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# Production and quality of Mombaça grass forage under different residual heights

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**ABSTRACT.** This study was conducted to evaluate management strategies in Mombaça grass pastures (*Panicum maximum*) under intermittent grazing subjected to different residual heights. A randomized-block design with two treatments (two post-grazing residual heights: 30 and 50 cm) and three replications was adopted. Pasture heights pre- and post-grazing, forage mass and accumulation, rest and occupation periods, pasture morphological components, milk yield and quality forage were evaluated. The data were submitted to analysis of variance and the means were compared by the F test at 5% probability. A longer grazing interval was observed in the treatments under the more severe grazing intensity. For forage mass post-grazing, larger production and higher percentage of leaves were found with the 50 cm residue, as well as higher crude protein contents and digestibility of leaves and stems and lower lignin and neutral detergent fiber contents. The residual height of 50 cm is recommended for the management of Mombaça grass pasture, as it provides greater milk yield per animal and a larger number of grazing cycles, ensuring better use of the area.

**Keywords:** defoliation, grazing system, pasture.

## Produção de pastos de capim-mombaça submetidos a alturas de resíduo

**RESUMO.** O experimento foi conduzido, objetivando-se avaliar estratégias de manejo em pastos de capim-mombaça (*Panicum maximum*) sob lotação intermitente, submetidos a diferentes alturas de resíduo. O delineamento utilizado foi em blocos casualizados, com dois tratamentos (duas diferentes alturas de resíduo pós-pastejo - 30 e 50 cm) e três repetições. Foram avaliadas a altura do pasto no pré e no pós-pastejo, a massa e o acúmulo de forragem, os períodos de descanso, de ocupação, a produção dos componentes morfológicos do pasto, a produção de leite e a qualidade da forragem. Os dados foram submetidos à análise de variância e as médias foram comparadas pelo teste F a 5% de probabilidade. Para tratamentos com intensidade de pastejo mais severa, notou-se maior intervalo de pastejo. Encontrou-se maior acúmulo de forragem para pastos manejados com altura de 50 cm de resíduo de pastejo. Para massa de forragem no pós-pastejo, obteve-se maior produção e maior porcentagem de folhas para o resíduo de 50 cm, bem como maiores teores de PB e digestibilidade para folhas e colmos, e menores teores de lignina e FDN. Para manejo de pastos de capim-mombaça, recomenda-se a altura de 50 cm de resíduo, por promover maior produção de leite por animal e maior número de ciclos de pastejo, garantindo melhor aproveitamento da área.

**Palavras-chave:** desfoliação, sistema de pastejo, pasto.

## Introduction

A significant part of milk production in Brazil is carried out in systems where the pasture is main feed source for these animals, which requires management actions aimed at optimizing the use of forage to maximize animal production. One of the ways to improve the efficiency of the pasture production process has been the application of techniques based on the control of its structure.

Among the forage plants mostly used for milk production, the *Panicum maximum* species stand outfor their high productivity and good nutritional value, and they have been predominantly used in intermittent grazing systems (Freitas, Fonseca, Braz, Martuscello, & Santos, 2012). However, mismanagement of plants of this species may explain low animal performance. Therefore, in view of the problems associated with management mistakes, many research studies have been proposed to evaluate the use of the light interception (LI) concept as a criterion to define the most appropriate moment for animals to start grazing (Carnevalli et al., 2006, Barbosa et al., 2007). In this condition, pastures are characterized by higher forage accumulation rates and favorable structure for animal intake and their nutritional value (Cunha et al., 2010, Difante et al., 2010). As a practical form of translating the LI concept to - farmers, the height of entry was adopted. For *Panicum maximum Jacq* cv. Mombaça, the height at which the pasture intercepts 95% of the incident light is 90 cm (Carnevalli et al., 2006). The residual height, in turn, is related to the minimum number of leaves that allow vigorous regrowth after defoliation. This height has not been clearly established yet, although Cunha et al. (2010) concluded that there are variations in the structure of Mombaça grass pastures kept under different residual heights. It is important to highlight that most of these studies have been conducted in the Central-West region of Brazil, and mostly with beef cattle. Few investigations have been developed on dairy cattle and in the state of Minas Gerais, which is the largest milk producer in Brazil (Instituto Brasileiro de Geografia e Estatística [IBGE], 2012).

