Effect of cutting interval and cutting height on morphogenesis and forage accumulation of guinea grass (*Panicum maximum*)

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Abstract

Response patterns of guinea grass to defoliation were assessed over a 4-month period at the Federal University of Viçosa using a randomised complete block design with 3 replications. The treatments were combinations of cutting height (25 and 50 cm) and cutting interval (2, 3 and 4 new leaves per tiller) and were arranged in a 2 x 3 factorial design. Morphological and structural characteristics, regrowth period and forage accumulation were assessed. The average regrowth period was similar for the cutting intensities assessed. Stem elongation, final leaf length and number of live leaves per tiller were greater with the 50 cm cutting height. Increasing the number of leaves/tiller at harvest increased period between harvests, canopy height at harvest and stem relative to leaf elongation, causing reduction of the leaf:stem ratio. It appears that cutting at the 3-leaf stage at 25 cm height would be the most appropriate for Mombaça guinea grass. However, a more practical standard would be cutting at a canopy height of about 90 cm. Longer-term studies are needed to confirm these preliminary findings, along with feeding studies to determine production benefits from this regime.

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Introduction

Most pastures that support Brazilian beef herds consist of monocultures of C_4 grass forages characterised by high levels of dry matter production (Da Silva and Nascimento Júnior 2007). However, when producers base management actions on simplistic and empirical criteria and do not fertilise, pasture degradation occurs after a few years. In an endeavour to correct this situation and increase the efficiency of livestock production, new technologies, based on factors that regulate the productivity of tropical forage plants, must be generated and diffused. Important issues to be considered include: regrowth following cutting or grazing; morphological characteristics; and the environmental conditions (Barbosa *et al*. 2002). In this context, significant improvements in the efficiency and productivity of pasture-animal production systems could be obtained by starting with simple actions, such as those related to grazing or defoliation management, that would result in highly efficient use of the forage produced. Identification of cutting intervals and cutting heights that optimise the net forage accumulation and delay senescence and stem accumulation would favour the efficient accumulation of large quantities of highly nutritious forage (Pinto *et al*. 2001; Carnevalli *et al*. 2006; Barbosa *et al*. 2007; Difante *et al*. 2009; Da Silva *et al*. 2009).

This study assesses the responses of Mombaça guinea grass (*Panicum maximum* cv. Mombaça) to various cutting strategies in terms of regrowth and forage accumulation in order to generate data for planning efficient management practices for this forage plant.

Material and methods

The experiment was carried out in the Department of Animal Science at the Federal University of Viçosa (UFV) (20º 45'S, 42º 51'W; 651 masl) in Viçosa, MG, from October 2003 to May 2004.

According to the Köppen classification, the climate of the region is subtropical (subtype Cwa) with mild, dry winters and well defined dry and wet seasons. The average annual temperature is 19°C, oscillating from 22 to 15°C for the maximum and minimum means. The average relative humidity is 80% and the mean annual rainfall is 1340 mm. Climatic conditions during the experimental period were monitored at the meteorological station of the Department of Agricultural Engineering, about 1 km from the experimental area. Monthly maximum, mean and minimum temperatures and rainfall during the experimental period are shown in Figure 1.

The soil type is classified as Red–Yellow Argissol (EMBRAPA 1999) with a sandy–clay texture. Soil samples were collected to a depth of 20 cm and chemically analysed to calculate the requirements for liming and phosphate and potassium fertilisation, to raise the base saturation to 50%, the phosphorus content to 8–12 mg/dm^3 (Mehlich I extraction) and the potassium content to 80–100 mg/dm^3 (EMBRAPA 1999).

Guinea grass was sown in September on plastic trays containing a commercial organic substrate in a greenhouse with daily irrigation. At transplanting to the experimental area in October 2003, 1.1 t/ha dolomitic limestone was applied to the soil, incorporated to a depth of 20 cm and homogenised manually using a hoe. Single superphosphate was then applied (48 kg/ha P) on the plot rows and incorporated to approximately 15 cm. Nitrogen (50 kg/ha N as urea) and potassium (75 kg/ha K as potassium chloride) fertilisers were applied in 2 applications after the plants were established.

A complete randomised block design was used with 3 replications. Each block consisted of 6 plots, with 18 subplots of 0.6 m^2 each (1.0 x 0.6 m). Subplots had 4 rows spaced at 20 cm, each with 6 plants spaced at 15 cm, giving a total of 24 plants per subplot. Experimental treatments were combinations of 2 cutting heights (25 and 50 cm) and 3 intercutting intervals, corresponding to the appearance of 2, 3 or 4 leaves per tiller. Four, 3 and 2 subplots were used in a block for intervals of 2, 3 and 4 leaves per tiller, respectively, to allow for different harvest frequencies.

