Forage production is not changed in dwarf elephantgrass swards managed in a wide range of pre-grazing canopy heights

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Abstract. Height corresponding to the critical leaf area index (LAI) has been successfully used to define pre-grazing management targets in pastures subjected to intermittent stocking. However, studies on short/stoloniferous grasses have demonstrated that it is possible to manage pastures at heights below those corresponding to the critical LAI (with a threshold grazing height of approximately 65% of those corresponding to the critical LAI) and achieve a similar forage yield, provided that the severity of defoliation does not exceed 50 percent of the pre-grazing height. In this study, we hypothesized that in tall tussock grasses (such as elephant grass), the amplitude of grazing height required to maintain the same forage yield is lower than that generally observed in small/stoloniferous grasses. Pennisetum purpureum Schum. BRS Kurumi's elephant grass pastures were grazed at three different heights (50, 65, and 80 cm), leaving residual heights of 25, 32, and 40 cm. Our preliminary results suggest that under moderate defoliation and no nutrient limitations, tall tussock-forming grasses exhibit forage accumulation flexibility in the same range of management heights as grasses of smaller size and growth habits. In the present study, elephant grass cv. Kurumi these heights corresponded to a pre-grazing height range of 50 to 80 cm.

Introduction

The height corresponding to the critical LAI has been successfully used to define pre-grazing management targets in pastures subjected to intermittent stocking. More recent research has demonstrated that if the defoliation height does not exceed 50% of the pre-grazing height, it is possible to manage pastures at heights lower than those corresponding to the critical LAI and achieve similar forage accumulation (Sbrissia et al., 2018; Mocelin et al., 2022). These results suggest that pasture management height objectives can be flexible, without compromising pasture production or persistence. This flexibility is possible because of the existence of a compensatory mechanism between tiller population density and size (Matthew et al., 1995), which occurs regardless of the stocking method used (Bircham and Hodgson, 1983; Sbrissia et al., 2018). The lower threshold of this range of heights, where flexibility in forage accumulation is possible, appears to oscillate around 65% of the height corresponding to the critical LAI in short grasses. It is possible that this adaptability is lower in tall-tufted grasses because plants lack the phenotypic plasticity needed to accommodate a wide range of management height targets. The purpose of this study was to test the hypothesis that the amplitude of flexibility for forage accumulation in elephant grass pastures managed under moderate defoliation conditions without nitrogen nutrition restrictions is less than that typically observed in short/stoloniferous grasses.

Material and Methods

The experiment was conducted at Santa Catarina State University in Brazil (27°47' S, 50°18' W) on pastures with elephant grass. The Köppen classification for the area's climate is Cfb, with well-distributed rainfall throughout the year, mild summers, and cool winters. Frequent frost during the cool season (autumn and winter) prevents elephant grass from growing until mid-spring. The experimental period was from September 1, 2021, to May 5, 2022, and the soil of the experimental area was classified as a Typical Humic Aluminum Cambisol (EMBRAPA, 2006). Soil acidity correction (2.1 T of lime ha^{-1}) was performed based on chemical characterization of the 0 - 20 cm soil profile before starting the experimental period. Nitrogen fertilization was divided into three urea applications between mid-spring and summer, totaling 400 kg N ha^{-1}year.

Treatments

The treatments corresponded to three pre-grazing canopy heights of 50, 65, and 80 cm, associated with a defoliation severity of 50%, generating post-grazing residual heights of 25, 32, and 40 cm, respectively. The treatments were allocated to nine experimental units of 145 m2 according to a randomized complete block (DBC) experimental design. The pre-grazing target heights were determined considering the existence of flexibility in the forage accumulation observed in small grasses with caespitose/stoloniferous growth habit (Sbrissia et al., 2018, Gomes, 2019). The amplitude of this flexibility is in the range of 65% of the canopy height, in which the intercept of the incident radiation corresponds to 95% (critical LAI). The experimental units were grazed by the Holstein heifers using an intermittent stocking method. Before the start of the experiment, all the experimental units were mowed to a uniform height of 10 cm. Pasture heights were monitored using a ruler at 30 points per experimental unit in a zigzag pattern every seven days during the regrowth period and every eight hours during the grazing period.

