Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v37i3.27101

Morphogenesis in pastures with Tanzania grass fertilized with nitrogen doses under a grazing system

Cecilio Viega Soares Filho[1*], Ulysses Cecato[2], Ossival Lolato Ribeiro[3], Claúdio Fabrício da Cruz Roma[4] and Tatiane Beloni[4]

*[1]Departamento de Apoio, Produção e Saúde Animal, Faculdade de Medicina Veterinária, Universidade Estadual Paulista "Júlio de Mesquita Filho", Rua Clóvis Pestana, 793, 16050-680, Araçatuba, São Paulo, Brazil. [2]Departamento de Zootecnia, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. [3]Departamento de Zootecnia, Universidade Federal Rural da Bahia, Cruz das Almas, Bahia, Brazil. [4]Programa de Pós-graduação em Zootecnia, Departamento de Zootecnia, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. *Author for correspondence. E-mail: cecilio@fmva.unesp.br*

ABSTRACT. The morphogenetic and structural characteristics, coupled to forage production of Tanzania grass with nitrogen (N) doses during the seasons of the year, at intermittent grazing, were analyzed. The experimental design consisted of a totally randomized block with split plots and four replications. The plots comprised 0, 150, 300 and 450 kg ha^{-1} N levels, whereas the sub-plots were the seasons. Urea was applied three times on the pasture and had a positive effect on the rates of leaf elongation and emergence and on the number of live leaves of Tanzania grass in the spring and summer. High nitrogen fertilization associated with shorter grazing intervals triggered a higher percentage of leaf blades in the management of Tanzania grass under rotational stocking at a height of 70 cm on the admittance of animals for grazing and their exit at 30 cm stubble height.

Keywords: *Panicum maximum,* grazing, leaf appearance rate, leaf elongation rate, urea.

Morfogênese em pastagens de capim-Tanzânia fertilizadas com doses de nitrogênio em pastejo

RESUMO. O objetivo do trabalho foi estudar as características morfogenéticas do *Panicum maximum* Jacq cv. Tanzânia sob o efeito de doses crescentes de nitrogênio (N) nas estações do ano, em pastejo intermitente. O delineamento experimental utilizado foi de blocos completos ao acaso, com parcelas subdivididas no tempo, com quatro repetições. Nas parcelas, encontravam-se as doses de N (0, 150, 300 e 450 kg ha^{-1} de N) e, nas subparcelas, as estações do ano (outono, inverno, primavera e verão). A adubação nitrogenada exerceu efeito positivo nas taxas de alongamento e aparecimento foliar, e no número de folhas vivas em plantas de capim-Tanzânia nas estações da primavera e verão. Elevadas adubações nitrogenadas associadas a intervalos menores de pastejo promovem maior porcentagem de lâmina foliar, no manejo de pastos de capim-Tanzânia em lotação rotacionada com altura de 70 cm na entrada dos animais para o pastejo e saída com 30 cm de altura do resíduo.

Palavras-chave: *Panicum maximum*, pastagem, taxa aparecimento foliar, taxa de alongamento foliar, ureia.

Introduction

Since grazing is the most practical and economical way to feed ruminants within the context of feed production modes, it should be specially focused for animal production at lower costs and made more competitive when compared to other agricultural and cattle-breeding activities (Silva et al., 2010). Full information of the forage species and its responses to environment and management, in particular, is required (Moreira et al., 2004).

Pasture structure is the distribution and arrangement of the components of the forage plant's aerial part within a community (Martuscello et al., 2005, 2006). Its analysis requires knowledge on the manner the vegetal community receives the benefits of the available abiotic resources (light, water and nutrients) and how the animal exploits the production provided. Therefore, information on the dynamics of growth and development of plants on pastureland and their morpho-physiological responses to influencing factors makes it easy to manage grazing aimed at the sustainability of the production system with high productivity of plant and animal components within the eco-physiological limits of foragers (Sbrissia et al., 2001).

Nitrogen (N) in pasture management practices brings the best production increase since it is the most important macro nutrient for growth and development of pastures. It provides the plant with a faster growth, increase in number, weight and size of shoots and foliar area index (Pereira et al., 2011).

According to Fagundes et al. (2006) growth and endurance of grass are often limited by the soil's N deficiency since the nutrient accelerates the initiation and expansion rate of new leaves and increases the shoot's strength. Consequently, a greater biomass production ensues and the supporting capacity of pastures is guaranteed.

