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Research Paper

Animal performance and sward characteristics of Mombaça guineagrass pastures subjected to two grazing frequencies

Desempeño animal y características de pasturas del pasto guinea cv. *Mombaça sometidas a dos frecuencias de pastoreo*

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Abstract

The aim of this work was to compare grazing management practices of Mombaça guineagrass (*Megathyrsus maximus* syn. *Panicum maximum* cv. Mombaça) based on the sward incident light interception (LI) concept. We tested, when the regrowth period in rotationally stocked Mombaça guineagrass ended, if LI (90 or 95%) affected forage accumulation, sward characteristics and animal performance. Both treatments had a common post-grazing canopy height of 50 cm and were replicated 4 times in a randomized complete block design. Pastures were sampled pre- and post-grazing to determine forage mass, morphological composition and forage accumulation rate (FAR). Nutritive value (NV) was estimated in pre-grazing samples. Stocking rate was adjusted twice a week, and animals were weighed every 28 days. Pre-grazing conditions of 90 and 95% LI were reached at pasture heights of approximately 80 and 90 cm, respectively. FAR, sward structure and NV were similar for pastures grazed at 90 and 95% LI. Consequently, stocking rate, average daily gain and liveweight gain/ha were similar for both LI treatments. Data suggest that Mombaça guineagrass can be grazed at pre-grazing heights of 80–90 cm (90–95% LI) without compromising pasture structure and animal performance provided moderate defoliation severity is employed. Further testing of this grazing strategy over longer periods should be carried out with this species as well as other tropical grasses.

Keywords: Canopy structure, forage accumulation, light interception, *Megathyrsus maximus*, nutritive value, stocking rate, tropical forages.

Resumen

El objetivo de este trabajo fue comparar prácticas de manejo de pastoreo de Mombaça (*Megathyrsus maximus* sin. *Panicum maximum* cv. Mombaça) con base en el concepto de intercepción de luz incidente (IL). Al finalizar el período de rebrote de Mombaça manejado de forma rotacional, se evaluó si la IL (90 o 95%) afectaba la acumulación de forraje, la estructura de la pastura y el rendimiento de los animales. En ambos tratamientos la altura del pasto después del pastoreo fue igual (50 cm). Se usó un diseño de bloques completos al azar con 4 repeticiones. Para las mediciones del pasto se tomaron muestras antes y después del pastoreo para determinar la masa forrajera, la composición morfológica y la tasa de acumulación de forraje. El valor nutritivo se determinó antes del comienzo del pastoreo. La carga animal se ajustó 2 veces por semana, y los animales fueron pesados cada 28 días. Las condiciones previas al pastoreo de 90 y 95% de IL se alcanzaron cuando el pasto llegó a una altura aproximada de 80 y 90 cm, respectivamente. La tasa de acumulación de forraje, la estructura de la pastura y el valor nutritivo fueron similares para pasturas con 90 y 95% IL. Por tanto, la carga animal, la ganancia diaria promedio y la ganancia de peso vivo/ha fueron similares para ambos tratamientos. Los datos sugieren que el pasto guinea cv. Mombaça se puede pastorear cuando alcanza una altura de 80–90 cm (90–95% IL), sin comprometer su estructura y el

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rendimiento animal, siempre y cuando la defoliación sea moderada. Se deben realizar pruebas con esta estrategia de pastoreo durante períodos prolongados con esta especie, así como con otros pastos tropicales.

Palabras clave: Acumulación de forraje, carga animal, estructura de la pastura, intercepción de luz, *Megathyrsus maximus* cv. Mombaça, pasturas tropicales, valor nutritivo.

Introduction

Some studies with tropical grasses under intermittent stocking have shown that the point at which the canopy intercepts 95% of photosynthetically active radiation (PAR) approximates an ideal time period to interrupt regrowth. After this point, forage accumulation and nutritive value decrease (Carnevalli et al. 2006; Barbosa et al. 2007; Zanini et al. 2012) as proportions of stem and dead material in pre-grazing forage mass increase (Silva et al. 2009).

However, insistence that an interruption of the rest period must occur precisely when the canopy intercepts 95% of the PAR can be restrictive and impractical for producers. Flexibility of management greatly facilitates the planning of livestock systems because it is common for more than one paddock to reach the ideal grazing condition at the same time during periods of vigorous forage growth (Zanine et al. 2011). On the other hand, when weather conditions are unfavorable for plant growth, the time required to achieve the target of 95% LI can be very long (Carnevalli et al. 2006; Barbosa et al. 2007; Giacomini et al. 2009), hindering the rotation of animals in paddocks available.

Using mathematical models, Parsons et al. (1988) demonstrated that, regardless of variation in management, there was a range in level of interception of PAR by the canopy in which forage production remained relatively stable. In this context, Barbosa et al. (2007) and Zanine et al. (2011) found no difference in the accumulation of leaf blades of guineagrass (*Megathyrsus maximus*) cv. Tanzania when the canopy LI was 90 or 95%. This suggests there could be some flexibility in the definition of pre-grazing targets, i.e. instead of a specific point there could be a range of possible values.