Forage accumulation and canopy structure

Forage accumulation was quantified throughout the experimental period. Five representative points per paddock were sampled (visual evaluation of herbage mass and height) using a 100 × 100 cm metal frame. Samples were collected when canopies reached the targeted pre-cutting height (50, 65 or 80 cm) and the cuts were performed at the targeted post-cutting height. Subsequently, they were dried in a forced draft oven at 60°C until constant weight. Data were used to calculate the average herbage accumulation per cycle (kg DM ha^{-1}), and total forage yield (kg DM ha^{-1}) throughout the experiment. Tiller population density ($tiller^{-1}$ m^2), herbage mass (kg DM ha^{-1}), and leaf area index were quantified once in Spring and Summer at the pre-grazing condition. Five representative points were sampled per paddock (visual evaluation of herbage mass and height) using a 100 × 100 cm metal frame and cutting all the herbage inside (cutting at ground level). Herbage samples were taken to the laboratory where the population density of total, aerial and basal tillers were determined. Subsequently, samples were homogenized, and a subsample separated to determine proportion of leaves, stem, dead material, and canopy leaf area index. The remaining part of the samples were dried in a forced draught oven at 60°C until constant weight. The results were used to calculate the canopy herbage mass (kg DM ha^{-1}). Leaf area was determined by scanning leaf blades from the subsample in a leaf area integrator model LI-3100 (Li-Cor, Lincoln, Nebraska, USA). Subsequently, scanned leaves were dried in a forced draught oven at 60°C until constant weight and date used to calculate the leaf area index (m^2 m^{-2}).

Statistical analysis

The cycles were considered repeated measures and subjected to analysis of variance using the mixed model procedure of the SAS® statistical package (Statistical Analysis System), version 9.0. The Akaike Information Criterion (AIC) was used to select the covariance matrix that best fitted the datasets. The estimation of means was performed using LSMEANS, and comparisons between them were performed using Tukey's test at 5% significance.

Results and Discussion

Forage accumulation did not differ among treatments, and the greatest forage accumulation was observed in summer (P<0001; Table 1). A lower leaf area index (LAI) was observed in canopies managed at 50 cm (Table 2). When compared to pastures managed at heights of 65 and 80 cm, the pastures managed at the lowest height (50 cm in pre-grazing) had more grazing cycles with shorter rest intervals (on average 29 days) than those managed at 45 and 50 days of 65 and 80 cm pastures, respectively.

Table 1. Seasonal and total forage accumulation (kg of DM ha^{-1}) in elephant grass canopies subjected to three grazing heights.

	Grazing height (cm)			
Season of the year	50	65	80	Mean (EPM)
Spring	3060	2485	2825	2788 ± 213 ^{C}
Summer	6185	7480	6940	6868 ± 213 ^{A}
Autumn	2170	3495	5250	3638 ± 232 ^{B}
Total	11700 ± 830 ^{a}	13200 ± 945 ^{a}	12600 ± 945 ^{a}	

Means followed by the same uppercase letter in columns and lowercase letters in rows are not significantly different (P ≥ 0.05).

The tiller population density (TPD) was similar between treatments (P = 0.17), with approximately 122 tillers.m^{-2} (on average, 60% basal tillers and 40% aerial tillers, regardless of management height).

Table 2. **Tiller population density (tillers.m^{-2}), morphological composition (%) and LAI in elephant grass canopies subjected to three grazing heights.**

	Grazing height (cm)			
Variable	50	65	80	Média
Tiller Population Density	129 ± 8 ^{a}	129 ± 10 ^{a}	108 ± 10 ^{a}	122 ± 10
LAI	3,4 ^{b}	4,7 ^{a}	4,2 ^{a}	4,1
Leaf proportion (%)	63 ^{a}	64 ^{a}	60 ^{a}	62
Stem proportion (%)	37 ^{a}	36 ^{a}	40 ^{a}	38

Means followed by the same lowercase letters in rows are not significantly different (P ≥ 0.05).

According to Bircham and Hodgson (1983), similar forage accumulation over a range of grazing heights could be the result of compensatory effects between TPD (community) and tissue flow in individual tillers. This could ensure a certain “homeostasis” during the forage accumulation process, as TPD and tissue flow are inversely affected by tiller weight (Matthew et al., 1995). This mechanism has been identified as the main force driving similar forage accumulation in different grass species (Da Silva et al., 2015; Sbrissia et al., 2018). However, the maintenance of the same forage accumulation over a wide range of management heights (50–80 cm) in the elephant grass cv. Kurumi did not result from this classic and inverse relationship between tiller size and population density since TPD was the same among treatments (Table 2). Therefore, it is reasonable to hypothesize that the balance between leaf growth and senescence is similar between treatments (this was already proposed by Mocelin et al., 2022 for tangolagrass pastures) but deserves further investigation. It is important to highlight that the similarity in forage production occurred despite significant variations in the LAI. A pre-grazing height of 50 cm resulted in lower LAI values than those managed at 65 and 80 cm. Under this scenario, maintaining the flexibility of forage accumulation in pastures with variations in LAI might be possible through differences in LAI quality (higher photosynthetic efficiency in shorter pastures). This possibility was demonstrated by Parsons et al. (1983) in continuous stocking and Parsons et al. (1988) in intermittent stocking method and can be another reason to explain the maintenance of forage accumulation in a wide range of pre-grazing canopy heights in elephant grass swards.

Conclusion

Our preliminary results suggest that under moderate defoliation and no nutrient limitations, tall tussock-forming grasses exhibit forage accumulation flexibility in the same range of management heights as grasses of smaller size and growth habit. In the case of the model plant used in this study (elephant grass cv. Kurumi), these heights corresponded to a pre-grazing height range of 50 to 80 cm.

Acknowledgments

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