This study thus aimed to evaluate milk production and forage mass accumulation, morphological composition, and nutritional value of forage from Mombaça grass pastures subjected to different residual heights.

## Material and methods

The experiment was conducted in São João Del-Rei, MG, Brazil (21° 08' 11" Sand 44° 15' 43" W, 904 m asl). The climate of the region, according to the Köppen (1948) classification, is a Cwa type, with well-defined dry (May to October) and rainy (November to April) seasons. During the experimental period (November 2012 to April 2013), minimum, average, and maximum temperatures and precipitation were measured (Figure 1) from a meteorological station approximately 350 m from the experimental area.

The experiment was approved by the Ethics Committee on Animal Use (CEUA) of Universidade Federal de São João Del-Rei (case no. 06/2012). Before the beginning of the experimental period, soil samples were collected for chemical analysis (Table 1). According to the Manual of Recommendation for the Use of Soil Amendments and Fertilizers of Minas Gerais/Brazil (Ribeiro, Guimarães, & Alvarez, 1999), liming at the start of the experiment were not necessary, possibly because the area had been used previously for corn growing for silage production.

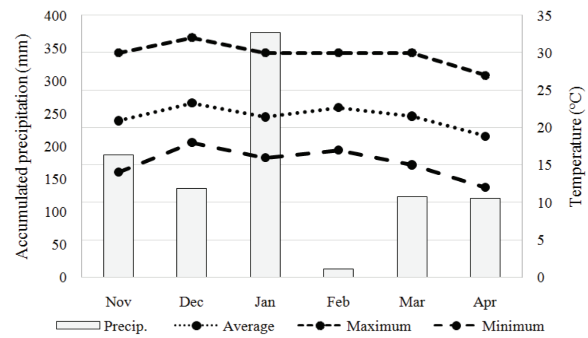


**Figure 1.** Precipitation and minimum, average, and maximum temperatures during the experimental period.

**Table 1.** Result of the soil chemical analysis in the paddocks (average of paddocks per treatment).

| Chemical characteristic | Treatment | |
|---|---|---|
| | 30 cm | 50 cm |
| P (mg $dm^{-3}$) | 6.7 | 6.55 |
| Organic matter (dag $kg^{-1}$) | 2.295 | 2.175 |
| pH ($H_2O$) relação 1:2.5 | 6.29 | 6.4 |
| K (mg $dm^{-3}$) | 116 | 130 |
| Ca ($cmol_c$ $dm^{-3}$) | 3.485 | 4.415 |
| Mg ($cmol_c$ $dm^{-3}$) | 0.64 | 0.81 |
| H + Al ($cmol_c$ $dm^{-3}$) | 1.765 | 1.695 |
| CEC ($cmol_c$ $dm^{-3}$) | 6.185 | 7.25 |
| Sum of bases ($cmol_c$ $dm^{-3}$) | 4.42 | 5.555 |
| Base saturation (%) | 71.05 | 76.55 |

CEC - cation exchange capacity.

The experiment was carried out on an already established pasture of Mombaça grass in a randomized-block design with two defoliation intensities (post-grazing residual heights of 30 and 50 cm) and three replications. The area utilized in the experiment was subdivided into three 1.5 ha blocks with six paddocks (experimental units) of 0.25 ha each, totaling 4.5 ha. The reserve area was 2.0 ha of Mombaça grass. The intervals between grazing sessions corresponded to the time necessary for the Mombaça grass to reach 90 cm in height (Carnevalli et al., 2006). The occupation and rest periods were determined according to the time necessary to reach the residual heights, and the number of days necessary for the height of 90 cm to be achieved after regrowth, respectively. It was decided to use a fixed stocking rate, thus the grazing period varied, according to the methodology adopted by Euclides, Macedo, Valle, Barbosa, and Gonçalves (2008). After the animals left the paddocks, this were fertilized with 75 kg $ha^{-1}$ of the NPK (20-05-20) formula (375 kg for the treatment of 30 cm and 450 kg for the treatment of 50 cm). As the grazing internals of the paddocks were variable, the amount of fertilizer application rates were also variable. The pasture height, both at the entry and exit of animals, was determined using a centimeter-graduated ruler, with 50 points measured at random per paddock.

