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Tillering pattern of marandu, mavuno, ipyporã and mulatto II grasses submitted to stockpiling

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ABSTRACT. The objective was to evaluate the tillering pattern in the period before and during the stockpiling of the marandu, mavuno, ipyporã and mulato II cultivars. The experimental design was completely randomized, with four replications. The tiller appearance rate (TAR) showed a similar pattern among grasses, being higher in the previous and initial stockpiling period. Among the forages, the ipyporã grass showed the highest TAR in the pre-stockpiling period. The tiller mortality rate was higher at the end of the stockpiling period. The balance between tiller appearance and mortality rates (BAL) was positive in the previous and initial stockpiling period and negative in the intermediate and final phases of stockpiling period. The BAL of the ipyporã grass was superior in the pre-stockpiling, in relation to the other grasses. The stability index showed a response pattern similar to the BAL. The number of tillers was higher in the middle, intermediate in the beginning and end, but lower in the pre-stockpiling period. The ipyporã grass has later regrowth vigor in the pre- stockpiling period. Population stability of tillers of the marandu, mavuno, ipyporã and mulato II grasses is not compromised during the stockpiling.

Keywords: Tiller appearance; tiller mortality; tiller stability; *Urochloa.*

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Introduction

The pasture ecosystem is dynamic and highly responsive to environmental and management conditions, which occurs through adaptive mechanisms of forage plants, called phenotypic plasticity. Due to phenotypic plasticity, the plant is able to alter the morphology and number of individual tillers, resulting in change in pasture structure (Shepard et al., 2018). However, this entire process is dependent on the genetics of the forage plant, which is why their understanding and the magnitude in which they occur must be studied as new forage grasses are launched on the national market (Martinez et al., 2020).

The new hybrid genotypes of the forage grass market have been developed to produce large amounts of forage mass, tolerance to drought and pest insects, however there are few research studies on the yield and quality of the forage produced (Martinez et al., 2020). Public and private companies have intensified the release of new grasses over the last decade, however many of these grasses have not yet been properly studied in specific management situations, such as stockpiled pasture.

Stockpiling consists of reserving an area of the property to store forage mass to be used at the time of greater food scarcity, in order to mitigate the effects of seasonality of forage production (Bork et al., 2017). In such management condition, very high stockpiled pastures are commonly observed, since the plants remain in free growth for a long period. It causes a change in the microclimate within the forage canopy, which alters the tillering pattern (Macedo et al., 2021), as well as morphological aspects of the grasses.

In this sense, with the study of tillering dynamics, it is possible to verify the perennialization and adaptation strategies of different grasses (Shepard et al., 2018; Sousa et al., 2019), when submitted to stockpiling. Based on this information, it can be inferred the suitability of grasses for stockpiling. Thus, our hypothesis was that there are differences in the patterns of appearance and mortality of tillers of marandu, ipyporã, mavuno and mulatto II grasses, when stockpiled.

Therefore, this study was carried out with the objective of comparing the tillering patterns of marandu, ipyporã, mavuno and mulatto II grasses during the period prior to the stockpiling, as well as during the stockpiling period, and thus infer about the suitability of these grasses for use under the stockpiling.

Material and methods

The experiment was conducted from September 2020 to June 2021, in the area of the Capim Branco Experimental Farm, belonging to the College of Veterinary Medicine of the Federal University of Uberlândia, in Uberlândia, MG. The geographical coordinates of the site are 18° 55' 20.7' S south latitude and 48° 16' 38'' W west longitude of Greenwich, and its altitude is 863 m. The average annual temperature is 22.3°C, while the average annual rainfall is 1,584 mm. The climate of the region is Aw, tropical savannah, with dry winters and hot, humid summers (Alvares et al., 2013). Information regarding climatic conditions during the experimental period was monitored at the meteorological station located approximately 200 m from the experimental area (Figure 1) and (Figure 2).