The end point of grazing events is also important. Maximization of short-term forage intake rate was achieved when the reduction in pasture height during grazing did not exceed 40% of the initial height (Fonseca et al. 2012; Mezzalira et al. 2014). This indicates that, regardless of the pre-grazing goals, an important condition for the maintenance of high livestock production is the use of relatively lenient defoliation levels.

Against this background, we aimed to evaluate forage accumulation and nutritive value, canopy characteristics and animal production in Mombaça guineagrass (*Megathyrsus maximus* syn. *Panicum maximum* cv. Mombaça) pastures subjected to 2 grazing frequencies, defined by 90 and 95% LI by the canopy, in conjunction with a common post-grazing canopy height of 50 cm.

Materials and Methods

The experiment was conducted during a single growing season from September 2012 to May 2013 at the National Beef Cattle Research Center in Campo Grande, MS, Brazil (20º25' S, 54º51' W; 530 masl). The climate, according to the Köppen classification, is rainy tropical savanna, corresponding to the Aw subtype, characterized by a seasonal distribution of rainfall with a well-defined dry period during the colder months. Average annual rainfall is about 1,500 mm, of which 80% falls during the 7-month wet period (October–April). The historical average minimum and maximum temperatures (1993–2013) in the coldest month were 15.3 and 27.3 °C, respectively, and during the summer 18.2 and 31.2 °C. Weather data during the experimental period were collected from a meteorological station located 2 km from the research site (Figure 1).

Average temperature and monthly precipitation were used to calculate the water balance (Figure 2). The soil water storage capacity was determined to be 75 mm.

Average chemical characteristics of the soil at the experimental site, a clay soil classified as red dystrophic latosol (Oxisol), were for the 0–10 cm layer: pH $CaCl_2$ = 5.8; OM = 43.4 g/dm^3; P (Mehlich 1) = 7.0 mg/dm^3; Ca = 4.8 cmol/dm^3; K = 0.5 cmol/dm^3; Mg = 1.5 cmol/dm^3; Al = 0.0 cmol/dm^3; sum of bases = 6.7 cmol/dm^3; cation exchange capacity = 9.9 cmol/dm^3; and base saturation = 68.7%.

Based on these analyses, commencing in October 2012 well-established pastures (planted in 2009) were fertilized with 39 kg P, 75 kg K and 200 kg N/ha, divided equally among 4 application times, namely: October, December, January and February. Nitrogen was applied as ammonium sulfate in October and the remaining applications were as urea.

The experimental area was 12.0 ha, divided into 8 pastures measuring 1.5 ha, and these pastures were subdivided into 6 paddocks of 0.25 ha each. A 6.0 ha reserve pasture was used for holding extra animals when they were not grazing experimental pastures.

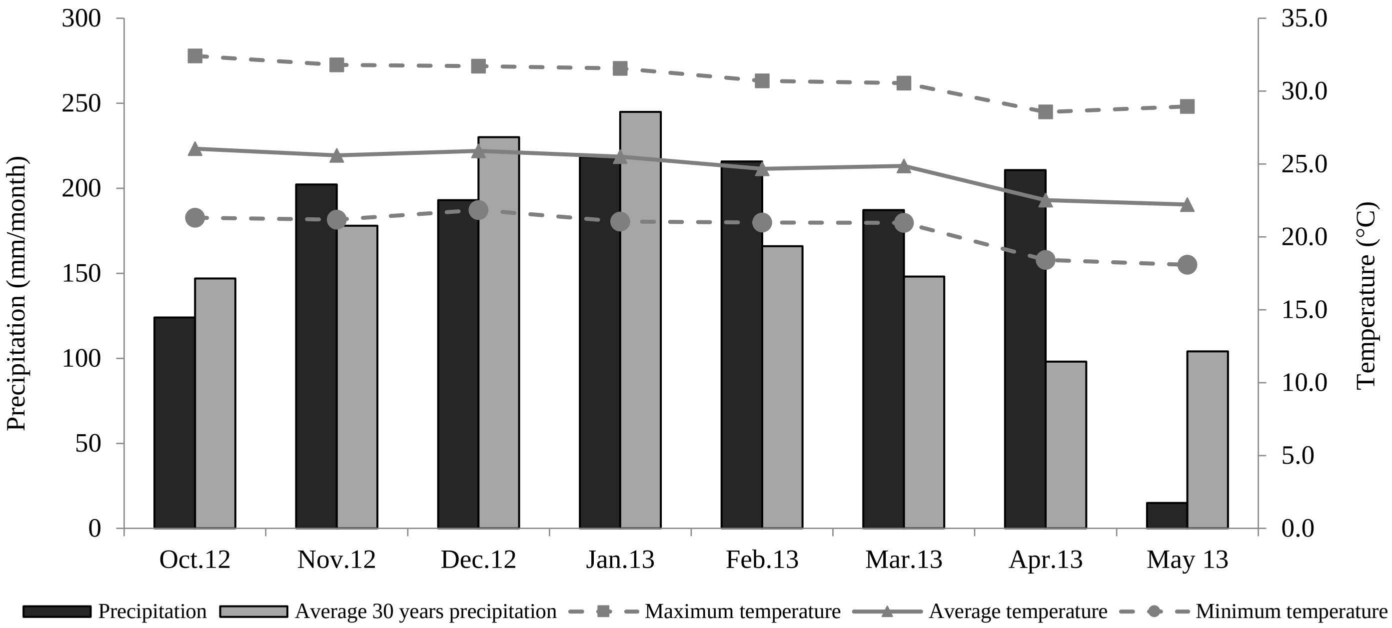

Figure 1. Monthly and historical 30-year rainfall plus maximum, average and minimum temperatures during the experimental period.