In Brazil, research on Mombaça (Garcez Neto et al., 2002) and Tanzânia (Oliveira et al., 2007) grass showed a significant effect of nitrogen fertilization on leaf-emergence (LER) and leaf lengthening (LLR) rates.

Current paper evaluates the effect of nitrogen doses on the morphogenic characteristics of pasture with *Panicum maximum* cv. Tanzania, under intermittent grazing during the four seasons.

Materials and methods

Current experiment was conducted at Iguatemi Experimental Farm (FEI) of the State University of Maringá, Maringá, Paraná State, Brazil, at 23°25'S and 51°57'W, average altitude 550 m. By Köppen's classification, the region's predominant climate is Cfa, or rather, subtropical hot, mesothermal climate, with a yearly average temperature of 22°C. The experiment was conducted between March 2007 and March 2008. Climate data are given in Figure 1.

The experiment was performed on pastureland with *Panicum maximum* Jacq. cv. Tanzania, with excellent plants and the required infrastructure, such as troughs and hedges. Soil (0-20 cm), classified as dystrophic red latosol, was chemically analyzed at the start of the experiment, featuring pH ($CaCl_2$) = 4.8; P (mg dm^{-3}) = 9.0; K ($cmol_c$ dm^{-3}) = 0.09; Ca^{2+} ($cmol_c$ dm^{-3}) = 1.02; Mg^{2+} ($cmol_c$ dm^{-3}) = 0.72; H+Al ($cmol_c$ dm^{-3}) = 2.94; SB ($cmol_c$ dm^{-3}) = 1.85; CTC ($cmol_c$ dm^{-3}) = 4.79; V (%) = 38.62.

The experimental design was totally randomized, with four replications, arranged in split plots, with repeated time measurements. Main plots comprised N doses of 0, 150, 300 and 450 kg ha^{-1}, with the sub-plot as the seasons of the year (autumn, winter, spring and summer). Application of treatments was analyzed during harvest throughout the period of pasture assessment.

Phosphate fertilization with 40 kg ha^{-1} P_2O_5 as simple superphosphate occurred at the first nitrogen fertilization. Correction of acidity with limestone for 60% saturation was undertaken separately from nitrogen fertilization to avoid N loss. Three nitrogen applications were undertaken, or rather, in autumn (18/Apr/2007), in spring (12/Nov/2007) and summer (24/Jan/2008), with urea as N source. Potassium fertilization was applied together with the first N application at 60 kg ha^{-1} K_2O, with potassium chloride. Fertilization was done after the exit of the animals from the plot.

The experiment was conducted on a 1,600 m^2 area divided into 16 paddocks measuring 100 m^2, with a drinking tough for two paddocks, separated by an aisle for easy movement of animals towards the center. Each plot was grazed with an intermittent pasture system, maximum of one day and a half, whereas the fallow period varied according to treatments. Entrance of animals occurred when pasture grass reached approximately a height of 70 cm and exited when the stubble was 30 cm. Calves, average 300 kg of live weight, were used in the experiment for pasture management.