The forage mass pre- and post-grazing was measured by using five 1 $m^2$ square frames in each experimental unit, and the forage within the frame was cut at the soil level. To evaluate the forage morphological contents, a subsample was collected to determine forage mass pre- and post-grazing, which was separated into the fractions leaf, stem + sheath, and dead forage, and their dry matter content was determined by conventional methods. Forage mass values were converted to kg $ha^{-1}$ of dry mass and morphological components expressed as a proportion (%) of the forage mass. Forage production (kg DM $ha^{-1}$) was calculated based on the difference between forage mass in the previous post-grazing and current pre-grazing conditions. To determine the forage accumulation rate (kg DM $ha^{-1}$ $day^{-1}$), the forage accumulation values were divided by the number of days between grazing sessions of each cycle. The samples were ground in a Wiley mill, using a 1 mm screen and analyzed for quality at the Embrapa Beef Cattle Animal Nutrition Laboratory by Near-infrared Reflectance Spectroscpy (NIRS). The following characteristics were evaluated: crude protein (CP), neutral detergent fiber (NDF), lignin (LIG), in vitro organic matter digestibity (IVOMD). The forage was evaluated in the pre- and post-grazing conditions for the treatments of 30 and 50 cm.

The area was grazed by 24 F1 (Holstein × Zebu) cowsin lactation, multiparous, with an average weight of 525.42±43.17 kg, supplemented as described by Hack et al. (2007), which were allocated to the treatments according to production level and order of lactation. The animals were milked twice daily, in mechanical milking machine and milk productions were recorded in each occasion. The stocking rate was the same in both treatments: 7.4±1.6 AU $ha^{-1}$, Thus for the establishment of residue heights, there was a change in the occupation period and not in the stocking rate. In October 2012, before the beginning of the experimental period, the area was subjected to intense grazing, aiming to ensure uniform regrowth. Animals were weighed at the beginning and end of each grazing cycle.

Data were subjected to analysis of variance, and treatments were compared by the F test, adopting 5% as the critical level of probability for type-I error. All analyses were performed on SAS software version 9.2 (Statistical Analysis System [SAS], 2008).

## Results and discussion

The average pre-grazing heights were 91.09±10.1 and 92.04±9.7 cm for the treatments with 30 and 50 cm of post-grazing residue, respectively. For the residual heights, however, 38.76±12.12 and 53.88±8.97 cm were observed at 30 and 50 cm, respectively. These results indicate that the recommended target for the entry of animals at a pasture height of 90 cm was kept satisfactorily, whereas the residual height targets were not met in the more intense post-grazing condition.

The use of the light interception (LI) concept in the interruption of the regrowth process and the entry height of 90 cm for the Mombaça grass have been recommended based on studies that attest the high degree of association between these variables (Carnevalli et al., 2006, Pereira et al., 2011). In a similar study with Tanzania grass, Difante et al. (2009) and Barbosa et al. (2007) reported that the height of 70 cm corresponded to the moment in which this forage reached the pre-grazing condition and that target was also achieved satisfactorily. In these studies, the LI of 95% provided better sward-structure conditions, which are characterized by a greater percentage of leaves in relation to stems and senescent material. These factors would greatly increase the forage quality, and, consequently, milk production. These pastures are also characterized by being at their maximal forage accumulation rate.