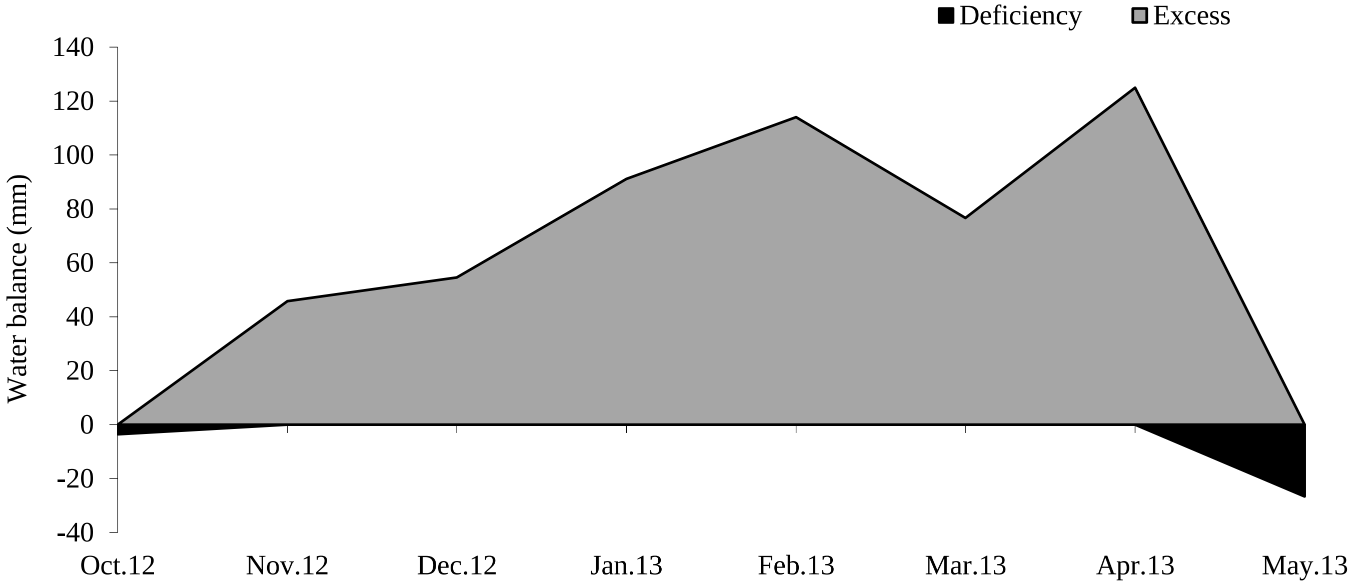

Figure 2. Water balance, i.e. deficit and surplus, in the soil during the experimental period.

The experimental design was a randomized complete block with 2 treatments and 4 replications. The grazing method used was rotational stocking with a variable stocking rate. The treatments comprised 2 grazing frequencies, characterized by pre-grazing conditions in which the canopy intercepted 90 and 95% of PAR at interruption of pasture growth, i.e. introduction of grazing animals. Stock were removed from each paddock of both treatments when grazing height had been reduced to 50 cm. When each pasture reached the predetermined level of light interception it was grazed by 6 Senepol × Caracu (50:50) tester steers (approximately 11 months of age and with an average weight of 224 ± 16 kg initially). The testers were assigned randomly to experimental units at the beginning of the experimental period; the differences in allocation weights across treatments were not significant at the beginning of the growing season. The tester animals grazed the same pasture (1.5 ha divided into 6 paddocks) for the entire experimental period. Fifty-two regulator steers, similar to the tester steers in weight, age, background and breeding, were kept in the reserve pasture and used whenever the stocking rate needed to be increased.

The animals were treated with a broad-spectrum anthelmintic at the beginning of the experiment and with pour-on ectocide during the experiment as needed for the control of ticks and horn flies. Animal health management was performed as recommended by the National Beef Cattle Research Center. All animals received water and a mineral mixture ad libitum.

Sward LI was monitored in 2 paddocks of each pasture, using a canopy analyzer apparatus (AccuPAR Linear PAR/LAI ceptometer, Model PAR-80; DECAGON Devices) at 20 random points per paddock, with one reading being taken above the canopy and one at ground level at each point. The measurements were performed weekly. When LI reached 85%, LI was monitored daily until the target was reached. Concurrently with the LI measurements, canopy height was monitored, using a 1 m ruler graduated in centimeters, at 40 random points per paddock. The readings of sward non-extended leaf height were taken from ground level to the ‘leaf horizon’ on the top of the sward as a reference, even during periods when plants were reproductive and produced taller flowering stems. Average heights corresponding to 90 and 95% LI were used as target heights for the other 4 paddocks from each pasture. Post-grazing heights were measured as soon as the animals left each paddock, as described above.