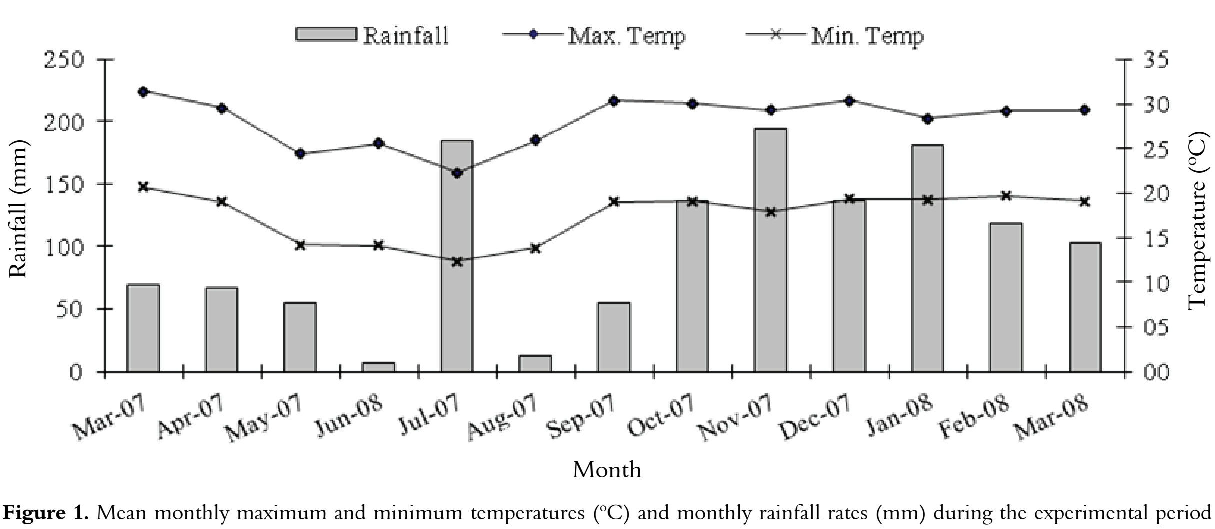

Figure 1. Mean monthly maximum and minimum temperatures (°C) and monthly rainfall rates (mm) during the experimental period (2007/2008). Source: Laboratório de Sementes da FEI.

There was a weekly measurement of plant height in the experimental plots by a graded ruler (20 points per plot) till pasture reached approximately 70 cm above the ground. Ten shoots were marked by wires to represent pasture so that the morphogenic characteristics could be evaluated: five lay within the clump and five around it during pasture re-growth. Shoots were selected three days after the lowering of the grass by the animals. The length of the leaf blades and the height of the ligule of the initially expanded first leaf were measured. Leaf blades and the number of new leaves from each shoot were measured twice a week. Measurements were undertaken on the pasture till it reached approximately 70 cm above the ground when the wires were removed and the grass was once more lowered by the animals for the marking of new shoots. The following variables were calculated: leaf emergence rate (LER) in leaf $shoot^{-1}$ day^{-1}; phyllochron (FIL)(inverse of leaf emergence rate) in days $leaf^{-1}$ $shoot^{-1}$; leaf lengthening rate (LLR) in cm $shoot^{-1}$ day^{-1}; leaf senescence rate (LSR) in cm day^{-1}; number of live leaves (NLL), count of number of non-senescent live leaves; life duration of live leaves (DLL) in days; stem lengthening rate (SLR) in cm $shoot^{-1}$ day^{-1}; final length of leaf blade (FLLB) in cm.

Data were tested for errors and homogeneity of variances and statistical analysis were undertaken with SAS 9.1 (SAS, 2004), within the GLM procedure for the time subdivision plots. N doses were the main treatments and the seasons as the sub-plots. Means were compared by F test and SNK mean test at 5% significance level. Regression analysis was undertaken according to N doses.

Results and discussion

Interaction between the seasons and N doses occurred only in Leaf Emergence Rate (LER) and Leaf lengthening Rate (LLR) for the evaluation of the morphogenic characteristics of Tanzania grass. Highest LER rates occurred in spring and summer and the lowest during the winter, mainly due to the ideal temperature for grass growth (Figure 1). Effects of N doses and seasons revealed different types of behavior (Table 1 and Figure 2a). N doses had a linear effect on LER, with doses 300 and 450 kg ha^{-1} N higher during autumn (Table 2). Rates varied between 0.035 (without nitrogen fertilization) and 0.087 leaves $shoot^{-1}$ day^{-1} (300 kg ha^{-1} N), with 57% increase in the variable when compared to lack of N in the application. This fact demonstrated N as an enhancer of leaf growth due to a great accumulation of nitrogen in the cell division zone (Cabrera-Bosquet et al., 2009). According to Duru & Ducrocq (2000), the effect of N on LER may be the result of a combination of factors such as sheath length, leave lengthening and temperature. In their research with four N doses (0, 50, 100 and 200 mg dm^{-3}) and three cutting intensities (5, 10 and 20 cm) in Mombaça grass, Garcez Neto et al. (2002) reported up to 104% increase in the variable. LLR rates were higher than those provided by Lopes et al. (2013) for Massai grass, with a 78% increase for this variable.