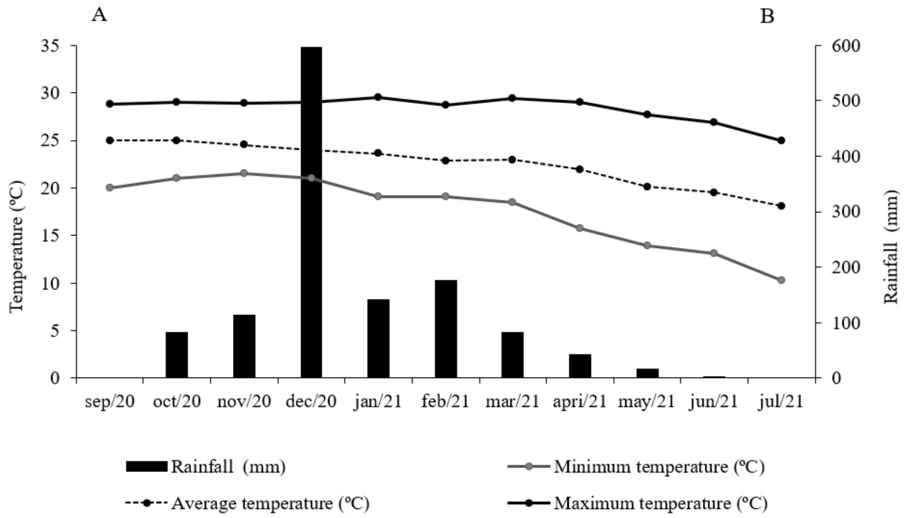

Figure 1. Monthly averages of minimum, maximum and average daily temperatures and rainfall from September 2020 to June 2021.

Temperature and monthly precipitation were used to calculate the soil water balance (Thornthwaite and Mather, 1955), considering the soil water storage capacity of 50 mm (Figure 2).

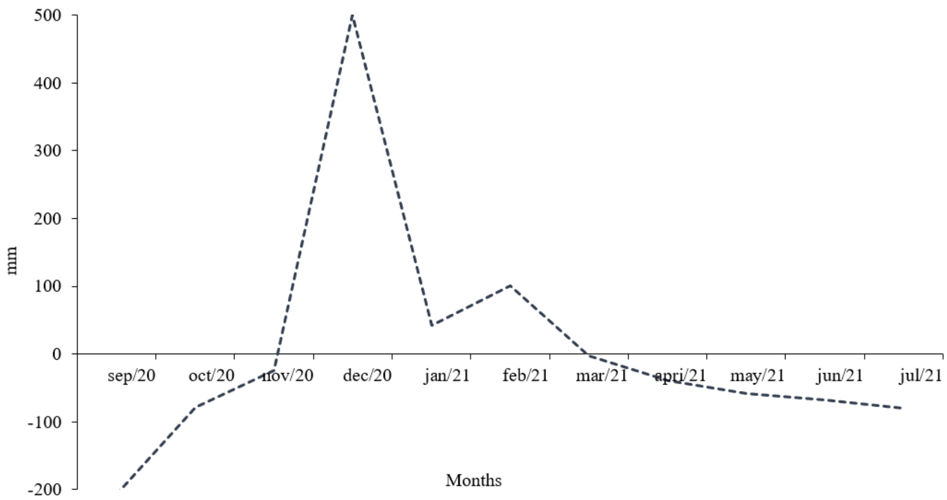

Figure 2. Balance of soil water from September 2020 to July 2021.

The relief of the experimental area is flat and the soil is classified as Dark Red Latosol (EMBRAPA, 2018). In September 2020, soil samples were taken in the 0 to 20 cm layer for fertility level analysis and the results were: pH in (H_2O): 6.2; P: 23.2 mg dm^{-3} (Mehlich^{-1}); P rem: 6.9 mg dm^{-3} ; K: 165 mg dm^{-3}; Ca^{2+}: 3.53 $cmol_c$ dm^{-3}; Mg^{2+}: 1.39 $cmol_c$ dm^{-3}; Al^{3+}: 0 $cmol_c$ dm^{-3} (KCl^{-1} mol L^{-1}); H + Al: 1.74 $cmol_c$ dm^{-3} and V: 75%. Based on these results, it was unnecessary to lime or fertilize with potassium (Cantarutti et al., 1999).