In December 2003, when the plants were completely established, a standardising cut was made at a height of 35 cm from the soil. Thirty days later, all subplots were cut to their planned target cutting height (25 or 50 cm), and observations commenced from this point. Two plants were chosen in each subplot to study tiller dynamics according to the methodology reported by Carvalho *et al*. (2000). Two tillers were marked on these plants with coloured plastic wires at random to monitor and study the morphogenetic and structural characteristics. Twice a week, the following measurements were made: length of leaf blades of expanding and expanded leaves; length of the green parts of senescent leaf blades; and the length of the pseudostem (height from

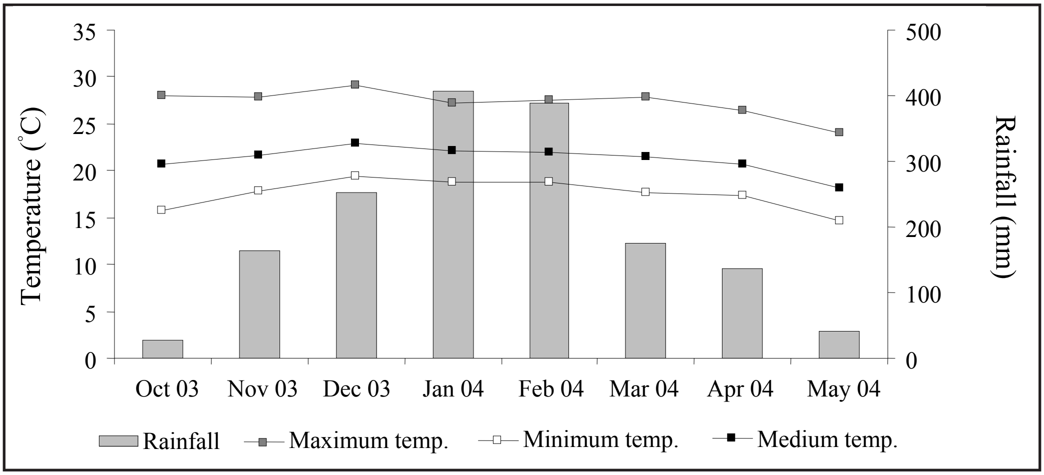

Figure 1. Monthly means of the maximum, average and minimum temperatures and rainfall during the experimental period.

the soil to the ligule of the last expanded leaf). New leaves were also recorded. These data were used to calculate: leaf appearance rate (LAR – leaves/tiller/day), the phyllochron (Phyl – days/leaf tiller), leaf elongation rate (LER – cm/tiller/day), stem elongation rate (SER – cm/tiller/day), final leaf blade length (FLL – cm/tiller), number of live leaves per tiller (NLL – leaves/tiller), leaf life span (LLS – days) and leaf blade senescence rate (LBS, cm/tiller/day).

Cutting dates were determined from the number of new leaves on the tillers being monitored. The mean for a treatment was calculated as a combination of cutting interval and height, regardless of the blocks. When the mean reached a pre-determined number of new leaves (NNL), cutting was carried out and the date was recorded. At cutting, the harvested forage from 4 plants per subplot was collected and used to calculate accumulated biomass and its morphological composition. The data were analysed as a balanced factorial in split plots in time, where the treatments, cutting height x cutting interval combinations, constituted the plots and the cuts constituted the subplots. The GLM procedure was used from the SAS statistical package (SAS Institute 1996). Means were compared using the appropriate contrasts both for the main effects of cutting height and cutting interval and for the effects of cutting height x cutting interval interaction and the cut within the cutting height x cutting interval interaction. A significance level of 5% was adopted.

The following model was used for the regrowth period variable:

$$Y_{ijk} = \mu + I_i + H_j + IH_{ij} + C_k + e_{ijk}$$

where:

Y_{ijk} = observed value of the cutting interval i and cutting height j in cut k;

μ = general constant (population mean);

I_i = effect of the cutting interval i, i = 1, 2, 3;

H_j = effect of the cutting height j, j = 1, 2;

IH_{ij} = interaction between cutting interval i and cutting height j;

C_k = effect of cut k, k = 1, 2, 3, 4; and

e_{ijk} = random error associated with each observation Y_{ijk}.