As a rule, Tanzania grass failed to respond positively to N fertilization mainly during spring and summer. This fact was probably due to the parceling of N application which was insufficient to increase LER and LLR, whereas the variations between the seasons were due to abiotic factors (Pereira et al., 2011). In current experiment, data were lower than those by Martuscello et al. (2005) who reported an increase of the variable in Tanzania and Xaraés grass in hothouses when compared to rates in N-less applications.

Table 1. Mean rates of leaf emergence (leaves $shoot^{-1}$ day^{-1}) and mean rate of leaf lengthening (cm $shoot^{-1}$ day^{-1}) of Tanzania grass according to N doses in different seasons.

Seasons	N doses (kg ha^{-1})			
	0	150	300	450
Leaf Emergence Rate (leaves $shoot^{-1}$ day^{-1})				
Autumn 2007	0.035 Bb	0.040 Bb	0.087 Aa	0.082 Aa
Winter 2007	0.042 Ba	0.045 Ba	0.027 Bb	0.027 Bb
Spring 2007	0.078 Aa	0.070 Aa	0.085 Aa	0.085 Aa
Summer 2007/8	0.068 Aa	0.072 Aa	0.072 Aa	0.075 Aa
Leaf lengthening Rate (cm $shoot^{-1}$ day^{-1})				
Autumn 2007	1.632 Bc	2.032 Bc	3.650 Ab	4.335 Aa
Winter 2007	1.580 Ba	1.440 Ba	0.882 Bb	1.110 Bc
Spring 2007	4.133 Aa	4.368 Aa	5.332 Aa	5.557 Aa
Summer2008	3.770 Aa	4.518 Aa	4.496 Aa	4.727 Aa

Means followed by different capital letters in the column and by lower case letters in the line do not differ by SNK test ($p < 0.05$).

Table 2. Regression equations for LER, LLR and SLR of Tanzania grass according to N doses and season.

Season	Adjusted equation	R^2
	LER (leaves $shoot^{-1}$ day^{-1})	
Autumn	$\hat{Y} = -1E\text{-}07x^2 + 0.0002x + 0.0303$ **	0.80
Winter	$\hat{Y} = -3E\text{-}08x^2 - 3E\text{-}05x + 0.044$ **	0.73
Spring	$\hat{Y} = 9E\text{-}08x^2 - 2E\text{-}05x + 0.0761$	0.53
Summer	$\hat{Y} = -1E\text{-}08x^2 + 2E\text{-}05x + 0.0683$	0.90
	LLR (cm.$shoot^{-1}$.day^{-1})	
Autumn	$\hat{Y} = 3E\text{-}06x^2 + 0.0051x + 1.5245$ **	0.95
Winter	$\hat{Y} = 4E\text{-}06x^2 - 0.0032x + 1.6402$ *	0.76
Spring	$\hat{Y} = -1E\text{-}07x^2 + 0.0035x + 4.0596$	0.93
Summer	$\hat{Y} = -6E\text{-}06x^2 + 0.0045x + 3.8212$	0.90
	SLR (cm.$shoot^{-1}$.day^{-1})	
N doses	$\hat{Y} = -1E\text{-}06x^2 + 0.0005x + 0.1791$ **	0.46

