NDF indigestible (%)	22.03 ab	26.86 a	24.59 a	0.051
DMpd (%)	77.31 a	72.61 ab	74.77 a	0.062
Intake of DM (kg day^{-1})	0.492	0.447	0.495	0.341
Intake of DM (% BW)	0.868 a	0.742 b	0.911 a	0.064
Intake of CP (kg day^{-1})	0.049 b	0.032 c	0.060 a	<0.001
NDF digestibility	32.65 b	29.24 c	37.10 a	<0.001

NDF: neutral detergent fiber; DMpd: potentially digestible dry matter; DM: dry matter; CP: crude protein. Means on the line followed by different letters differ statistically by the Least Square Difference (LSD, $P<0.10$).

DMpd is negatively influenced by iNDF (Paulino et al., 2008). Therefore, a lower DMpd occurred in the middle of the grazing period, a period with a greater amount of dead leaves and dead stems (Tables 1 and 3), which have higher levels of iNDF (A. P. Santos et al., 2008). The highest levels of NDF in the middle of the grazing period can be explained by the large amount of dead leaves and dead stems that accumulated during the dry season. This can also explain the longer rumination time in the middle of the grazing period. According to Welch and Hooper (1988), rumination time is strongly correlated (0.96) with NDF intake in cattle.

Changes in the morphological characteristics of pastures in response to stockpiling strategies did not result in variations in the nutritive value of the forage. While the morphological characteristics of forage originated from samples collected close to the ground (total forage mass), the nutritional value variables originated from samples collected via simulated grazing. In this context, M. E. R. Santos et al. (2016) evaluated the selectivity of cattle under grazing stockpiled signalgrass (*Brachiaria decumbens* cv. Basilisk) with different stockpiling periods (73, 103, 131 and 163 days). These authors reported that simulated grazing samples of animals showed higher levels of live leaf blades, potentially digestible dry matter (DMpd) and crude protein than the forage mass samples. This occurs because the animals can select forage, giving preference to components with greater nutritional value.

The DM intake (animal kg^{-1} day^{-1}) was similar throughout the grazing period, with an average of 0.468 kg DM day^{-1}. However, DM intake per animal (in % of body weight), CP (kg day^{-1}) and NDF digestibility were lower in the middle of the grazing period, corresponding to 85.48, 53.33 and 78.81% of the highest reported value, respectively, which occurred at the end of the grazing period for these variables (Table 4). Changes in the structure and nutritional value of stockpiled pastures resulted in higher intake in the initial and final periods of grazing (Table 4). During these periods, the animals consumed forage with higher levels of CP and digestible NDF (Table 4). This occurred by live leaf selection and rejection of dead forage and stems by animals. However, in the middle of the grazing period, the percentage of live leaves decreased, and the percentage of stems increased, resulting in a reduction in forage intake. At the end of the grazing period, the highest DMI (%BW) occurred due to the onset of precipitation in mid-August and early September (Figure 1), which stimulated the regrowth of pastures and, with that, increased the DMI (%BW), as well as the CP intake. This regrowth of the pastures allowed the animals to consume forage with a higher percentage of live leaves, which was responsible for the higher NDF digestibility at the end of the grazing period.

In the first experimental year (2018), the grazing time was longer when the animals were kept in pastures with the 15 cm and 25/15 cm treatments than on those of 35/18 cm. A contrasting response pattern occurred with idle time. Indeed, grazing efficiency was higher in pastures under 35/18 cm than in the others (Table 5). These different structures of stockpiled pastures influenced feeding behavior during grazing (Tables 6 and 7). In fact, the shortest grazing time and the longest idle time of animals were verified in the pasture under 35/18 cm. This treatment had a lower pasture height in 2018 (Table 1), but with the same percentage of live leaves in the forage mass (Table 2) compared to the others. This probably resulted in a higher live leaf density in the pasture under 35/18 cm, an indication that pasture structure was more favorable for grazing animals (Benvenutti et al., 2008; Zanini et al., 2012).

Regarding this relationship, the consumption and performance of sheep were not influenced by LSs, in contrast to our hypothesis. A similar result was presented by Silva et al. (2021), evaluating the intake and digestibility of nutrients in sheep on stockpiled grazing of Marandu grass with different initial heights (15, 25, 35 and 45 cm). Pastures stockpiled with 15 and 25 cm showed a higher DMpd, CP and NDF digestibility and lower NDF content at the beginning of the grazing period compared to taller stockpiled ones. However, despite these differences, there was no difference in forage intake by grazing animals.

Table 5
Grazing time, idling and grazing efficiency of sheep on *Urochloa brizantha* cv. Marandu stockpiled with different lowering strategies before deferral in 2018

Variable	Lowering Strategy			Valor-P
	15	25/15	35/18	
Grazing time (min day^{-1})	355.2 a	338.6 a	295.7 b	0.010
Idle time (min day^{-1})	271.7 b	285.2 b	331.9 a	0.041
Grazing efficiency (g min^{-1})	1.39 b	1.32 b	1.67 a	0.052

Means on the row followed by different letters differ by the Least Square Difference (LSD, P<0.10).