Although the residual treatment of 30 cm did not allow the residual height target to be achieved, results were consistent, especially when we evaluate the difficulty to maintain Mombaça grass pastures at high grazing intensities, due to the resistance of animals to consume the forage mass from the lower strata at the end of the occupation period and to the intake limitations imposed by the lower nutritive value and structure unfavorable to the seizure of forage by the animals. Difante et al. (2009) also reported difficulties to reach the residual height of 30 cm in Tanzania grass. Thus, it is assumed that the forage located near the 30 cm target is already characterized by a low amount of leaves and a large amount of stems and senescent material. In fact, Trindade et al. (2007) observed a decrease in percentage of leaf blades from the esophageal extrusa of cattle with a reduction of residual height in Marandu grass pastures under rotational grazing.

There was effect of residual heights on the duration of the rest period of the pastures (Table 2) - the more lenient grazing, with a residual height of 50 cm, provided shorter intervals, whereas the more intense grazing demanded more time for the forage to reach the pre-grazing conditiononce again.

**Table 2.** Grazing cycle, forage availability, and forage accumulation rate in Mombaça grass pastures under different post-grazing residual heights.

| Characteristic | Residual height (cm) | | CV (%) | p > F |
|---|---|---|---|---|
| | 30 | 50 | | |
| Occupation period (days) | 9.3 | 5.1 | 2.5 | 0.0239 |
| Rest period (days) | 41.5 | 27.5 | 10.6 | 0.0407 |
| Number of cycles | 5.0 | 6.0 | 0.8 | < 0.0001 |
| Forage mass pre-grazing (kg DM $ha^{-1}$) | 7503.28 | 8731.79 | 6.06 | 0.1564 |
| Forage mass post-grazing (kg DM $ha^{-1}$) | 3328.19 | 5979.18 | 15.88 | 0.0489 |
| Forage accumulation (kg DM $ha^{-1}$ $day^{-1}$) | 97.01 | 100.07 | 14.97 | 0.0287 |

CV - coefficient of variation.

The difference in the number of cycles occurred due to variation of the occupation period, since the stocking rate was the same in both treatments. Coupled with this, the occupation period of paddocks managed with a height of 30 cm was longer (Table 2), which was due to the longer time necessary for the target height to be achieved. The variation in the occupation period of the paddocks can be explained by the fact that the stocking rate was the same in both treatments (7.4±1.6 AU $ha^{-1}$). Thus, at the more intense grazing, because of the larger amount of forage to be consumed, the animals had to be kept grazing for a longer time so that the target was achieved. The occupation period was nine days for the pastures kept with a residual height of 30 cm (Table 2), due to the greater consumption need. For pastures with a residual height of 50 cm, the occupation period was five days. Also Euclides et al. (2008) working with Mombaça and Massai grasses, used a grazing period of seven days with a fixed stocking rate. It should be mentioned that the occupation period for dairy cattle must be the shortest possible to prevent milk production from being affected by the variation in forage quality observed in successive days caused by animal selectivity. Fernandes, Derez, Henrique, Lopez, and Glória (2014) indicated the three days occupation period in Tanzania grass in a rotational system for milk production.

Given the results observed during the occupation period, it may be suggested that the use of period of pastures and a variable stocking rate is the best alternative when aiming to reduce the occupation maintain the target heights for management. We must emphasize that an increase in this stocking rate would lead to an increment in production per area, with little or no increase in animal production, since the genetic potential for milk production of grazing animals might have already been achieved. Thus, Mombaça grass pastures managed with a pre-grazing height of 90 cm and a residual height of 30 cm may increase production per area, whereas pastures kept at a residual height of 50 cm would increase animal production.

The pasture occupation and rest periods directly influence the number of grazing cycles, since six grazing cycles were observed for pastures subjected to the post-grazing residual height of 50 cm and five cycles were observed for pastures with a residual height of 30 cm (Table 2). These results can be explained by the lower need for forage accumulation in order to restore the height of 90 cm pre-grazing for pastures managed with a residual height of 50 cm. Thus, as the grazing intensity is increased, more time is necessary to lower the pasture, and consequently more time is required for accumulation and for the entry height be achieved.