** $p < 0.01$; * $p < 0.05$.

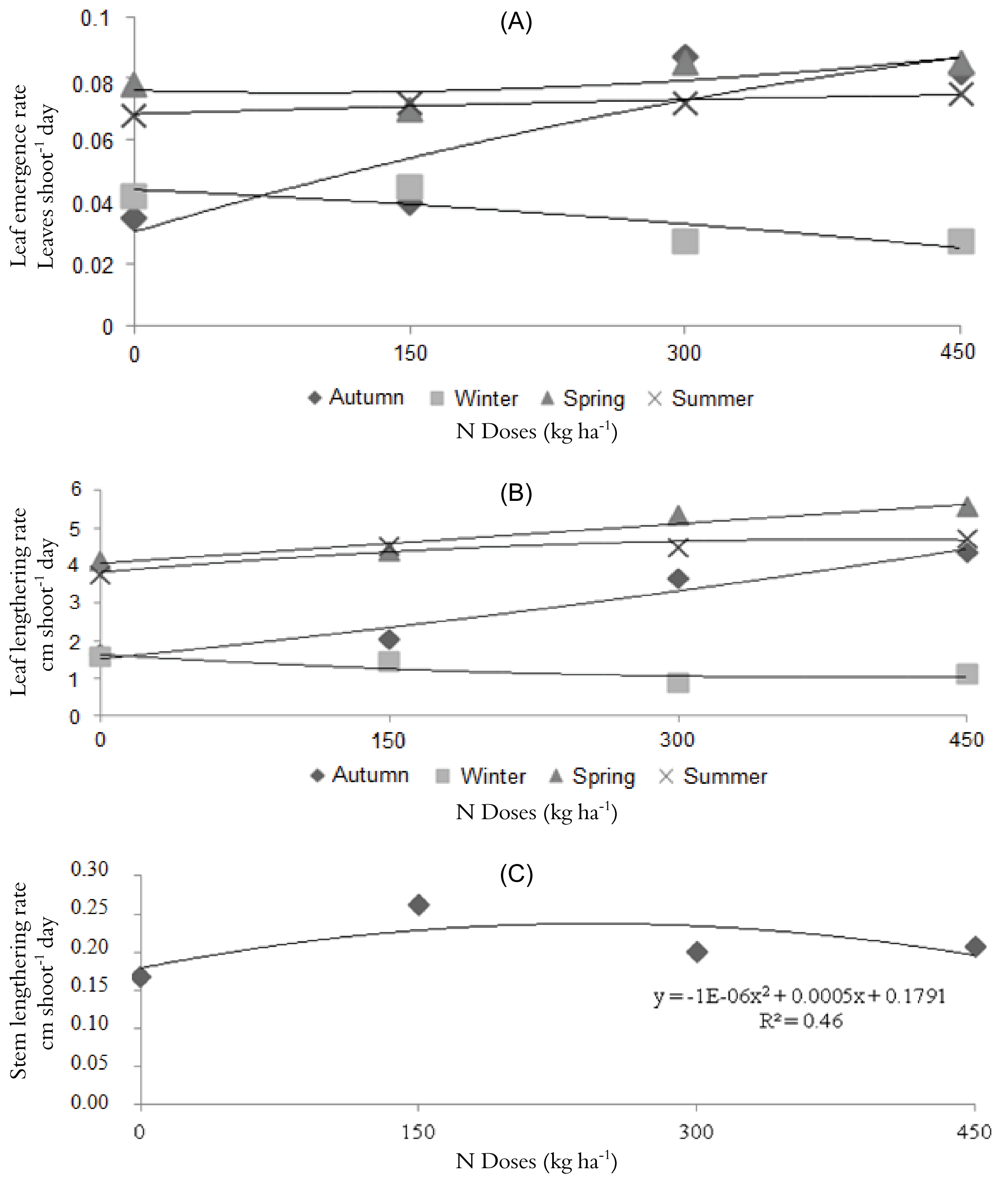

Figure 2. (a) Leaf Emergence Rate (leaves shoot^{-1} day^{-1}); (b) Leaf Lengthening Rate (cm shoot^{-1} day^{-1}); (c) Stem Lengthening Rate (cm shoot^{-1} day^{-1}) of Tanzania grass according to N doses and seasons.

LLF was greatly affected by the season of the year, such as spring and summer, with higher rates during periods of high availability of growth factors (Table 1 and Figure 2b). However, LLF did not vary according to N doses during spring and summer. In their research on Mombaça grass, Santos et al. (2004) reported higher LLF rates than those in current assay, or rather, 1.82; 1.5; 6.58 and 9.51 cm shoot^{-1} day^{-1}, respectively during autumn, winter, spring and summer. Current research evidenced the seasonality of LLRs which were higher during periods of high temperature and rainfall rates. Forage production proved this fact since the grass grows at an optimal temperature of 30-35ºC. In the case of Tanzania grass, Mendonça & Rassini (2006) registered that basal development temperature was 15°C and reported that 86% of Tanzania grass production was concentrated in the period with the highest temperature and rainfall rates.

There was a 25% LLR increase for the highest N dose (450 kg ha^{-1} N) due to the lack of nitrogen fertilization during summer. LLR is the most affected morphogenic characteristic by N fertilization (Garcez Neto et al., 2002; Lopes et al., 2013; Magalhães et al., 2013; Martuscello et al., 2005, 2006; Oliveira et al., 2007). Leaf lengthening in grasses is restricted to the zone at the base of the expanding leaf which is protected by the pseudostem (Skinner & Nelson, 1995). The plant's capacity in lengthening its leaves depends on the lengthening rate of the intercalating meristem (cell division zones). The lengthening zone is an active site intensively demanding nutrients (Skinner & Nelson, 1995). Consequently, the positive response of Tanzania grass to nitrogen fertilization is due to the great accumulation of N in the leaves' cell division zone.