Forage mass, morphological composition and total forage and leaf accumulation rates were measured in a single paddock per pasture for each grazing cycle. Pre- and post-grazing forage mass were estimated by cutting 9 randomly selected samples (1 m^2 each) at ground level in each paddock using a manual mower. The samples were divided into 2 subsamples: 1 subsample was weighed and oven-dried at 65 °C until constant weight, and the other subsample was separated into green blades (leaf blades), green stems (stem and sheath) and dead material, and these fractions were dried at 55 °C until constant weight.

Forage accumulation rate was calculated as the difference between the current pre-grazing and the previous post-grazing forage mass, considering only the green portion (leaves and stems), divided by the number of days between samplings. For leaf accumulation rate, we used the same procedure, considering only the leaf portion in the samples. The total herbage accumulated from the entire experimental period, i.e. grazing season, was the sum of forage accumulation values across all grazing cycles.

In a second paddock of each pasture, 3 stratified samples were collected. A 1 m^2 frame was placed in areas that were representative of the average sward condition (based on visual assessment of height and herbage mass). At each location, the canopy was sampled using scissors in 4 vertical strata: >80, 60–80, 40–60 and 0–40 cm, commencing from top to basal layers. Samples from each stratum were weighed and handled as described above to estimate forage mass and its morphological components. Leaf samples were dried, ground and analyzed for crude protein (CP), neutral detergent fiber (NDF) and acid detergent lignin (ADL) concentrations, as well as in vitro organic matter digestibility (IVOMD), using near-infrared spectroscopy (NIRS).

Steers were weighed at 28-d intervals following a 16-hour fasting period to minimize gut-fill effects on liveweight measurements, i.e. fasted from both water and feed. The average daily gain was calculated as the increase in live weight of the testers divided by the number of days between weighings.

The stocking rate per cycle was calculated as the sum of the animal days (tester and regulator steers) spent in each of 6 paddocks (0.25 ha) divided by the total number of grazing days of a complete cycle, and divided by the pasture area (1.5 ha). It was expressed in animal units (AU = 450 kg live weight) per hectare. Liveweight gain/ha was calculated as the product of average daily gain and the number of steers/ha.

The data were grouped by season as follows: spring (15 October–20 December), summer (21 December–20 March) and autumn (21 March–16 May). The experimental unit for both vegetation and animal data was the pasture. The data were subjected to an analysis of variance using the Mixed Procedure in SAS (Statistical Analysis Systems, version 9.4). The choice of the covariance matrix was made using the Akaike Information Criterion (AIC) (Wolfinger 1993), and analysis was performed considering sward light interception levels and season of the year and their interactions as fixed effects and blocks as a random effect (Littell et al. 2000). The season effect (spring, summer and autumn) means were compared using a Tukey test at a 5% significance level. For the stratified herbage samples, the same model was applied, but the effect of the stratum was added and considered fixed. Average daily gain data were analyzed via multivariate analysis with repeated measures according to Littell et al. (2000). Furthermore, we performed analyses of the relationships between the means of pre-grazing sward height and the means of interception of incident light by the canopy for each experimental unit for the entire experimental period

Results

There were no significant (P>0.05) interactions between LI and season for all variables associated with pasture characteristics. However, pastures grazed at 95% LI had longer rest and grazing periods, greater pre-grazing sward heights, forage mass, green stem (GSP) and dead material (DMP) percentages, plus fewer grazing cycles with lower green leaf percentages (GLP) and leaf:stem ratios (LSR) than those managed at 90% LI (Table 1).

Table 1. Means, s.e.m. and significance level (P) for leaf accumulation rate, rest and grazing periods, number of grazing cycles, pre-grazing sward height, forage mass, percentages of green leaf, stem and dead material and leaf:stem ratio in *Megathyrsus maximus* cv. Mombaça pastures subjected to rotational stocking targeting either a light interception (LI) of 90 or 95% pre-grazing.

Parameter	LI[1] 90	LI 95	s.e.m.	P
Rest period (days)	27.1	30.2	0.2	0.0001
Grazing period (days)	4.2	5.5	0.1	0.0001
Grazing cycles (n)	7.0	5.6	0.2	0.0082
Sward height (cm)	82	88	1.1	0.0003
Forage mass (kg DM/ha)	6,610	7,160	111	0.0007
Green leaf (%)	69.8	64.5	0.4	0.0001
Green stem (%)	17.1	21.9	0.4	0.0001
Dead material (%)	12.3	14.0	0.3	0.0002
Leaf:stem ratio	4.2	3.0	0.09	0.0001

[1] Light interception (%).

On the other hand, LI had no significant effect on forage accumulation rates (FAR; P = 0.248) and leaf accumulation rates (P = 0.085). The means and standard errors were: 86.7 ± 4.3 kg DM/ha/d and 59.6 ± 2.2 kg DM/ha/d, respectively.