At the beginning and middle of the grazing period, the sheep had a shorter grazing time, with greater grazing efficiency at the beginning of the stockpiled pasture period. This occurred because the pasture had a better structure, with a higher percentage of live leaves and lower live stems and dead stems, which allowed the animal to eat more easily during grazing. A similar result was found by Mezzalira et al. (2014), evaluating *Cynodon* spp. (Tifton-85 grass) and *Avena strigosa* grazed by cattle at five lowering levels (0, 20, 40, 60 and 80% lowering). These authors reported a reduction in grazing efficiency with a longer grazing time. This occurred because, with the lowering of the pasture, the total mass availability was reduced, while there was an increase in the percentage of stem and dead forage in the available mass. These are factors that increase forage selection and grazing time while reducing forage intake. Studies conducted by Miranda (2008) and Jochims et al. (2010) with grazing sheep showed an intake of Marandu grass and millet pasture equal to 1.93 and 2.17% of BW, respectively, and these values are higher than those found in this study.

Sheep performed better at the beginning of the grazing period (0-30 days) due to a greater forage mass in this period, with a higher percentage of live leaves and lower percentage of dead leaves and dead stems. This pasture structure resulted in a higher CP and DMpd content but a lower NDF and iNDF content. Stockpiling Marandu grass is a low-cost strategy to maintain the weight and body condition of animals. Therefore, the experimental unit was adult, non-pregnant sheep with good body conditions. The objective of animals maintaining their body condition during the dry period of the year was achieved. The forage intake by the sheep did not vary according to the SL, but the grazing time of the animals was shorter when the pasture was managed at 35/18 cm. It is natural that grazing efficiency (calculated as the relationship between DM intake and grazing time) was higher in this situation (Table 5). This greater grazing efficiency demonstrates that the 35/18 cm management provided the animal with a better structure for the forage intake. Lowering from 35 to 18 cm before stockpiling modified the distribution of morphological components in the vertical profile of the canopy. Thus, it is possible that the stem, mainly the dead stems, was concentrated in the basal stratum, while the leaves in the upper stratum. This structure favors consumption and reduces the time spent selecting pastures by the animal. (Benvenutti et al., 2008; Fonseca et al., 2012; Zanini et al., 2012). This greater efficiency has a positive result for the animal on the choice of grazing period, allowing the choice of times with lower temperature, resulting in greater thermal comfort. However, greater grazing efficiency results in more time for other activities, such as reproduction, surveillance and social interaction. Grazing time was longer, while idle time was shorter at the end than at the beginning and in the middle of the grazing period. Grazing efficiency and animal performance (ADG) were higher at the beginning than in the other grazing periods (Table 6). However, the ADG was similar between the LSs (average 0.046 kg animal^{-1} day^{-1}). From the middle of the grazing period, the animal's performance decreased, even becoming negative (Table 6). However, as animal performance was high in the initial 30 days of the grazing period, this compensation was responsible for keeping the animals' body weight relatively constant throughout the entire 90-day grazing period in winter. This can be considered a satisfactory result, given that, under grazing conditions, it is common for animals to lose weight throughout the entire winter period when kept exclusively on non-stockpiled pastures (Poore & Drewnoski, 2010; A. P. Santos et al., 2008).

Table 6

Effect of grazing period on feeding behavior, grazing efficiency, and performance of sheep on pasture of *Urochloa brizantha* cv. Marandu submitted to lowering strategies before grazing stockpiled in 2018

Variable	Grazing Period			P-value
	Beginning	Middle	End	
Grazing time (min day^{-1})	273.8 b	292.4 b	423.3 a	<0.010
Idle time (min day^{-1})	306.9 b	332.1 a	249.7 c	<0.010
Grazing efficiency (g min^{-1})	1.74 a	1.45 b	1.15 c	<0.010
Performance (kg animal^{-1} day^{-1})	0.158 a	−0.064 b	−0.107 c	<0.100

Means in the row followed by different letters differ by Least Square Difference, LSD (P<0.10).

The interaction between the grazing period and SL influenced the rumination time. This was higher in the middle of the grazing period when the animals were kept on pastures managed at 15 and 35/18 cm as well as at the beginning of the pasture grazing period under 25/15 cm. At the beginning and end of the grazing period, the animals on pasture under 25/15 cm showed longer rumination times in relation to the middle period (Table 7).

Table 7
Interaction effect between deferred sward lowering strategies (LS) and grazing period on rumination time (min day^{-1}) of sheep on stockpiled pastures of *Urochloa brizantha* cv. marandu in 2018

LS	Grazing Period			P-value
	Beginning	Middle	End	
15 cm	70.71 Ba	92.13 Aa	29.29 Cb	<0.001
25/15 cm	100.70 Aa	57.86 Bb	65.70 Ab	<0.001
35/18 cm	52.86 Bb	91.43 Aa	60.70 Bb	<0.001

LS: Lowering strategy; Means followed by different uppercase letters in the column and lowercase letters in the row differ by the Least Square Difference (LSD, P<0.10).

The main objective of pasture stockpiling is to obtain a stock of forage mass in the winter. For this, management strategies that improve the quality of stockpiled pastures must be adopted. In this context, the lowering strategies evaluated in this work resulted in pastures with the same forage mass at the beginning of the grazing period in winter, but with different structures. Despite having different structures, stockpiled pastures did not influence animal performance in the winter. This indicates the existence of flexibility in grazing management that can be adopted before the start of stockpiling. However, an LS of 35/18 cm resulted in greater grazing efficiency and, therefore, can be considered more adequate to improve the pastoral environment for animals during stockpiled grazing in winter.

Conclusions

Lowering strategies influenced the structure of the Marandu grass pasture. Lowering the Marandu grass pasture from 35 to 18 cm at the beginning of the deferral period improved pasture structure and sheep grazing efficiency, indicating that this management results in a pastoral environment that is more suitable for winter grazing. The best structure and highest consumption of deferred pasture occurred at the beginning of the grazing period rather than at the end.

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