Nitrogen fertilization was divided into two applications that took place on October 21, 2020 and February 19, 2021, with the application of 50 kg ha^{-1} of N in the form of urea on each date, with urea diluted in 3 liters of water and sprinkled with a watering can on each plot to standardize the application. Phosphate fertilization took place on October 21, 2020 in a single application of 50 kg ha^{-1} of P_2O_5. Fertilization was carried out in the late afternoon and in topdressing.

The experimental area consisted of 16 plots (experimental units) of 12.25 m² each. The establishment of grasses in the plots was carried out in 2018, with a sowing rate of 6.0 kg ha^{-1} of seeds with a cultural value of 64%. The sowing depth was 3 cm and sowing were done with a spacing of 30 cm between rows.

The experimental treatments were four forage grasses: *Urochloa brizantha* cv. Marandu and hybrid of *Urochloa* spp. (Mulatto II, Mavuno and Ipyporã grasses). The experiment was carried out in a completely randomized design, in a split-plot design, with four replications. The grasses were the plots and the periods (prior to the stockpiling, beginning, middle and end of the stockpiling) corresponded to the subplots.

In September 2020, a uniform cut was made in all forage canopies at a height of 5 cm, with all cut material removed from the plots. Subsequently, the plants remained growing until they reached 30 cm in height. This height was maintained until March 2021 through weekly cuts, with the use of pruning shears, in order to mimic a *steady state* condition. During this period, all forage canopies were kept at 30 cm in height. The canopy height was controlled at 10 points per plot with weekly cuts, in which the parts of the plants above the target height (30 cm) were cut. For this, a graduated ruler was used. The desired height was chosen taking into account the other grasses of the genus *Urochloa*, which in a situation of continuous grazing have a height range that comprises this value, as being an adequate height for most of the grasses of this genus.

The pre-stockpiling period corresponded to the beginning of November 2020 until March 9, 2020. The stockpiling period began on March 09 and ended on June 09, 2021, totaling 92 days. The stockpiling was separated into three periods: the beginning, which corresponded to March 9 to April 9; middle period, April 10 to May 9; and end period, May 10 to June 9. During the stockpiling period, the plants remained in free growth, without being cut.

From November 2020 to June 2021, the baseline tillering dynamics were evaluated in two areas of 0.07 m^2 per experimental unit. The areas were demarcated with a 30 cm diameter PVC ring, which were fixed to the ground with metal clamps. All basal tillers within the ring were accounted for and marked. From then on, the new basal tillers were again counted and marked every 30 days with plastic-coated wire, and a different color was used for each evaluation, to identify each generation of tillers until June 2021. From these data, the rates of appearance, mortality, survival, as well as the balance between the rates of appearance and mortality and the stability index of the tiller population were calculated.

The number of tillers in the pasture was obtained by means of the tillering dynamics ring, extrapolating the tiller number values to m^2 for each cultivar. The values corresponding to the pre-stockpiling period were obtained through the average number of tillers from November 2020 to February 2021. During the stockpiling, the initial period referred to the month of March, while the intermediate period referred to the average of the months of April and May, while the end referred to the month of June.

For the statistical analysis, the SAS 9.0 program and the PROC ANOVA were used, with the value of the means estimated by the MEANS. The variables were analyzed according to the assumptions of normal distribution. Among the response variables analyzed, two (tiller appearance rate and tiller mortality rate) needed to be transformed in order to meet the assumptions of the analysis of variance, while the tiller survival rate and number of tillers variables did not meet the required assumptions and were analyzed by non-parametric statistics. The means of the treatments were compared using the Tukey test, in the parametric analysis, and Kruskal-Wallis, in the non-parametric analysis, and a probability of type I error of 5%.

Results

For all forage cultivars, the tiller survival rate (TSR) was higher in the pre-stockpiling period and in the initial stockpiling phase, decreasing during the intermediate phase and presenting the lowest values in the final stockpiling period (SP). Regardless of the cultivar, the number of tiller (NT) was equal and higher throughout the stockpiling period, when compared to the pre-stockpiling period (Table 1).

The tiller appearance rate (P = 0.0072), tiller mortality rate (P = 0.0072), tiller appearance and tiller mortality balance (P = 0.0002) and stability index (P = 0.0002) were influenced by the interaction between the factors studied.

