Revista Brasileira de Zootecnia
© 2010 Sociedade Brasileira de Zootecnia
ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.39, n.10, p.2141-2147, 2010

Morphogenetic and structural characteristics of andropogon grass submitted to different cutting heights[1]

Braulio Maia de Lana Sousa[2], Domicio do Nascimento Júnior[2], Sila Carneiro da Silva[3], Hélida Christhine de Freitas Monteiro[2], Carlindo Santos Rodrigues[2], Dilermando Miranda da Fonseca[2], Márcia Cristina Teixeira da Silveira[2], André Fischer Sbrissia[4]

[1] Financiado pelo CNPq.
[2] Departamento de Zootecnia - UFV, Viçosa, MG.
[3] Departamento de Zootecnia - USP/ESALQ, Piracicaba, SP.
[4] Departamento de Produção Animal e Alimentos - UDESC, Lages, SC.

ABSTRACT - This work was performed aiming to evaluate the morphogenetic and structural characteristics of *Andropogon gayanus* cv. Planaltina species submitted to three cutting heights (20, 27 and 34 cm). The three cutting heights were allocated in experimental units (12 m^2) in a complete randomized block design with three replications. The cuts were done when the light interception by the sward reached 95%. At this moment, the sward height revealed itself constant with values close to 50 cm. The lowest cutting height (20 cm) influenced negatively the final leaf blade length, the number of live leaves, the leaf lifespan, the stem elongation rate and the tiller population density, and it influenced positively the phyllochron and the leaf senescence rate. Probably, cuts at 20 cm height caused a high decapitation and death of the tillers. The worst growth conditions in addition to the blossom of this specie occurred during fall resulted in higher stem elongation rates and number of live leaves, and lower phyllochron, final leaf blade length, and leaf lifespan. The sward height can be used as a practical and efficient criterion in the management of andropogon grass. Under intermittent management conditions, the regrowth of andropogon grass must be interrupted when the sward reaches 50 cm height, and the defoliation must be interrupted when the stubble height is close to 27 cm.

Key Words: *Andropogon gayanus*, ecophysiology, light interception, morphogenesis, sward height

Características morfogênicas e estruturais do capim-andropógon submetido a diferentes alturas de corte

RESUMO - Este trabalho foi realizado com o objetivo de avaliar as características morfogênicas e estruturais da espécie *Andropogon gayanus* cv. Planaltina, submetida a três alturas de corte (20, 27 e 34 cm). As três alturas de corte foram alocadas às unidades experimentais (12 m^2) em delineamento de blocos completos casualizados com três repetições. Os cortes foram realizados quando a interceptação luminosa pelo dossel atingiu 95%. A altura do dossel nesse momento mostrou-se constante, com valores próximos a 50 cm. A menor altura de corte (20 cm) influenciou negativamente o comprimento final da lâmina foliar, o número de folhas vivas, a duração de vida da folha, a taxa de alongamento de colmo e a densidade populacional de perfilhos, e positivamente o filocrono e a taxa de senescência de folhas. Provavelmente, cortes a 20 cm de altura causaram elevada decapitação e morte de perfilhos. As piores condições de crescimento junto do florescimento ocorrido durante o outono resultaram em maiores taxas de alongamento de colmos e número de folhas vivas e em menor filocrono, comprimento final da lâmina foliar e duração de vida da folha. A altura do dossel pode ser utilizada como critério prático e eficiente de manejo do capim-andropógon. Em condições de manejo intermitente, a rebrotação deve ser interrompida quando o dossel atingir 50 cm de altura, e a desfolhação, quando a altura de resíduo ficar próxima de 27 cm.

Palavras-chave: altura do dossel, *Andropogon gayanus*, ecofisiologia, interceptação luminosa, morfogênese

Introduction

Andropogon grass, cv. Planaltina, is a caespitose plant originally from Africa and it is indicated for areas with a long dry season and low fertility, acidic soils. It was introduced in Brazil during the 1980s to form pastures in the Cerrado region as an alternative to *Brachiaria decumbens*, which, although adapted and widespread in the region, is susceptible to attacks by spittlebug (*Deois flavopicta* Stal) and it can cause photosensitization in cattle (Thomas et al., 1981). Recommendations for the management of this plant are scarce in the Brazilian literature and they have been

---

Received October 6, 2009 and accepted December 30, 2009.
Corresponding author: bmaiasousa@yahoo.com.br

based on defoliation intervals on fixed days or heights ranging from 1.0 to 3.0 m without control of sward structure, resulting in an excessive stem elongation and in an increase in senescence, which reduces biomass production and hinders animal consumption.