A significant effect for SLR was only reported for N doses (Table 2 and Figure 2c). Higher SLR rates were registered during the summer (0.33 cm shoot^{-1} day^{-1}) when compared to spring (0.10 cm shoot^{-1} day^{-1}). In mean N doses, SLR was higher in fertilized plants (0.21 cm shoot^{-1} day^{-1}) that in N-less treatments (0.17 cm shoot^{-1} day^{-1}). The above indicates that fertilization with N enhanced the lengthening of the stem (Pereira et al., 2011). Data show a trend that N fertilization (doses 300 and 450 kg ha^{-1}) at shorter grazing periods is an important tool in the control and development of stems and consequently of the forage canopy structure (Figure 3).

Since the relationship between LLR and LER determines the final length of the leaf blade (FLLB), LLR and LER variations due to fertilization management and de-leafing frequency or climate fluctuations cause variations in FLLB. No interaction occurred for FLLB between the seasons and N doses; it was only significant for the seasons (Table 3). In fact, treatments with higher N doses were grazed less often (Figure 3) and thus shortened the length of the leaf sheath, probably due to a reduction of the cell multiplication phase, causing a similar FLLB (Duru & Ducrocq, 2000). FLLB varied according to the seasons: the highest rates of leaf blade length were registered during the autumn, perhaps due to rainfall during the period (Figure 1) associated to N fertilization which caused the pasture management to be extended till leaf lengthening and FLLB decreased.

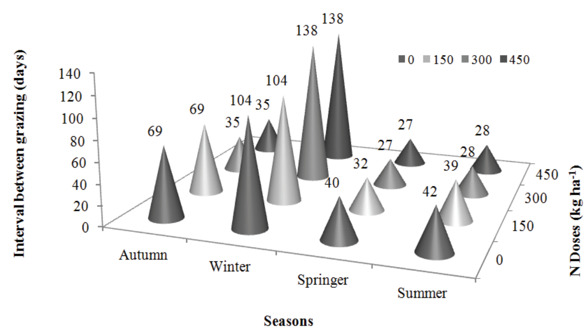

Figure 3. Interval between grazing (days) during the experimental period for Tanzania grass at different N doses according to the seasons of the year.

FLLB had an inverse behavior from LLR. In other words, LLR increase with an increase of N doses was positively associated. However, FLLB failed to respond to N doses applied. Highest LLR rates in spring and summer for doses 300 and 450 kg ha^{-1} N did not cause an increase in FLLB due to a shorter interval between grazing (Figure 3). In their research on Andropogon grass, Magalhães et al. (2013) had a positive response for the two parameters evaluated due to irrigation and nitrogen doses. Castagnara et al. (2014) assessed Tanzania, Mombaça and Mulato grass with 0, 40, 80 and 160 kg ha^{-1} N doses and morphogenetic characteristics failed to have any significant effect on Pearson's linear co-relationships between FLLB and LLR.

Only the seasons affected the phyllochron. Highest phyllochron rate occurred in the winter ($p < 0.05$) and the lowest in spring and summer (Table 3). Phyllochron tended to decrease linearly according to N doses and thus corroborating results by Martuscello et al. (2006). In their research on N fertilization of Massai grass, these authors reported decrease in the phyllochron during spring and summer.

Table 3. Means of final length of leaf blade (FLLB, cm), phyllochron (days leaf^{-1} shoot^{-1}), number of live leaves (NLL), duration of live leaves (DLL, days) and leaf senescence rate (LSR, cm day^{-1}) of Tanzania grass according to the seasons of the year.

Seasons	FLLB (cm/folha)	Phyllochron (dia/folha)	NLL (folhas/perf.)	DLL (dias)	LSR perfilho.dia^{-1})
Autumn 2007	29.56 a	19.63 b	3.61 b	70.05 b	----
Winter 2007	25.85 b	30.62 a	3.73 b	114.67 a	----
Spring 2007	25.87 b	13.24 c	4.94 a	65.41 b	0.51 a
Summer2007/8	25.19 b	14.46 c	4.79 a	66.21 b	0.53 a

Means followed by different small case letters in the column differ by SNK test ($p < 0.05$).