Table 1. Tiller survival (TSR) and number of tiller (NT) in the period prior to and during the stockpiling periods (DP) of marandu, mulato II, mavuno and ipyporã grasses.

Variable	Periods			
	Pre-stockpiling	Start of SP*	Middle of SP*	End of SP*
TSR	94.4 a	96.6 a	90.0 b	85.1 c
NT	1065 c	1373 b	1481 a	1307 b

*SP: Stockpiling period; for each variable, means followed by the same letter did not differ from each other according to the Tukey test (P > 0.05).

The tiller appearance rate (TAR) showed a similar response pattern between marandu and mulatto II grasses, which had higher values in the pre-stockpiling and at the beginning of the SP, compared to the end of the DP. For these grasses, the middle of the SP did not differ from the other periods evaluated. The mavuno grass showed higher TAR in the pre-stockpiling period and at the beginning of the SP, in relation to the middle of the SP. However, at the end of the SP, the TAR of mavuno grass was similar among the other periods evaluated. The TAR of ipyporã grass was higher in the pre-stockpiling, intermediate at the beginning of the SP and lower at the end of the SP, with the middle of the SP not differing from the initial and final periods. Only in the pre-stockpiling period the TAR higher in the canopy of ipyporã grass was superior than mavuno and marandu grasses, and mulatto grass II presented values similar to the other grasses. Throughout the SP, the TAR did not vary among the grasses (Table 2).

Table 2. Characteristics of tillering dynamics before and during the stockpiling period of marandu, mulato II, mavuno and ipyporã grasses.

Period	Grass			
	Mavuno	Ipyporã	Marandu	Mulato II
	Tiller appearance rate (% at 30 days)			
Pre-stockpiling	12.3 Ab	25.3 Aa	12.0 Ab	12.6 Aab
Start of SP*	8.7 ABa	9.7 Ba	11.7 Aa	13.5 Aa
Middle of SP*	2.9 Ba	2.8 BCa	5.4 ABa	4.2 ABa
End of SP*	4.6 ABa	2.1 Ca	2.0 Ba	4.0 Ba
	Tiller mortality rate (% at 30 days)			
Pre-stockpiling	3.7 Ba	4.4 Ba	7.0 ABa	7.2 ABa
Start of SP*	3.6 Ba	4.1 Ba	2.1 Ba	3.7 Ba
Middle of SP*	15.1 Aa	6.1 Bb	11.9 Aab	7.0 ABab
End of SP*	19.1 Aa	15.2 Aa	14.3 Aa	11.1 Aa
	Balance between tiller appearance and mortality (% at 30 days)			
Pre-stockpiling	8.5 Ab	20.9 Aa	5.0 Bb	5.4 Bb
Start of SP*	5.1 Aa	5.5 Ba	9.5 Aa	9.8 Aa
Middle of SP*	-12.2 Ba	-3.2 BCa	-6.5 BCa	-2.8 BCa
End of SP*	-14.5 Ba	-13.1 Ca	-12.3 Ca	-7.0 Ca
	Stability index of tiller			
Pre-stockpiling	1.08 Ab	1.20 Aa	1.04 Bb	1.04 Bb
Start of SP*	1.05 Aa	1.05 Ba	1.09 Aa	1.09 Aa
Middle of SP*	0.87 Ba	0.96 BCa	0.92 Ca	0.96 BCa
End of SP*	0.84 Ba	0.86 Ca	0.87 Ca	0.92 Ca

*SP: Stockpiling period; means followed by the same letter, uppercase in the column and lowercase in the row, did not differ according to Tukey's test (P > 0.05).

The tiller mortality rate (TMR) of mavuno grass was higher in the middle and end of the SP, compared to the pre and initial stockpiling period. The ipyporã grass showed higher TMR at the end of stockpiling, in relation to the other periods. Marandu grass showed higher TMR in the intermediate and final periods, in relation to the beginning of the SP, with the pre- stockpiling period not differing from the other periods. The TMR of mulatto grass II was higher at the end than at the beginning of the SP, with similar values in the pre-stockpiling and middle period of the SP. Among the four grasses studied, TMR did not vary in the pre-stockpiling, beginning and end of SP. However, when analyzing the SP middle, the mavuno grass was superior to the ipyporã grass, with the mulatto II and marandu grasses presenting TMR values similar to the other grasses (Table 2).