However, since late 1990s, the study of grazing management in Brazil has progressed significantly. This plant has been evaluated with a reductionist approach based on morphogenesis allied to a tight control of sward structure by frequency and severity of defoliation (Marcelino et al., 2006; Giacomini et al., 2009). This new approach has enabled the generation of more consistent information allowing a better understanding of the factors that regulate forage production on tropical pastures (Da Silva & Nascimento Jr., 2007).

Therefore, to know and to understand the dynamic of the growth and development of plants that compose the pastures, as well as their morphophysiological modifications in response to interfering agents, the search for higher and sustainable productivity of pasture production systems is essential. Thus, if properly managed, forage species not commonly used in the country, such as the andropogon grass, may gain importance in the productive system.

Many studies indicate that the optimal moment to interrupt regrowth coincides with the 95% light interception by the sward (Carnevalli et al., 2006; Barbosa et al., 2007). Nevertheles, the defoliation severity still needs to be adjusted to ensure a remaining leaf area to promote a fast and efficient regrowth without compromising the organic reserves of the plants or the structure of their swards.

This study aimed to evaluate the morphogenetic and structural characteristics of the gramineous plant *Andropogon gayanus* Kunth var. *bisquamulatus* (Hochst.) Hack cv. Planaltina submitted to three cutting heights.

Material and Methods

The study was carried out from November 2007 to November 2008 in a 108 m^2 area cultivated with *Andropogon gayanus* cv. Planaltina, in the Departamento de Zootecnia of Universidade Federal de Viçosa - UFV, Viçosa - MG (20º45' S; 42º51' W; 651 m). The climate is classified according to Köppen, as Cwa, subtropical with well-defined dry (winter) and rainy (summer) seasons. The climate data (Figure 1) were obtained at the UFV meteorological station, which is about 1,000 m from the experimental area. The monthly hydric balance (Figure 2) was calculated using water storage ability of 50 mm (Thornthwaite & Mather, 1955).

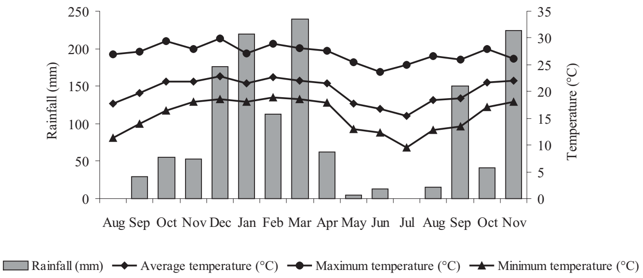


Figure 1 - Accumulated monthly rainfall, and minimum, medium, and maximum air temperature from August 2007 to November 2008.

The soil is classified as red-yellowish Acrisol with loam-clay texture (EMBRAPA, 1999). According to the results of the chemical analysis, which was performed in the beginning of the experimental phase, the layer from 0 to 20 cm presented the following characteristics: pH in H_2O = 5.2; P = 1.2 (Mehlich-1) and K = 22 mg/dm^3; Ca^{+2} = 2.5; Mg^{2+} = 0.5; Al^{3+} = 0.1; H+Al = 4.13; CTC (T) = 7.19 and CTC (t) = 3.16 cmol$_c$/dm^3; and V = 43%. The studied area suffered correctional processes in previous experiments, when a small amount of exchangeable aluminum was detected. The pH values were within the satisfactory range for the studied grass (CFSEMG, 1999).

It was assessed three cutting heights (20, 27 and 34 cm), which were performed consistently when the plants reached 95% of light interception during regrowth. The three cutting heights were allocated to the experimental units (12 m^2) in a complete randomized block design with three replications.