The number of green leaves per shoot (NGLS) varied significantly for each season (Table 3). Highest NGLS rates were reported in the spring and summer when compared to rates for the other seasons. However, there was no difference between them and, within experimental conditions, no effects due to N doses occurred. On the other hand, Silveira & Monteiro (2007) and Castagnara et al. (2014) reported that N doses positively affected NGLS of Tanzania, Mombaça and *Brachiaria* sp. hybrid Mulato grass under analysis.

There was a significant effect on DLL for the seasons of the year (Table 3). N doses did not differ and tended to be higher for pastures without N fertilization (75 days) than those with 450 kg ha^{-1} N (69 days). DLL was higher during the winter when compared to rates in other seasons. A decrease of 48 days occurred in DLL between winter and summer. Results showed that plants without N kept their live leaves for a longer period to the detriment of the expansion of new leaves. Results for DLL decrease with N doses may be due to a greater renewal of tissues in nitrogen-fertilized plants (Janaina Azevedo Martuscello et al., 2005). Mazzanti et al. (1994) underscored that generally DLL decreased when there was a great N availability due to an increase in LLR and FLLB. According to Martuscello et al. (2006), higher DLL rates and lower NLL rates in pastures without fertilization was probably due to N effect which anticipated the senescence process in plants through the translocation of nutrients for the expansion of new leaves. In their research on Mombaça grass, Pereira et al. (2011) reported an influence ($p > 0.10$) on DLL in the autumn and winter. However, N fertilization affected linearly and negatively the variable during spring and summer.

There was no significant difference for leaf senescence rate (LSR) between N doses and the seasons of the year (Table 3). Santos et al. (2004) did not report any interaction effect between grazing and the evaluation periods. LSR was higher (0.74 cm day^{-1}) after 28 days fallow than that in current experiment. Fagundes et al. (2006) did not register any changes in LSR for different N doses. Results of current analysis corroborated those of the above authors, even though they were smaller, perhaps due to differences in the growth period, soil fertility and fertilization level.

Conclusion

Nitrogen fertilization had a positive effect on the rates of leaf length and emergence and on the number of live leaves in Tanzania grass during spring and summer. High nitrogen fertilization rates associated to shorter grazing intervals caused a higher percentage of leaf blades in the management of Tanzania pastures at intermittent parceling at a height of 70 cm on the entrance of animals for grazing and their exit at a height of 30 cm of stubble.

Acknowledgements

The authors would like to thank the Department of Animal Science of the State University of Maringá for its support during the Post-doctorate period. Thanks are also due to the CNPq for funding.

References

Cabrera-Bosquet, L., Albrizio, R., Araus, J. L. & Nogués, S. (2009). Photosynthetic capacity of field-grown durum wheat under different N availabilities: A comparative study from leaf to canopy. *Environmental and Experimental Botany, 67*(1), 145-152.

Castagnara, D. D., Mesquita, E. E., Neres, M. A., Rabello, P. S. O., Zoz, T. & Zoz, A. (2014). Morphogenesis and production of tanzânia, mombaça and mulato grasses under nitrogen fertilization. . *Bioscience Journal, 30*(1), 45-54.

Duru, M. & Ducrocq, H. (2000). Growth and senescence of the successive grass leaves on a tiller. Ontogenic development and effect of temperature. *Annals of Botany, 85*(5), 635-643.

Fagundes, J. L., Fonseca, D., Mistura, C., Morais, R., Vitor, C. M. T., Gomide, J. A., ... Costa, L. (2006). Características morfogênicas e estruturais do capim-braquiária em pastagem adubada com nitrogênio avaliadas nas quatro estações do ano. *Revista Brasileira de Zootecnia, 35*(1), 21-29.

Garcez Neto, A., Nascimento Júnior, D. & Regazzi, A. J. (2002). Respostas morfogênicas e estruturais de Panicum maximum cv. Mombaça sob diferentes níveis de adubação nitrogenada e alturas de corte. *Revista Brasileira de Zootecnia, 31*(5), 1890-1900.