There was a positive correlation (P = 0.0001; $r^2 = 0.86$; n = 61) between sward height and LI.

With regard to seasonal effects (Table 2), lengths of rest periods followed the order summer<spring<autumn, while the reverse order (autumn<spring<summer) was observed for forage and leaf accumulation rates. Grazing periods were longer in autumn than during summer, with those in spring being intermediate. During autumn, pastures had greater stem percentages and lesser forage and leaf accumulations per cycle, leaf percentages and leaf:stem ratios than in spring and summer. However, pre-grazing forage mass (P = 0.725) and dead material percentages did not differ (P = 0.6738) between seasons.

There was no effect of LI (P>0.05) on forage dry mass in each layer and the distribution of the various morphological components in the vertical canopy profile. However, a stratum effect was observed for those variables. Forage dry mass and percentages of green stem and dead material decreased, but green leaf percentage increased from the basal to upper strata of the canopy (Table 3). Furthermore, no interactions were observed for LI by stratum (P>0.05), season by stratum (P>0.05) or LI by season by stratum (P>0.05).

Table 2. Means and significance level (P) for rest and grazing periods, forage (FAR) and leaf accumulation rates (LAR), forage (FA) and leaf accumulations (LA) per grazing cycle, pre-grazing green leaf and stem percentages and leaf:stem ratios in *Megathyrsus maximus* cv. Mombaça pastures under rotational stocking from October 2012 to May 2013.

Parameter	Season			P
	Spring	Summer	Autumn	
Rest period (days)	28.9b (0.3)	24.5c (0.2)	33.6a (0.3)	0.0001
Grazing period (days)	4.9ab (0.3)	4.5b (0.2)	5.9a (0.4)	0.0007
FAR (kg DM /ha/d)	93b (4.3)	107a (4.4)	61c (5.3)	0.0001
LAR (kg DM/ ha/d)	64b (2.9)	74a (3.0)	38c (3.6)	0.0001
FA (kg DM/ha/ grazing cycle)	2,750a (83)	2,820a (84)	2,300b (101)	0.0012
LA (kg DM/ha/ grazing cycle)	1,900a (57)	1,950a (58)	1,450b (70)	0.0001
Green leaf (%)	69.3a (0.5)	68.8a (0.4)	63.2b (0.5)	0.0001
Green stem (%)	18.2b (0.5)	18.4b (0.4)	21.9a (0.6)	0.0001
Leaf:stem ratio	4.0a (0.12)	3.9a (0.09)	3.1b (0.13)	0.0001

Means within rows followed by different letters differ significantly at P<0.05. Values in parentheses correspond to the standard error of the mean.

Table 3. Means, standard error of the mean (s.e.m.) and significance level (P) for forage dry mass (FDM) and percentages of green leaf, stem and dead material in the vertical strata of *Megathyrsus maximus* cv. Mombaça pastures under rotational stocking.

Stratum (cm)	FDM (kg/ha)	Leaf (%)	Stem (%)	Dead material (%)
0–40	4,640a	24c	35a	41a
40–60	1,530b	88b	5.5b	6.3b
60–80	660c	98a	1.5c	0.1c
>80	320d	99a	0.1c	0.4c
s.e.m.	127	1.9	1.0	1.4
P	0.0001	0.0001	0.0001	0.0001

Means within columns followed by different letters differ significantly at P<0.05.

Post-grazing residues were maintained close to the target height of 50 cm throughout. Means ± SD were: 47.1 ± 1.3 and 49.7 ± 1.5 cm for pastures grazed at 90 and 95% LI, respectively.

No differences were observed between pastures managed at 90 and 95% LI for post-grazing forage mass (mean ± s.e.m. 4,260 ± 51 kg DM/ha, P = 0.127) and percentages of green leaf (mean 27.5 ± 0.7%, P = 0.564), green stem (mean 30.4 ± 1.0%, P = 0.554) and dead material (mean 42.1 ± 1.2%, P = 0.522). However, post-grazing forage mass was greater in autumn than in spring and summer (Table 4). During spring, the pastures had lesser stem percentage and greater dead material percentage than in the other seasons (Table 4).

Table 4. Means and significance level (P) for forage dry mass and percentages of green stem and dead material in post-grazing residual of *Megathyrsus maximus* cv. Mombaça pastures under rotational stocking.

Parameter	Seasons			P
	Spring	Summer	Autumn	
Forage mass (kg DM/ha)	4,220b (52)	4,102b (53)	4,465a (77)	0.0028
Green stem (%)	27.4b (1.06)	31.0a (1.09)	32.7a (1.57)	0.0179
Dead material (%)	47.1a (1.27)	39.8b (1.30)	39.3b (1.88)	0.0006

Means within rows followed by different letters differ significantly at P<0.05. Values in parentheses correspond to the standard error of the mean.

In the pre-grazing condition, percentages of CP (P = 0.367), IVOMD (P = 0.458), NDF (P = 0.196) and ADL (P = 0.352) of the leaves were similar for pastures grazed at 90 and 95% LI. The means ± s.e.m. were 11.8 ± 0.3%, 61.2 ± 0.5%, 77.2 ± 0.4% and 3.6 ± 0.1%, respectively.