The following model was used for the variables dry matter, morphological composition and those regarding the canopy morphogenetic and structural characteristics:

$$Y_{ijkl} = \mu + I_i + H_j + IH_{ij} + B_k + e_a + C_l(IH_{ij}) + e_b$$

where:

Y_{ijkl} = observed value of the cutting interval i, cutting height j and block k in cutting l;

μ = general constant (population mean);

I_i = effect of the cutting interval i, i = 1, 2, 3;

H_j = effect of cutting height j, j = 1, 2;

IH_{ij} = interaction between cutting interval i and cutting height j;

B_k = effect of the block k, k = 1, 2, 3;

e_a = IHB_{ijk}, error where I_i, H_j and IH_{ij} will be tested;

$C_l(IH_{ij})$ = effect of cut l, nested to interaction IH_{ij}, l = 1, 2, 3, 4; and

$e_b = BC_{kl}(IH_{ij})$, error where $C_l(IH_{ij})$ will be tested.

Results

The effects of cutting height and cutting interval on morphogenetic and structural characteristics are presented in Tables 1 and 2. Cutting at 25 cm significantly ($P<0.05$) reduced stem elongation rate (SER), final leaf blade length (FLL) and number of live leaves/tiller relative to cutting at 50 cm. In addition, cutting at 25 cm produced lighter tillers than cutting at 50 cm but produced a more intense tillering activity (more tillers/plant; Table 1). While cutting at 25 cm reduced leaf life span and increased leaf:stem ratio, these effects were not significant ($P>0.05$).

The most frequent cutting regime (2 new leaves/tiller) reduced SER (Table 2) and increased leaf:stem ratio relative to the longest cutting interval (4-leaf stage). Mean tiller weight increased as number of new leaves at cutting increased ($P<0.05$). While mean inter-cutting interval was not affected by cutting height, it increased progressively ($P<0.05$) as the number of new leaves at harvest increased. Mean height of the canopy at the 4-leaf stage was greater than at the 2- or 3-leaf stage.

The number of cuts made for each assessed cutting height differed during the experimental period, but total forage accumulation (sum of the cuts) was similar (Figure 2) among treatments.

Table 1. Morphogenetic and structural traits and regrowth periods of guinea grass submitted to 2 cutting heights (25 and 50 cm).

Characteristics	Cutting heights	
	25	50
Stem elongation rate (cm/tiller/d)	0.33 b[1]	0.71 a
Leaf elongation rate (cm/tiller/d)	4.07 a	4.39 a
Leaf appearance rate (leaves/tiller/d)	0.084 a	0.080 a
Leaf lifespan (d)	74 a	90 a
Leaf:stem ratio	6.59:1 a	5.47:1 a
Final leaf blade length (cm)	25.4 b	31.8 a
Tiller weight (g/tiller)	2.27 b	4.89 a
Tiller population density (tillers/plant)	11 a	7 b
Number of live leaves per tiller	5.6 b	6.5 a
Regrowth period (d)	41.8	39.9

[1] Within rows, values followed by different letters differ significantly (P<0.05).

Table 2. Morphogenetic and structural traits, regrowth period and pre-defoliation heights of guinea grass submitted to 3 cutting intervals (2, 3 and 4 leaves/tiller).

Characteristics	Defoliation interval		
	2	3	4
Stem elongation rate (cm/tiller/d)	0.27 b[1]	0.66 a	0.62 a
Leaf elongation rate (cm/tiller/d)	4.5 a	4.5 a	3.7 a
Leaf appearance rate (leaves/tiller/d)	0.085 a	0.083 a	0.078 a
Leaf lifespan (d)	84.6 a	79.8 a	81.5 a
Leaf:stem ratio	8.5:1 a	6.8:1 a	2.8:1 b
Final leaf blade length (cm)	27.1 a	30.1 a	28.7 a
Tiller weight (g/tiller)	2.69 b	3.68 ab	4.38 a
Tiller population density (tillers/plant)	10 a	9 a	11 a
Number of live leaves per tiller	6.0 a	6.2 a	5.9 a
Regrowth period (d)	30.1 b	40.5 ab	51.9 a
Pre-defoliation heights (cm)	79 b	85.7 b	104 a

[1] Within rows, values followed by different letters differ significantly (P<0.05).

Discussion

This study has provided valuable information on the effects and interaction of cutting frequency and cutting height on growth and morphology of Mombaca guinea grass. While delaying cutting from the 2-leaf to 4-leaf stage produced no significant impact on forage yield, it dramatically affected the composition of the harvested forage. As harvesting was delayed, leaf:stem ratio in the forage available declined, which would be expected to lower the digestibility of the material. As a result, animal performance on the harvested material would be expected to suffer.