For the forage mass pre-grazing, no difference was observed between treatments (Table 2), which was expected, since, for both treatments, an entry-height target of 90 cm was adopted for the Mombaça grass. Considering the post-grazing condition, lower forage availability was observed in pastures managed with a residual height of 30 cm in relation to those managed with 50 cm (Table 2). For forage accumulation (kg DM $ha^{-1}$ $day^{-1}$), a difference was observed between treatments, with higher values observed in pastures kept with a residual grazing height of 50 cm (Table 2). However, a biggest proportion of this forage accumulation in pastures with a 50 cm residual height may be due to the stem fraction, since the management with a higher residue allows plant greater stem elongation. Thus, the maintenance of Mombaça grass pastures with 50 cm, despite benefiting animal performance, elevates the difficulty to reach management targets, especially the pre-grazing targets, due to alteration in the canopy struture, caused by the greater elongation of the stems in this treatment. Difante et al. (2009) also observed a similar result in Tanzania grass pastures.

The high average daily forage accumulation rates can be explained by the fact that the experiment took place during the summer. In fact, when growth factors are available at adequate amounts, an increase in environmental factors (temperature, precipitation, humidity, amons others) has a direct impact on the elongation and appearance of new leaves, in addition to an increase in the number of tillers. The importance of management given the variations in forage accumulation rate is a noteworthy aspect, as the increased forage production in the summer should be accompanied by adjustments in the stocking rate. Regarding the forage morphological components, no significant differences were observed between treatments for the percentages of leaves and stems pre-grazing (Table 3).

**Table 3.** Percentage of leaf blades, stems, and dead material pre- and post-grazing and milk yield of cows kept on Mombaça grass pastures under different residual heights.

| Characteristic | Residual height (cm) | | CV (%) | p > F |
|---|---|---|---|---|
| | 30 | 50 | | |
| % leaves pre-grazing | 63.08 | 61.70 | 1.83 | 0.3490 |
| % stems pre-grazing | 18.75 | 23.80 | 8.48 | 0.1075 |
| % dead material pre-grazing | 18.17 | 14.50 | 4.16 | 0.0328 |
| % leaves post-grazing | 8.42 | 11.06 | 2.53 | 0.0086 |
| % stems post-grazing | 69.25 | 58.75 | 1.04 | 0.0040 |
| % dead material post-grazing | 22.33 | 30.19 | 3.48 | 0.0132 |
| Milk yield (L animal$^{-1}$ day$^{-1}$) | 15.83 | 19.09 | 4.41 | 0.0100 |

CV - coefficient of variation.

However, in the post-grazing condition, a larger proportion of leaves was observed in the treatment with the residual height of 50 cm (Table 3), which is due to the greater removal of forage by animals at the higher residue. For the post-grazing residue of 30 cm, a larger proportion of stems and dead material was observed (Table 3), resulting from the greater defoliation intensity and selectivity by the grazing animals. The percentage of dead material pre-grazing varied, with a greater participation of this component observed at the residual height of 30 cm. It is possible that this condition contributed to increasing forage losses, also as a result of the animal selectivity and damage caused on the plants by trampling and intense grazing (Carnevalli et al., 2006).

The residual heights influenced milk production (L animal$^{-1}$ day$^{-1}$), which was higher for the pastures kept at 50 cm (Table 3). This result was likely influenced by the greater proportion and availability of leaves at the 50 cm residue (Table 3), since the leaf fraction is known to have a greater nutritive value than stems.

When a fixed stocking rate is used, the greater milk production in pastures managed under lower defoliation intensities is indicative that this management may improve the use of the area, as a higher number of grazing cycles was observed with a shorter duration for pastures of this treatment (Table 2). Thus, both the occupation and rest intervals are shorter, allowing the leaf intake to be higher and thereby increasing selectivity. Hack et al. (2007) found greater milk production by cows on Mombaça grass pastures with a greater proportion of leaves. Difante et al. (2009), observed greater weight gain for animals kept on Tanzania grass pastures with a lower grazing intensity.