The balance between tiller appearance and tiller mortality rates (BAL) of mavuno grass was higher in the pre and initial SP, compared to the middle and end of the SP. The ipyporã grass showed higher BAL in the pre-stockpiling, intermediate at the beginning of the SP and lower at the end of the SP, with the BAL in the middle of the SP not differing from the beginning and end of the SP. The BAL of marandu grass was higher at the beginning, intermediate at the pre-stockpiling, and lower at the end of the SP. In the middle of the SP, the BAL of marandu grass was similar to the pre-stockpiling and end of the SP. Only in the pre-stockpiling period did the ipyporã grass show higher BAL, compared to the other forage grasses (Table 2).

The stability index of the tiller population (SI) of mavuno grass was higher in the pre-stockpiling and at the beginning of the SP than in the other periods. The ipyporã grass showed higher SI in the pre-stockpiling, intermediate value at the beginning of the SP and lower value at the end of the SP, so that in the middle of the SP there were values similar to the beginning and end of the SP. The SI of marandu grass was higher at the beginning of the SP, intermediate in the pre-stockpiling period and lower in the middle and end of the SP. The SI of mulatto grass II had a response pattern similar to that of marandu grass, with the exception of the middle of the SP, in which the SI did not differ from the pre and end of SP. Only in the pre-stockpiling period was the SI higher for the ipyporã grass. In the other periods, there was no difference in SI between cultivars (Table 2).

According to the monthly variation of tiller generations (Figure 3), it was found that the ipyporã grass registered the lowest number of tillers in the first evaluation. However, in the subsequent months and until the beginning of the SP, the other generations had great importance in the composition of the ipyporã grass canopy, which is why there was an increase in the total tiller population (sum of all generations) of ipyporã grass during the period prior to the stockpiling. On the other hand, the other grasses showed a relatively stable tiller population from November to February. From February to March, there was an increase in the number of tillers in all grasses. From the beginning of the SP, there was a similar response pattern among the grasses, which increased the number of tillers at the beginning of the SD, but these gradually decreased until the end of the SP (Figure 3).