Based on the results obtained, there would seem to be little merit in delaying harvesting beyond the 3-leaf stage, which could be used as a target for management. However, this would necessitate a high monitoring capacity and a very intense sampling of tillers, activities that are not easily performed in a field situation. A more practical criterion than 3 leaves per tiller would be preferable as the indicator of the appropriate time to cut or graze a stand of guinea grass. Recent studies have detected a strong relationship between tropical grass canopy height and canopy light interception (LI) under pre-grazing conditions, and consequently with the critical leaf area index (LAI) (Carnevalli *et al*. 2006; Barbosa *et al*. 2007; Da Silva *et al.* 2009; Difante *et al*. 2009). This suggests that forage height may be a reliable characteristic for initiating grazing under intermittent stocking conditions. It is considered that plants modify their dry matter accumulation

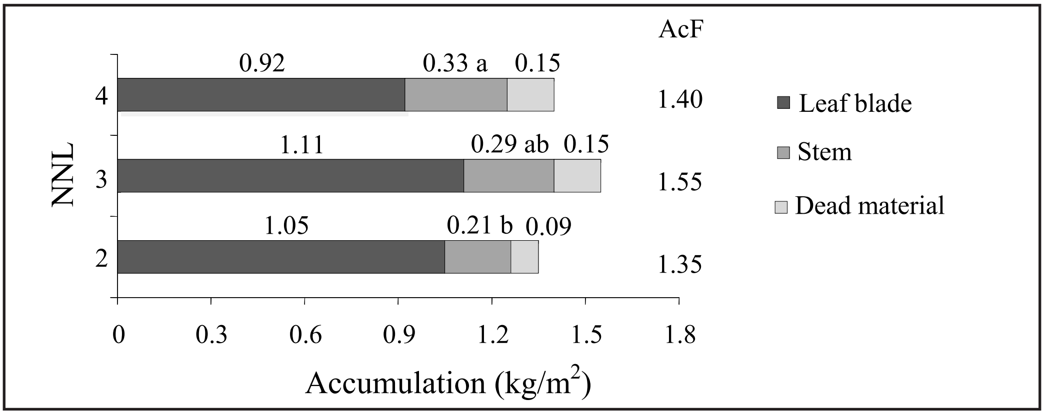

Figure 2. Forage accumulation (AcF), leaf blade, stem and dead material accumulation in guinea grass submitted to 3 cutting intervals (NNL; 2, 3 and 4 = 2, 3 and 4 leaves/tiller) during the experimental period. Within components, values followed by different letters differ (P<0.05).

dynamic, reducing leaf blade accumulation and rapidly increasing stem and dry matter accumulation at a light interception of 95% (Da Silva and Corsi 2003). In Tanzania guinea grass, Barbosa *et al*. (2007) and Difante *et al*. (2009) observed that 95% LI occurred at about 70 cm pre-grazing height, while Carnevalli *et al*. (2006) and Da Silva *et al*. (2009) reported height values close to 90 cm for Mombaça guinea grass. It is significant that, in our study with Mombaca guinea grass, the appearance of 3 leaves per tiller, when maximum growth occurred, corresponded with a stand height of 86 cm (Table 2).

Our data suggest that there were very few differences in production when plants were cut at either 25 or 50 cm. While stem elongation rate was greater at the greater cutting height, producing bigger tillers, the number of tillers produced decreased. There would seem to be merit in having a greater number of smaller tillers, suggesting that the lower cutting height of 25 cm would be preferable to cutting at 50 cm. This is supported by the higher leaf:stem ratio in harvested material cut at 25 cm, though the differences were not significant. Digestion studies with the forage produced would provide evidence to support an argument for cutting at the lower height.

In general, plants subjected to higher defoliation intensities have less remaining foliar area (Carnevalli 2003; Barbosa 2004), a characteristic directly related to plant recovery after defoliation (Ward and Blaser 1961). In the present experiment, no differences were found in the regrowth periods for the 2 cutting heights (Table 1), suggesting that cutting height could not have been drastic enough to promote significant differences in the regrowth period. According to Buxton and Fales (1994), fluctuations in climatic conditions and stresses can modify morphology and forage plant growth rates, limiting their production and nutritive value.

Conclusions

While cutting interval had a marked effect on forage composition of guinea grass, there was limited effect of cutting height. Cutting at the 3-leaf stage at 25 cm would seem to provide maximum yield of material with an acceptable leaf:stem ratio. However, a more practical criterion for initiating cutting or grazing would seem to be a stand height of about 90 cm. Feeding and digestion studies are needed to confirm whether animal production was also optimal under this regime. Since this study was conducted for only 4 months, it would be unwise to base management decisions on these findings. Field studies over at least a full year would be needed to confirm these findings before firm recommendations on optimal cutting/grazing management strategies could be made.

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