In addition, there were no differences in the percentages of CP (P = 0.194), IVOMD (P = 0.132), NDF (P = 0.626) or ADL (P = 0.321) of green stems from the 2 grazing strategies, with means ± s.e.m. of 5.3 ± 0.3%, 48.3 ± 0.6%, 81.0 ± 0.5% and 4.8 ± 0.1%, respectively. Moreover, there was no effect of season on the percentages of CP, IVDOM, NDF or ADL of either green leaves or stems.

On the other hand, when variables associated with the nutritive value of green leaf were evaluated in the vertical canopy profile, percentages of CP and IVDOM increased and concentrations of NDF and ADL decreased from the basal to the top strata (Table 5). No interactions were observed between LI and stratum, LI and season and season and stratum (P>0.05) for the variables associated with nutritional value of leaves.

There was no interaction between LI and season for stocking rate (SR; P = 0.578) or for average daily gain (ADG; P = 0.671). Moreover, there was no effect of light interception on SR, ADG or liveweight gain/ha (Table 6).

With regard to seasons, ADG was least in autumn and SR and liveweight gain/ha were greater in summer than in spring and autumn (Table 7).

Table 5. Means, standard error of the mean (s.e.m.) and significance level (P) for percentage of crude protein (CP), in vitro organic matter digestibility (IVOMD), neutral detergent fiber (NDF) and acid detergent lignin (ADL) of leaves in the pre-grazing vertical strata of *Megathyrsus maximus* cv. Mombaça pastures under rotational stocking.

Stratum (cm)	CP (%)	IVOMD (%)	NDF (%)	ADL (%)
0–40	8.8d	51.1d	78.5a	3.9a
40–60	10.2c	54.8c	77.3b	3.7b
60–80	11.9b	59.5b	75.9c	3.4c
>80	13.5a	65.1a	74.6d	3.1d
s.e.m.	0.2	0.5	0.3	0.06
P	0.0001	0.0001	0.0001	0.0001

Means within columns followed by different letter differ significantly at P<0.05.

Table 6. Means, standard error of the mean (s.e.m.) and significance level (P) for stocking rate, average daily gain and liveweight gain/ha in *Megathyrsus maximus* cv. Mombaça pastures subjected to rotational stocking targeting either a 90 or 95% LI pre-grazing.

Parameter	LI 90[2]	LI 95	s.e.m.	P
Stocking rate (AU/ha)[1]	3.60	3.87	0.15	0.1042
Average daily gain (kg/hd/d)	0.77	0.72	0.03	0.1363
Liveweight gain/ha (kg/ha)	995	986	52	0.9135

[1]AU = 450 kg live weight; [2]Light interception (%).

Table 7. Means and significance level (P) for seasonal effects on stocking rate, average daily gain and liveweight gain/ha of *Megathyrsus maximus* cv. Mombaça pastures under rotational stocking.

Parameter	Season			P
	Spring	Summer	Autumn	
Stocking rate (AU/ha)[1]	2.9b (0.13)	5.0a (0.11)	3.3b (0.14)	0.0001
Average daily gain (g/hd/d)	780a (25)	800a (23)	655b (29)	0.0006
Liveweight gain/ha (kg/ha)	223b (34)	554a (34)	213b (34)	0.0001

[1]AU = 450 kg live weight.

Means within rows followed by different letters differ significantly at P<0.05. Values in parentheses correspond to the standard error of the mean.

Discussion

Pre-grazing canopy heights for the pastures managed at light interceptions (LI) of 90 and 95% remained relatively stable during the experimental period (Table 1). There was a positive correlation ($P = 0.0001$; $r^2 = 0.86$) between LI and sward height, which highlights the potential use of canopy height as a field guide for monitoring grazing management of this cultivar. This result supports Silva and Nascimento Júnior (2007), who suggested that canopy height could be used as a reliable criterion on which to base the optimal time to interrupt pasture regrowth.

Regardless of the LI target used to define the time to re-graze pasture, forage accumulation resumed quickly after defoliation because a lenient grazing strategy was adopted (post-grazing target of 50 cm), which led to 42 and 44% decreases in the pre-grazing heights for pastures managed at 90 and 95% LI, respectively. According to Parsons et al. (1988), the rate of photosynthesis is reduced less by defoliation and the maximum rate of photosynthesis is restored sooner in more leniently defoliated swards. Total forage accumulations were similar for pastures managed at 90 or 95% LI. This was in agreement with the results of Barbosa et al. (2007) and Zanine et al. (2011), who found that leaf accumulation was similar in Tanzania guineagrass pastures managed at 90 and 95% LI, and those of Sbrissia et al. (2013), who observed similar forage accumulation values in kikuyu grass (*Cenchrus clandestinus* syn. *Pennisetum clandestinum*) pastures managed at 15 and 25 cm (25 cm corresponding with 95% LI).