Lopes, M. N., Cândido, M. J. D., Pompeu, R. C. F. F., Silva, R. G., Lopes, J. W. B., Fernandes, F. R. B., ... Bezerra, F. M. L. (2013). Fluxo de biomassa em capim-massai durante o estabelecimento e rebrotação com e sem adubação nitrogenada1. *Revista Ceres, 60*(3), 363-371.

Magalhães, J. A., Souza Carneiro, M. S., Andrade, A. C., Pereira, E. S., Andrade, A. P., Bakke, O. A., ... Lucena Costa, N. (2013). Características morfogênicas e estruturais do capim-andropogon sob irrigação e adubação. *Semina: Ciências Agrárias, 34*(5), 2427-2436.

Martuscello, J. A., Fonseca, D., Nascimento Júnior, D., Santos, P., Ribeiro Júnior, J., Cunha, D. & Moreira, L. M. (2005). Características morfogênicas e estruturais do capim-xaraés submetido à adubação nitrogenada e desfolhação. *Revista Brasileira de Zootecnia, 34*(5), 1475-1482.

Martuscello, J. A., Fonseca, D. M., Nascimento Júnior, D., Santos, P. M., Cunha, D. N. F. V. & Moreira, L. M. (2006). Características morfogênicas e estruturais de capim-massai submetido a adubação nitrogenada e desfolhação. *Revista Brasileira de Zootecnia, 35*(3), 665-671.

Mazzanti, A., Lemaire, G. & Gastal, F. (1994). The effect of nitrogen fertilization upon the herbage production of tall fescue swards continuously grazed with sheep. 1. Herbage growth dynamics. *Grass and Forage Science, 49*(2), 111-120.

Mendonça, F. C. & Rassini, J. B. (2006). Temperatura-base inferior e estacionalidade de produção de gramíneas forrageiras tropicais. *Circular técnica/Embrapa Pecuária Sudeste, 45*.

Moreira, F. B., Prado, I. N., Cecato, U., Wada, F. Y. & Mizubuti, I. Y. (2004). Forage evaluation, chemical composition, and in vitro digestibility of continuously grazed star grass. *Animal Feed Science and Technology, 113*(1), 239-249.

Oliveira, A. B., Pires, A. J. V., Matos Neto, U., Carvalho, G. G. P., Veloso, C. M. & Silva, F. F. (2007). Morfogênese do capim-tanzânia submetido a adubações e intensidades de corte. *Revista Brasileira de Zootecnia, 36*(4), 1006-1013.

Pereira, V. V., Fonseca, D. M., Martuscello, J. A., Braz, T. G. S., Santos, M. V. & Cecon, P. R. (2011). Características morfogênicas e estruturais de capim-mombaça em três densidades de cultivo adubado com nitrogênio. *Revista Brasileira de Zootecnia, 40*(12), 2681-2689.

Santos, P. M., Balsalobre, M. A. A. & Corsi, M. (2004). Características morfogenéticas e taxa de acúmulo de forragem do capim-mombaça submetido a três intervalos de pastejo. *Revista Brasileira de Zootecnia, 33*(4), 843-851.

SAS. (2004). *SAS/STAT User guide, Version 9.1.2*. Cary, NC, USA: SAS Institute Inc.

Sbrissia, A. F., Silva, S. C., Carvalho, C. A. B., Carnevalli, R. A., Pinto, L. F. d. M., Fagundes, J. L. & Pedreira, C. G. S. (2001). Tiller size/population density compensation in grazed coastcross bermudagrass swards. *Scientia Agricola, 58*(4), 655-665.

Silva, R. R., Prado, I. N., Carvalho, G. G. P., Silva, F. F., Almeida, V. V. S., Santana Júnior, H. A., ... Abreu Filho, G. (2010). Níveis de suplementação na terminação de novilhos Nelore em pastagens: aspectos econômicos. *Revista Brasileira de Zootecnia, 39*(9), 2091-2097.

Silveira, C. P. & Monteiro, F. A. (2007). Morfogênese e produção de biomassa do capim-tanzânia adubado com nitrogênio e cálcio. *Revista Brasileira de Zootecnia, 36*(2), 335-342.

Skinner, R. H. & Nelson, C. J. (1995). Elongation of the grass leaf and its relationship to the phyllochron. *Crop Science, 35*(1), 4-10.

Received on March 23, 2015.
Accepted on May 27, 2015.