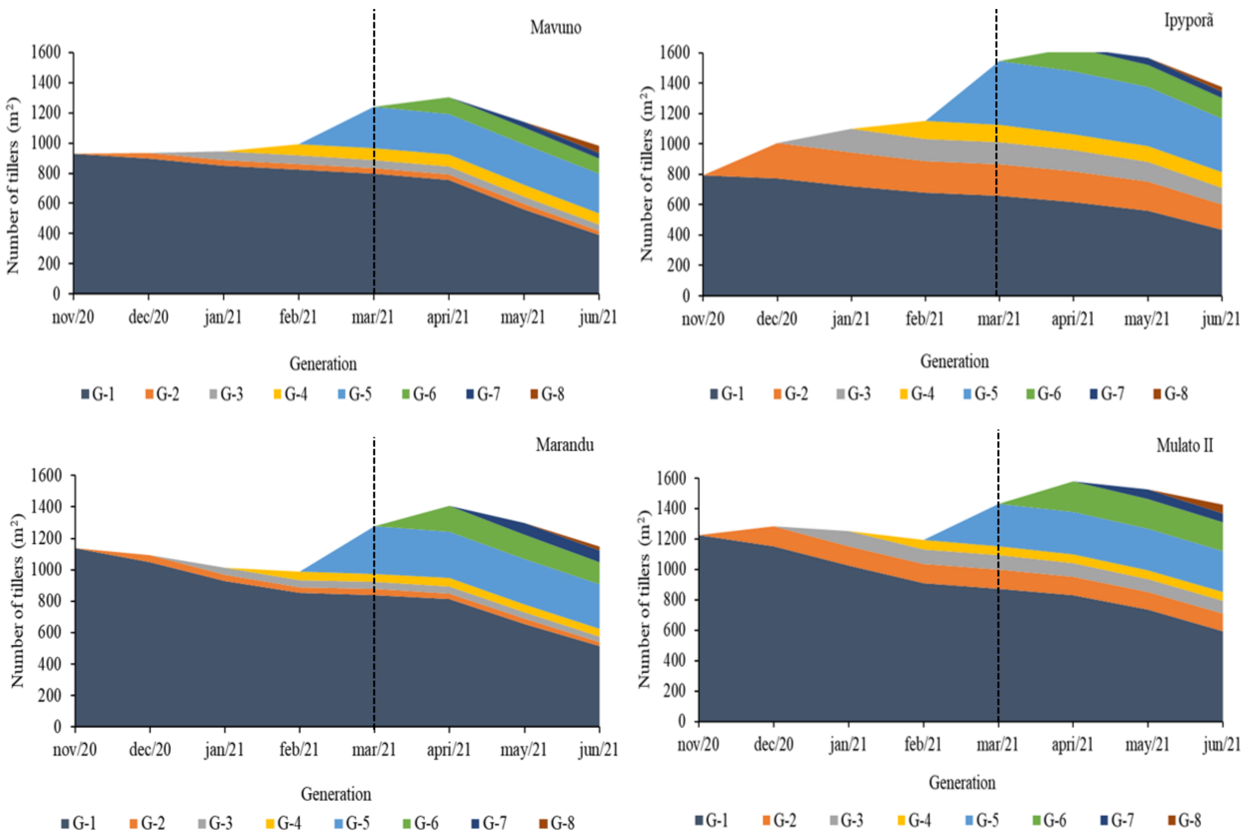

Figure 3. Demographic pattern of tillering in mavuno, ipyporã, marandu and mulatto II grass canopies before and during the stockpiling period. The dashed line in the vertical direction delimits the pre-and stockpiling periods.

Discussion

The tiller number is an important descriptive characteristic of pasture structure, being influenced by forage plant genetics, pasture management, and climatic conditions (Macedo et al., 2021). In this sense, during the pre-stockpiling period (SP), which corresponded to the interval from November 2020 to March 2021, a high number of tillers was expected in the forage canopies, due to favorable climatic conditions (high temperature and rainfall) for tillering (Figure 1) and (Figure 2). On the other hand, during SP, a lower tiller number was expected, due to the more restrictive autumn weather (Figure 1) and (Figure 2), as well as the greater competition for light between tillers in the stockpiled and taller canopies (Baldissera et al., 2016). However, the number of tillers in the pre-stockpiling period was on average 23% lower when compared to the SP.

It is possible that the uniformity cut and the application of the first portion of nitrogen fertilizer, in October, increased the number of tillers until November. As a result, when the evaluation of tillering dynamics began in November, this increase in the number of tillers had already occurred. Thus, from November onwards, the tiller population remained relatively stable, except for ipyporã grass, which showed a significant increase in the number of tillers until February (Figure 3). Possibly, the lower number of tillers in the ipyporã grass canopy during the beginning of the evaluation of tillering dynamics resulted in a higher incidence of light at the base of the canopy, favoring tillering. In fact, Santos et al. (2018), evaluating the effect of three strategies for lowering marandu grass prior to stockpiling, found higher TAR levels in pastures that had higher height and that were abruptly lowered before stockpiling; and attributed this increase to the greater incidence of light at the base of the canopy.

In the second half of February, the application of the second portion of nitrogen fertilizer (50 kg ha^{-1} N) before the beginning of the SP intensified the tillering, markedly increasing the number of tillers, which therefore remained high during the SP, compared to the pre-stockpiling period (Table 1). Nitrogen fertilization increases the rate of leaf appearance and, in effect, the formation of axillary buds, which can potentially give rise to new tillers (Cabral et al., 2021). This effect of nitrogen fertilization may have been favored by the adequate amount of rainfall in February (Figure 1).

It is worth noting that, from November to February (pre-deferral), the marandu, mavuno and mulatto II grasses kept their number of tillers relatively stable (Figure 3), which can be seen by their low BAL values in this period (6%, on average). This indicates stability of the tiller population (Table 2) in these forage canopies, which may have been favored by the maintenance of plants with a constant height of 30 cm in this period.