However, pre-grazing green stem and dead material percentages were greater in pastures managed at 95% LI (Table 1), indicating that stem elongation may have started even before the pasture reached 95% LI. Santos et al. (2016) observed up to a 7-fold increase in stem elongation rate in annual ryegrass when the pastures exceeded a height of 17 cm, a condition in which there was still no restriction by high light interception. This supports the hypothesis that stem elongation can be initiated with a LI of the PAR lower than 95%.

In this context, Barbosa et al. (2012) observed that the forage mass of Tanzania guineagrass pasture grazed at 90% LI was composed of younger tillers than that in pastures grazed at 95 and 100% LI. These authors also observed that younger tillers had higher leaf appearance and leaf elongation rates, and consequently a greater leaf length and number of live leaves than mature and/or older tillers.

By contrast, fluctuations in weather conditions (Figures 1 and 2) and the dates of nitrogen application (1/3 in spring and 2/3 in summer) affected forage and leaf accumulation rates throughout the experiment (Table 2). This, in turn, influenced the variation in rest periods (Table 2; Figure 3) and stocking rates (Table 7; Figure 3) of the pastures, throughout the experiment. It is highlighted that weather conditions were similar to the historical 30-year average rainfall.

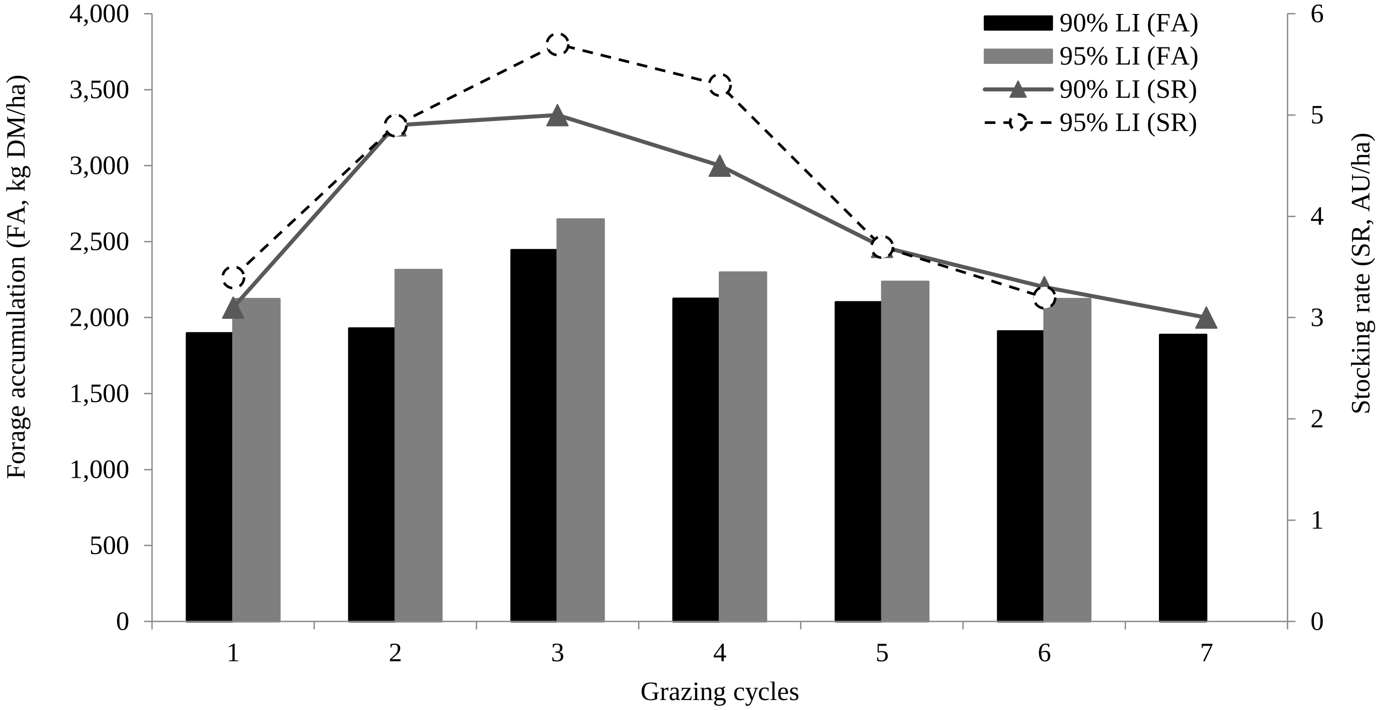

Figure 3. Forage accumulation (FA) per grazing cycle, stocking rate (SR) and rest period in *Megathyrsus maximus* cv. Mombaça pastures subjected to rotational stocking targeting either a 90 or 95% LI pre-grazing from October 2012 to May 2013.

Considering that post-grazing target height was the same for both treatments and forage accumulation rates were similar for these treatments, light interception levels determined the lengths of the resting periods (Table 1; Figure 3). Pastures grazed at 90% LI required less time to reach the pre-grazing target, resulting in an additional 1.4 grazing cycles for these pastures than for pastures managed at 95% LI (Table 1).