For fertilizing management, 50 kg/ha of phosphorous, 200 kg/ha of nitrogen and 100 kg/ha of potassium in the form of simple superphosphate, ammonium sulfate and potassium chloride were used, respectively. The potassium and nitrogen were separated into three and four applications, respectively, while phosphorous fertilization was accomplished in a single application.

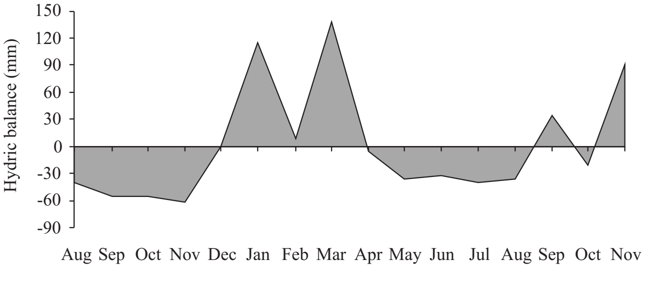


Figure 2 - Monthly hydric balance during the experimental period from August 2007 to November 2008.

Two cuts were performed at 20 cm from the soil (the lowest cutting height) in September and October in order to adapt the studied plant to defoliation. To improve grass growth, the first two doses of planned fertilization were applied at the same time to the cuts. In November, a new cut was performed in all plots at 20 cm height, and the third fertilization was performed. This procedure marked the beginning of the evaluations. After the end of the first regrowth cycle, each plot was lowered to its respective cutting height. In February, the last nitrogen dose was applied.

The monitoring of the light interception, foliage area index and foliage angle (leaves, stem and dead material) was performed after cutting and during pasture regrowth (every five days) until pre-cut. *Plant Canopy Analyzer LAI* 2000 (LI COR®) was used in two random spots per experimental unit. In each spot, one reading was performed above the sward, and five readings were performed at the soil surface (under the sward).

Sward height was measured concurrently to light interception evaluations by using a transparency sheet as reference and a centimeter-graduated ruler. Five readings were performed in each experimental unit. At each point of the four corners of the transparency sheet, the highest and the lowest height values were registered; the average height per point. The experimental unit average corresponded to the average of the readings in the five points of each plot.

To evaluate the morphogenetic and structural characteristics, ten tillers in each experimental unit was marked in the beginning of each regrowth period. Development of the tiller was monitored every two weeks by evaluating leaf blade elongation, pseudostem (stem and leaf sheaths) and leaf senescence. Based on these data, calculations of leaf elongation rate (cm/tiller.day), leaf senescence rates (cm/tiller.day), stem elongation rate (cm/tiller.day), phyllochron (days/leaf), final leaf blade length (cm), number of live leaves per tiller (leaves/tiller) and leaf lifespan (days/leaf) were done. The tiller population density (tillers/m^2) was obtained in the post-cut by counting the live tillers in two randomly chosen areas of 25 m^2 (0.25 m × 1.00 m) per experimental unit.

Data were organized according to different seasons. The morphogenetic and structural variables, which were monitored from November 2007 to June 2008, were grouped within each chosen period, generating representative means (weighted to the duration of the cutting cycles) in order to analyze the variance. The periods were defined as it follows: late spring (November and December); summer (January, February and March); and fall (April, May and June).

In the late fall, the morphogenetic and structural evaluations were accomplished. However, during this period, as most of the plots did not reach cutting conditions, light interception, sward height, foliage area index, and the foliage angle continued to be evaluated until the plants reached 95% of light interception. Due to restrictive conditions for plant growth during the winter (photoperiod, temperature, rainfall), the monitoring of these variables was extended until early spring. Therefore, either in post- or pre-cut, the data were grouped as it follows: late spring (November and December); summer (January, February and March); and fall-winter-early spring (from April to mid-November).