However, the ipyporã grass had a different response pattern, with a significant increase in the number of tillers during the pre-stockpiling period (Figure 3), as evidenced by its high values of TAR, BAL and SI (Table 2). It is possible that the ipyporã grass had a more pronounced reduction in its tiller number during the previous winter, which explains why the number of base tillers, marked at the beginning of the tillering dynamics evaluations, was lower compared to the other grasses (Figure 3). As a result, the canopy of ipyporã grass maintained at 30 cm during the pre-stockpiling period was less dense, which increased the availability of light on the basal buds, stimulating tillering (Pilon et al., 2020) (Table 2).

The intense cutting of plant uniformity carried out in October eliminated practically all basal tillers and stimulated the appearance of new tillers. Because they were young, they remained alive throughout the pre-stockpiling period and also at the beginning of the SP, which is why TSR values were higher in these periods (Table 1). On the other hand, in the middle and especially at the end of the SP, TSR decreased (Table 1), possibly due to the fact that the forage canopies presented a higher percentage of old tiller in limiting climatic conditions, notably the low temperature (Figure 1) and the scarcity of water in the soil (Figure 2).

The stability index (SI) analyzes the stability of a plant population and its ability to persist in the face of management or climatic conditions. SI equal to 1.0 means that the tiller population is in equilibrium; values higher than 1.0 indicate an upward trend in the tiller population; and values below 1.0 indicate that stability is compromised, tending to a reduction in the tiller population (Pilon et al., 2020; Pour-Aboughadareh et al., 2022).

In this sense, in the pre-stockpiling period and at the beginning of the SP, the SI was higher and close to 1.0, indicating stability of the tiller population in the forage canopies (Table 2). This result is due to the favorable climatic conditions during these periods (Figure 1) and (Figure 2). In addition, nitrogen fertilization performed before each of these periods promoted nitrogen input to the soil, which also stimulates tillering and, thus, contributes to the stability of the tiller population (Machado et al., 2017). Throughout the middle and end of the SP the climatic conditions became more unfavorable, which resulted in lower SI (Table 2), indicating momentary imbalance of the tiller population.

The TAR was higher in the pre-stockpiling period and at the beginning of the SP, but decreased over the course of the SP. In the Southeast region of Brazil, from October onwards, the climatic conditions are once again favorable for the growth and development of tillers (Da Silva et al., 2015). On the other hand, in autumn (middle and end of the SP) the climate becomes more restrictive to plants. In addition, with stockpiling, the height of the plants increases, resulting in high shade inside the canopy, which reduces the TAR. Santos et al. (2018), working with three pasture lowering strategies prior to SP, also found a similar response pattern.

Throughout the SP, the height of the pasture increases, which in turn stimulates many tillers to move from the category of vegetative to reproductive tillers. These, in turn, tend to die, according to the natural phenological cycle of the tiller, especially under more limiting climatic conditions, such as those prevailing at the end of SP (Nave et al., 2014). In this situation, the TMR increases during the SP, even with the plant's efforts to increase TSR, through adaptive mechanisms during periods with limiting resources (Da Silva et al., 2015). In this context, all grasses showed high TMR at the end of SP (Table 1). However, the marandu and mulatto II grasses also showed high TMR in the pre-stockpiling period. Probably, the higher number of tillers in these last forage canopies, compared to the mavuno grass (Figure 3), may have promoted self-shading inside the canopy, intensifying TMR.

Conclusion

The number of tillers of ipyporã grass showed reestablishment of tillers later, indicating lower regrowth vigor in the pre-stockpiling period, when compared to marandu, mulatto II and mavuno grasses.

The stability index of the tiller population remained relatively stable in the canopy of Ipyporã, Marandu, Mulatto II and Mavuno grasses, indicating that all grasses are suitable to be used under stockpiling.

Data availability

The data in this article are part of a doctoral thesis entitled "Dynamics of tillering, growth and senescence of grass Marandu, Mulato II, Mavuno and Ipyporã under deferral," which is available at https://repositorio.ufu.br/handle/123456789/38927.

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