The changes in lengths of the grazing periods throughout the study (Tables 1 and 3) could be explained by the variation in forage accumulation rates (Table 3), stocking rate adjustments (Figure 3) to maintain the pre-grazing treatment targets and the need for animals to remain in their current paddocks until the next paddocks to be grazed reached the pre-grazing LI target.

The greater pre-grazing forage mass values for pastures managed at 95% LI (Table 1) did not result in a higher stocking rate in these pastures (Table 6). This can be explained by the need to use fewer animals because the grazing period was longer (Table 1) as a longer resting period was required for these pastures to reach 95% LI (Figure 3).

Despite the greater green stem and dead material percentages in pastures managed at 95% LI, when considering vertical distribution in the canopy profile, we found that about 95% of the green stems and dead material were located in the 0–40 cm stratum (Table 3). This stratum is below the post-grazing target (approximately 50 cm), so theoretically the animals did not have to explore this stratum. This finding supports the results of Zanini et al. (2012), wherein approximately 90% of all stem mass is located in the lower half of the canopy, regardless of the grass species or the targeted pre-grazing height.

Considering only the theoretical grazing horizon (that part of the canopy above 40 cm), green leaf and green stem percentages were 92.3 and 3.9%, respectively (Table 4), resulting in a leaf:stem ratio of 24:1. This indicates that, regardless of the pre-grazing LI target, the canopy structure above 40 cm did not limit the selection and prehension of leaves, and consequently, forage intake by the animals.

Even with the strict control of pre- and post-grazing targets, the morphological composition of the forage varied between seasons. The decrease in leaf percentage and increase in stem percentage during the autumn (Table 2) can be partly explained by the onset of flowering of the Mombaça guineagrass in mid-April. In this period, 6.5% of the forage mass was inflorescences, regardless of the pre-grazing height targets. It is known that, after the inflorescence emerges, the appearance of leaves ceases and stem elongation increases; this was confirmed by the lowest leaf percentage and the highest stem percentage in the pre-grazing forage being recorded in this period of the year (Table 2). This greater growth of stems may explain the high stem percentage in the stubble in autumn (Table 4). On the other hand, regardless of the management strategy used, dead material percentage was higher in spring than in summer and autumn (Table 4). The increased presence of dead material is common in early spring when pastures begin to recover from the dry season (Barbosa et al. 2007; Difante et al. 2009).

The similarity in nutritional value of the leaves and stems in the pastures managed using these 2 grazing strategies could be explained by their very close stage of growth, since the major changes in nutritive value occurring in pasture plants are those that accompany maturation (Van Soest 1994).

The similarity in animal performance in pastures grazed at 90 and 95% LI (Table 6) can be explained by the similarities in the canopy structures (Table 3), percentages of the stratum removed and nutritional value of the forage, indicating that the animals accessed similar pasture conditions. In this context, when analyzing the nutritional value of the leaves in the strata over 40 cm (Table 5) and considering the stem percentages above 40 cm (Table 3) and their nutritional values, the average crude protein concentration and in vitro digestibility of organic matter were 11.5 and 58.6%, respectively, for the forage theoretically available to the animals. The estimated average daily gains of the animals as a function of the amount of protein and energy (NRC 1996) revealed that the daily gain possible from the nutritive value of this grass was 810 g, a value close to those observed in the spring and summer (Table 7).

However, average daily gain in autumn was much lower (Table 7). Since there was no change in pasture nutritive value between seasons, the variation in pasture structure (Table 2) was the probable cause of the decrease in forage intake, and consequently, weight gain of the animals in autumn. According to Benvenutti et al. (2008), in pastures in the reproductive stage stems act as a physical barrier by interfering with the process of bite formation, thus affecting bite dimensions and selectivity, and consequently daily nutrient intake. Recent studies have shown that maximum short-term forage intake rates could be maintained until forage in the upper 40% of the optimal pre-grazing canopy height had been consumed (Fonseca et al. 2012; Mezzalira et al. 2014). In this study, similar (P = 0.258) defoliation severity (in percentage of the height removed) was found for both treatments. The averages and standard errors for extent of reduction in canopy height during grazing were 43.8 ± 0.3 and 42.4 ± 0.3% for the pastures managed at 95 and 90% LI, respectively. Therefore, these results suggest that relatively moderate defoliation levels are more important than pre-grazing goals per se (provided the maximum height limit does not exceed the critical PAR) when the objective is to maximize animal performance.

Similarly, because there was no change in forage accumulation or stocking rate, the similar levels of liveweight gain/ha with the two LIs indicate that Mombaça guineagrass pastures can be managed using either of these management strategies. Thus, instead of basing decisions on a specific LI, some flexibility exists in the pre-grazing target used, without impairment of the productive performance of the animals (Table 6).

Our data indicate that Mombaça guineagrass pastures can be grazed under a rotational system using pre-grazing heights of 80–90 cm (90–95% LI) without compromising the performance of either the pasture or the animals provided a moderate defoliation severity is employed, i.e. approximately 45% of the optimal pre-grazing height of pasture is consumed before animals are removed. This hypothesis should be tested further with this pasture and other erect grass species plus prostrate species.

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