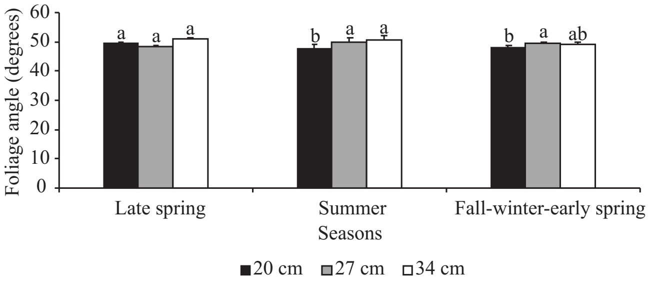
The data were submitted to variance analysis using PROC MIXED, SAS® software (*Statistical Analysis System*), version 8.2 for Windows®. All sets of data were tested to ensure that the basic prerogatives of analysis of variance would meet, and when necessary, data were transformed. Therefore, final leaf blade length and stem elongation rate were inverted to perform the analysis of variance; however, means of non-transformed values were presented in the results. Akaike’s Information Criterion (AIC) was used for choosing the variance and co-variance matrix (Wolfinger, 1993). Thus, the effects of main variation causes (cutting height and season) and the interaction between these causes could be detected. Fixed effects included cutting height, season and their interactions and variable effects included the block and its interactions (Littel et al., 2000). The means between treatments were estimated using LSMEANS and they were compared through probabilistic differences (PDIFF) using the t-Student test at 5% significance.

Results and Discussion

The elevation in the cutting height increased the light interception ($P<0.0001$) in the early regrowth period (68.8, 77.1 and 83.7% for heights of 20, 27 and 34 cm, respectively), which was probably due to larger remaining foliage area ($P<0.0001$) and smaller foliage angle ($P = 0.0186$), sward presenting more horizontal orientation, during this period. Higher cuts removed less forage, resulting in larger remaining foliage areas (1.66, 2.07 and 2.47 for heights of 20, 27 and 34 cm, respectively). In addition, more participation of leaves when compared to stems, as well as greater length of remaining leaves, favored a more horizontal disposition of the sward (smaller foliage angle) (67.7, 63.1 and 60.8º for heights of 20, 27 and 34 cm, respectively). Plants with leaves horizontally arranged intercept more light with lower leaf area index compared to those with more erect leaves

(Bernardes, 1987). These results corroborate those available in the literature for *Panicum maximum* cv. Mombaça (Carnevalli et al., 2006; Da Silva et al., 2009), *P. maximum* cv. Tanzânia (Barbosa et al., 2007; Difante et al., 2009), *Brachiaria brizantha* cv. Xaraés (Pedreira et al., 2007) and *B. brizantha* cv. Marandu (Trindade et al., 2007), indicating changes in the sward in response to management.

Because the conditions for cutting were the same for all heights, 95% of light interception, the foliage area index during the pre-cutting stage did not change (P>0.05), presenting values of approximately 3.87. During this period, the foliage angle was affected by the interaction between cutting height and season (P = 0.0065) so that cuts performed at 27 and 34 cm height showed higher foliage angle (more vertical orientation) (Figure 3) in the summer and fall-winter-early spring periods. Despite the lower final leaf blade length (Table 1), plots cut at 20 cm had lower tiller population density, which may have favored a more horizontal arrangement of tillers. Therefore, the interception of 95% of incident light was reached with a lower sward for the cutting height of 20 cm (48 cm) compared to the 27 and 34 cm (50 cm) (P = 0.0143). However, the difference of only 2 cm (4%) may be considered not significant, indicating that sward height strongly correlated to 95% of light interception at a value of approximately 50 cm. As it was stated in recent studies with tropical gramineous plants, especially the genera *Panicum* and *Brachiaria*, the relationship between sward height and light interception (Carnevalli et al., 2006; Barbosa et al., 2007; Da Silva et al., 2009; Difante et al., 2009; Trindade et al., 2007) is important because it enables the use of defoliation targets by height, which is the same approach for the management of temperate grasses (Hodgson, 1990; Hodgson & Da Silva, 2002).



Means followed by the same small letter did not differ (P>0.05).
Bar above the columns correspond to mean standard error.

Figure 3 - Pre-cutting foliage angles of andropogon grass submitted to cutting heights when they reach 95% of light interception during regrowth in three seasons.

The removal of aerial parts through cutting or grazing represents a stress to the plant whose magnitude depends on the severity of defoliation. Thus, the responses from the plant to defoliation must be understood as a mechanism of restoration and maintenance of growth patterns in which all available factors are used to form new photosynthesizing tissues (Lemaire & Chapman, 1996). During the regrowth period, competition for light gradually increases, reducing the quantity and modifying the quality of the light that reaches the inner part of the sward, which results in morphophysiological changes in the plants. Nevertheless, defoliation management based on interception of 95% of incident light prevents the intense competition for light, reducing both the accumulation of stems and leaves senescence. However, even before this condition, some leaf senescence and stem accumulation had already occurred.