The greater milk yield for cows kept on Mombaça grass pastures with a post-grazing height of 50 cm can also be explained by abetter mean forage quality in this treatment (Table 4).

**Table 4.** Nutritional value of Mombaça grass pastures under different residual heights pre- and post-grazing.

| Characteristic (%) | Residual height (cm) | | CV (%) | p > F |
|---|---|---|---|---|
| | 30 | 50 | | |
| Pre-grazing | | | | |
| Leaf crude protein (g kg$^{-1}$ DM) | 9.8 | 9.6 | 13.2 | 0.7830 |
| Stem crude protein (g kg$^{-1}$ DM) | 4.5 | 4.3 | 11.8 | 0.4510 |
| Leaf IVDMD | 52.3 | 54.6 | 12.4 | 0.1650 |
| Stem IVDMD | 45.3 | 44.8 | 11.8 | 0.2250 |
| Leaf neutral detergent fiber | 76.3 | 77.0 | 19.7 | 0.8070 |
| Stem neutral detergent fiber | 79.8 | 79.3 | 11.8 | 0.5190 |
| Leaf lignin | 3.7 | 3.9 | 9.8 | 0.7620 |
| Stem lignin | 4.6 | 4.4 | 10.4 | 0.8430 |
| Post-grazing | | | | |
| Leaf crude protein (g kg$^{-1}$ DM) | 5.4 | 6.7 | 18.5 | 0.0010 |
| Stem crude protein (g kg$^{-1}$ DM) | 3.9 | 4.8 | 11.4 | 0.0043 |
| Leaf IVDMD | 52.1 | 56.4 | 9.08 | 0.0014 |
| Stem IVDMD | 43.1 | 46.9 | 15.2 | 0.0038 |
| Leaf neutral detergent fiber | 78.2 | 76.8 | 9.5 | 0.0010 |
| Stem neutral detergent fiber | 80.1 | 79.3 | 18.5 | 0.0580 |
| Leaf lignin | 4.2 | 3.3 | 15.0 | 0.0010 |
| Stem lignin | 5.2 | 4.6 | 22.0 | 0.0010 |

CV - coefficient of variation; IVDMD - *in vitro* dry matter digestibility.

At pre-grazing, no differences were observed between treatments regarding crude protein (CP), neutral detergent fiber (NDF), *in vitro* organic matter digestibility (IVOMD), and lignin (Table 4), which indicates uniform pre-grazing conditions for both treatments. This is explained by the same entry height (90 cm) adopted for both treatments.

Overall, the forage nutritional value pre-grazing can be considered adequate for the maintenance of the milk production of crossbred cows, since CP contents around 10% can ensure the maintenance of production to these animals. This is because of the management of entry of the animals into the paddocks with a height corresponding to 95% LI that ensures better quality forage (Carnevalli et al. 2006).

Analyzing the post-grazing condition, a difference was observed between treatments (Table 4), with higher CP contents, higher digestibility of leaves and stems, and lower lignin and NDF contents found in pastures managed with a residual height of 50 cm. The better nutritional value is possibly due to the greater proportion of leaves of the pastures with 50 cm residual height over those with 30 cm (Table 3). Similarly, Difante et al. (2009) also observed better nutritional value in forage sampled pre- or post-grazing in Tanzania grass pastures subjected to lower defoliation intensity. Another possible explanation for the reduced nutritional value of the forage harvested post-grazing in the treatment with 30 cm residual height is the sampled stratum, which, in addition to being richer in stems and senescent material, also concentrates a larger quantity of tissues formed for a longer time, and which are thus more mature from the physiological perspective.

## Conclusion

The management of Mombaça grass pastures with a post-grazing residual height of 50 cm provides greater milk production per animal and a higher number of grazing cycles.

The use of a residual height of 50 cm improves forage accumulation; however, it does not change its morphological composition or nutritional value.

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