The stem elongation rate was influenced by cutting height (P = 0.0072) and season (P<0.001). Cuts performed at 20 cm showed lower stem elongation rate (0.150 cm/tiller.day) compared to cuts performed at 27 cm (0.278 cm/tiller.day) and 34 cm (0.259 cm/tiller.day). The time when plants were cut to 20 cm coincided with the beginning of flowering; thus, cut was strategical and determined the occurrence of smaller tillers and also a lower stem elongation rate. The highest stem elongation rate was observed during the fall (0.503 cm/tiller.day) and the lowest one during late spring (0.091 cm/tiller.day) and summer (0.093 cm/tiller.day), which was obviously due to the blossoming of andropogon grass.

Additionally, interactions among cutting height and season for final leaf blade length (P = 0.0081), phyllochron (P = 0.0087) and leaf elongation rate (P = 0.0409) were observed. Regardless of the season evaluated, the lowest final leaf blade length (Table 1) was recorded for 20 cm cutting height. The final leaf blade length is a plastic characteristic that is responsive to the severity of defoliation (Briske, 1996), being the highest values associated to the greatest defoliation height due to the elevated leaf sheath length (Grant et al., 1981). During the fall, the lowest final leaf blade length was observed for all evaluated cutting heights, which was certainly due to lower phyllochron (Table 2) and leaf elongation rate (Table 2) during this period. Andropogon grass blossom, during this time, modified growth and development patterns of the plant. The acceleration of stem elongation causes the apical meristem to be located in a higher position on the tiller, allowing a fast emergence of the expanding leaves and a reduction in the phyllochron (Lemaire & Chapman, 1996; Duru & Ducrocq, 2000; Gomide & Gomide, 2000). Moreover, fall was characterized by hydric deficit and a decrease in average temperatures (Figures 1 and 2), resulting in restritive environmental conditions to plant growth and development, which, therefore, reduced the leaf elongation rate (Peacock, 1975). The combination of these factors contributed to the low final leaf blade length observed during this period.

Interactions between cutting heights and seasons to number of live leaves (P = 0.0028) and leaf lifespan (P<0.001) were observed. Regardless of the evaluated cutting heights, the highest number of live leaves (Table 1) was registered during fall. This is probably due to the elevation of the apical meristem, which consequently reduces the phyllochron (Table 2) and increases the number of live leaves in the tiller during this period. Therefore, the lowest leaf lifespan (Table 2) presented during the fall is consistent with the low phyllochron values because the number of live leaves is genetically determined and it has a relatively constant value (Davies, 1988; Marcelino et al., 2006; Oliveira et al., 2000). Thus, the reduction in leaf lifespan in the fall would be a method to keep the number of live leaves relatively stable. However, despite the occurrence of this adjustment, the number of live leaves is subjected to variations due to environmental conditions and pasture management (Lemaire & Chapman, 1996), which may explain its higher value during the fall. For all seasons evaluated, the number of live leaves was lower at the 20 cm cutting height, which was certainly due to lower leaf lifespan and higher leaf senescence rates (P = 0.0104) (0.564, 0.508 and 0.417 cm/tiller/day for cutting heights of 20, 27 and 34 cm, respectively).

Table 1 - Structural characteristics of andropogon grass submitted to cutting heights when they reach 95% of light interception during regrowth

Season	Cutting height (cm)		
	20	27	34
	Final leaf blade length (cm)*		
Late spring	16.8Ca	18.2Ba	19.8Aa
	(0.43)	(0.43)	(0.43)
Summer	16.2Ba	17.7Aa	17.8Ab
	(0.58)	(0.58)	(0.58)
Fall	13.7Cb	16.3Ab	15.5Bc
	(0.34)	(0.34)	(0.34)
	Number of live leaves (leaf/tiller)		
Late spring	3.13Ba	3.36Abc	3.76Ac
	(0.105)	(0.105)	(0.105)
Summer	2.98Cb	3.66Bb	4.34Ab
	(0.110)	(0.110)	(0.110)
Fall	3.55Cab	4.84Ba	5.88Aa
	(0.158)	(0.158)	(0.158)

Means followed by the same small letter in the columns and capital letter in the rows did not differ (P>0.05).
Numbers in parentheses correspond to the standard error of the mean interaction
*ANOVA performed in transformed data (inverse).

The tiller population density was affected by cutting height (P = 0.0180) and season (P = 0.0043). The highest tiller population density values were registered in the late spring (1,277 tillers/m^2) and reduced with the advance of summer (1,048 tillers/m^2) and fall (1,144 tillers/m^2). The higher values in the late spring may be an effect of the fertilization performed from September to November 2007, because nitrogen promotes the increase of tiller numbers (Mazzanti et al., 1994; Fagundes et al., 2006) and it also favors a greater ability to form axillary buds, which would potentially originate new tillers (Da Silva & Nascimento Jr., 2007; Euclides, 2008). The highest tiller population density values were recorded for the cutting heights of 34 (1,181 tillers/m^2) and 27 cm (1,196 tillers/m^2) and the lowest for 20 cm (1,091 tillers/m^2). Cutting height of 20 cm probably caused high decapitation and death of the tillers.

Overall, plants cut at 20 cm height showed lower final leaf blade length (Table 1), number of live leaves (Table 1), leaf lifespan (Table 2), stem elongation rate, tiller population density and higher leaf senescence rate, regardless of the evaluated season. It is possible that the 20 cm cutting height was very drastic, causing high decapitation and death of tillers, which resulted in a decrease of growth rates and an increase of senescence at the beginning of regrowth. Moreover, few morphogenetic alterations were observed

Table 2 - Morphogenetic characteristics of andropogon grass submitted to cutting heights when they reach 95% of light interception during regrowth

Season	Cutting height (cm)		
	20	27	34
	Phyllochron (days/leaf)		
Late spring	11.0Bb	12.5Aa	10.9Bb
	(0.21)	(0.21)	(0.21)
Summer	13.2Aa	13.6Aa	12.8Aa
	(0.46)	(0.46)	(0.46)
Fall	10.7Aa	7.5Bb	6.1Bc
	(0.80)	(0.80)	(0.80)
	Leaf elongation rate (cm/tiller.day)		
Late spring	2.68Aa	2.81Aa	3.34Aa
	(0.382)	(0.382)	(0.382)
Summer	2.50Aa	2.93Aa	3.23Aa
	(0.334)	(0.334)	(0.334)
Fall	1.77Cb	2.71Ba	3.71Aa
	(0.227)	(0.227)	(0.227)
	Leaf lifespan (days/leaf)		
Late spring	34.5Bb	41.9Ab	40.7Ab
	(0.47)	(0.47)	(0.47)
Summer	39.4Ba	49.6Aa	55.4Aa
	(1.87)	(1.87)	(1.87)
Fall	37.9Aa	30.0Bc	35.8Ac
	(0.75)	(0.75)	(0.75)

Means followed by the same small letter in the columns and capital letter in the rows did not differ (P>0.05).
Numbers in parentheses correspond to the standard error of the mean interaction.

between the cutting heights of 27 and 34 cm. Montagner (2007), who analyzed the mombaça guinea grass under different severities of grazing that were all performed when the sward reached 95% light interception, reported no significant differences in the morphogenetic and structural characteristics among grazing heights. This fact indicates that the defoliation frequencies, and not the severity, could be more decisive in promoting alterations in the morphogenetic characteristics of the tillers. Thus, the choice for defoliation severity may vary according to productivity, desired grazing efficiency (Difante et al., 2009), level of soil fertility and use of fertilizers (Da Silva & Nascimento Jr., 2007; Da Silva et al., 2008).

Conclusions

A sward height close to 50 cm is a good parameter to interrupt defoliation because it is strongly related to the interception of 95% of incident light, making it an efficient and practical guide for andropogon grass management. A cutting height of 20 cm may be drastic for the andropogon grass when it is submitted to management in which 95% of incident light is intercepted by the sward. Under conditions of intermittent defoliation, the regrowth of andropogon grass can be interrupted at 50 cm leaving a stubble height of 27 cm to provide maximum efficiency.

Acknowledgements

Thanks to CNPq and to Departamento de Zootecnia of Universidade Federal de Viçosa the given opportunity and sponsorship for first author. Thanks are also for the teammates: Salim Jacaúna de Souza Júnior, Karina Ellen Matias de Oliveira, Rodrigo Soares Ramos, Filipe Velten Silva and Felipe Borges Carneiro, for their help in carrying out the research project.

References

BARBOSA, R.A.; NASCIMENTO JR., D.; EUCLIDES, V.B.P. et al. Capim-tanzânia submetido a combinações entre intensidade e frequência de pastejo. **Pesquisa Agropecuária Brasileira**, v.42, n.3, p.329-340, 2007.

BERNARDES, M.S. Fotossíntese no dossel das plantas cultivadas. In: CASTRO, P.R.C.; FERREIRA, S.O.; YAMADA, T. (Eds.). **Ecofisiologia da produção agrícola**. Piracicaba: Associação Brasileira de Pesquisa de Potassa e do Fosfato, 1987. p.13-48.

BRISKE, D.D. Strategies of plant survival in grazed systems: a functional interpretation. In: HODGSON, J.; ILLIS, A.W. (Eds.). **The ecology and management of grazing systems**. Wallingford: CAB International, 1996. p.37-68.

COMISSÃO DE FERTILIDADE DO SOLO DO ESTADO DE MINAS GERAIS - CFSEMG. **Recomendações para o uso de corretivos e fertilizantes em MINAS GERAIS**: 5ª Aproximação. RIBEIRO, A.C. et al. (Eds.). Viçosa, MG: UFV, 1999. 359p.

CARNEVALLI, R.A.; DA SILVA, S.C.; BUENO, A.A.O. et al. Herbage production and grazing losses in *Panicum maximum* cv. Mombaça under four grazing managements. **Tropical Grasslands**, v.40, p.165-176, 2006.

DAVIES, A. The regrowth of grass swards. In: JONES M.B.; LAZEMBY A. (Eds.). **The grass crop**: **The physiological basis of production**. London: Chapman and Hall, 1988. p.85-127.

DA SILVA, S.C.; BUENO, A.A.O.; CARNEVALLI, R.A. et al. Sward structural characteristics and herbage accumulation of *Panicum maximum* cv. Mombaça subjected to rotational stocking managements. **Scientia Agricola**, v.66, n.1, p.8-19, 2009.

DA SILVA, S.C.; NASCIMENTO JR., D. Avanços na pesquisa com plantas forrageiras tropicais em pastagens: características morfofisiológicas e manejo do pastejo. **Revista Brasileira de Zootecnia**, v.36, n.4, p.121-138, 2007 (supl. especial).

DA SILVA, S.C.; NASCIMENTO JR., D.; EUCLIDES, V.B.P. **Pastagens: Conceitos básicos, produção e manejo**. Viçosa, MG: Suprema, 2008. 115p.

DIFANTE, G.S.; NASCIMENTO JR., D.; EUCLIDES, V.P.B. et al. Sward structure and nutritive value of tanzânia guineagrass subjected to rotational stocking managements. **Revista Brasileira de Zootecnia**, v.38, n.1, p.9-19, 2009.

DRUDI, A.; FAVORETTO, V. Influência da frequência, época e altura de corte na produção e na composição química do capim-andropógon. **Pesquisa Agropecuária Brasileira**, v.22, p.1287-1292, 1987.

DURU, M.; DUCROCQ, H. Growth and senescence of the successive grass leaves o a tiller ontogenic development and effect of temperature. **Annals of Botany**, v.85, p.635-643, 2000.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. Serviço Nacional de Levantamento e Conservação de Solos. **Sistema brasileiro de classificação de solos**. Brasília: Embrapa Produção e Informação, 1999. 412p.

FAGUNDES, J.L.; FONSECA, D.M.; MORAIS, R.V. et al. Avaliação das características estruturais do capim-braquiária em pastagens adubadas com nitrogênio nas quatro estações do ano. **Revista Brasileira de Zootecnia**, v.35, n.1, p.30-37, 2006.

GIACOMINI, A.A.; DA SILVA, S.C.; SARMENTO, D.O.L. et al. Growth of marandu palisadegrass subjected to strategies of intermittent stocking. **Scientia Agricola**, v.66, n.6, p.733-741, 2009.

GOMIDE, C.A.M.; GOMIDE, J.A. Morfogênese de cultivares de *Panicum maximum* Jacq. **Revista Brasileira de Zootecnia**, v.29, n.2, p.341-348, 2000.

GRANT, S.A.; BARTHRAM, G.T.; TORVEL, L. Components of regrowth in grazed and cut *Lolium perenne* swards. **Grass and Forage Science**, v.36, p.155-168, 1981.

HODGSON, J. **Grazing management**: science into practice. New York: John Wiley and Sons, 1990. 203p.

HODGSON, J.; DA SILVA, S.C. Options in tropical pasture management. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 39., 2002, Recife. **Anais...** Recife: SBZ, 2002. p.180-202.

LEMAIRE, G.; CHAPMAN, D. Tissue flows in grazed plant communities. In: HODGSON, J.; ILLIUS, A.W. (Eds.). **The ecology and management of grazing systems**. Wallingford: CAB International, 1996. p.3-36.

LITTEL, R.C.; PENDERGAST, J.; NATARAJAN, R. Modelling covariance structure in the analysis of repeated measures data. **Statistics in Medicine**, v.19, p.1793-1819, 2000.

MARCELINO, K.R.A.; NASCIMENTO JR., D.; DA SILVA, S.C. et al. Características morfogênicas e estruturais e produção de forragem do capim-marandu submetido a intensidades e frequências de desfolhação. **Revista Brasileira de Zootecnia**, v.35, n.6, p.2243-2252, 2006.

MAZZANTI, A.; LEMAIRE, G.; GASTAL, F. The effect of nitrogen fertilization upon herbage production of tall fescue swards grazed by shepp. 1. Herbage growth dynamics. **Grass and Forage Science**, v.49, p.111-120, 1994.

MONTAGNER, D.B. **Morfogênese e acúmulo de forragem em capim-mombaça submetido a intensidades de pastejo rotativo**. 2007. 60f. Tese (Doutorado em Zootecnia) - Universidade Federal de Viçosa, Viçosa, MG.

OLIVEIRA, M.A.; PEREIRA, O.G.; MARTINEZ Y HUAMAN, C.A. et al. Características morfogênicas e estruturais do capim-bermuda "Tifton 85" (*Cynodon* spp.) em diferentes idades de rebrota. **Revista Brasileira de Zootecnia**, v.29, n.6, p.1939-1948, 2000 (supl.).

PEACOCK, J.M. Temperature and leaf growth in *Lolium perene*. 1. The thermal microclimate: its measurement and relation to plant growth. **Journal of Applied Ecology**, v.12, p.115-123, 1975.

PEDREIRA, B.C.; PEDREIRA, C.G.S.; DA SILVA, S.C. Estrutura do dossel e acúmulo de forragem de *Brachiaria brizantha* cv. Xaraés em resposta a estratégias de pastejo. **Pesquisa Agropecuária Brasileira**, v.42, n.2, p.281-287, 2007.

THOMAS, D.; DE ANDRADE, R.P.; COUTO, W. et al. *Andropogon gayanus* var. *Bisquamulatus* cv. Planaltina: principais características forrageiras. **Pesquisa Agropecuária Brasileira**, v.16, n.3, p.347-355, 1981.

THORNTHWAITE, C.W.; MATHER, R.J. **The water balance**. New Jersey: Laboratory of Climatology, v.8, 1955. 104p.

TRINDADE, J.K.; DA SILVA, S.C.; SOUZA JR., S.J. et al. Composição morfológica da forragem consumida por bovinos de corte durante o rebaixamento do capim-marandu submetido a estratégias de pastejo rotativo **Pesquisa Agropecuária Brasileira**, v.42, n.6, p.883-890, 2007.

WOLFINGER, R.D. Covariance structure selection in general mixed models. **Communications in Statistics Simulation and Computation**, v.22, n.4, p.1079-1106, 1993.