Original Article

MORPHOGENESIS AND PRODUCTION OF TANZÂNIA, MOMBAÇA AND MULATO GRASSES UNDER NITROGEN FERTILIZATION

MORFOGÊNESE E PRODUÇÃO DOS CAPINS TANZÂNIA, MOMBAÇA E MULATO SOB ADUBAÇÃO NITROGENADA

Deise Dalazen CASTAGNARA[1]; Eduardo Eustáquio MESQUITA[2]; Marcela Abbado NERES[2]; Paulo Sérgio Rabello de OLIVEIRA[2]; Tiago ZOZ[3]; André ZOZ[4]

1. Professora Auxiliar Nivel I, Curso de Medicina Veterinária, UNIPAMPA, Uruguaiana, RS, Brasil.deisecastagnara@yahoo.com.br; 2. Professor Associado, Centro de Ciências Agrárias, UNIOESTE, Marechal Cândido Rondon, PR, Brasil; 3. Doutorando em Agronomia, Faculdade de Agronomia, UNESP, Botucatu, SP, Brasil; 4. Acadêmico de Agronomia, Centro de Ciências Agrárias, UNIOESTE, Marechal Cândido Rondon, PR, Brasil;

ABSTRACT: A field trial was conducted designed in a completely randomized block in a 4 x 3 factorial arrangement to evaluate the application of nitrogen doses (N) (0, 40, 80 and 160 kg/ha) on the morphogenical characteristics and dry matter partition of three forage grasses (*Panicum maximum* cvs. Mombasa and Tanzania and *Brachiaria* sp. Hybrid Mulato). The leaf appearance (LAR, leaf/day) and stretching (LER; mm/day) rates, the number of green leaves per tiller (NLT) and the average weight of tillers (MTW; g) presented s positive linear response to the N dose while the phyllochron (Phil; day/leaves) showed a negative linear response. The highest LER, IAL and final leaf length (FLL; cm) occurred in the Mombaça and Tanzania grasses, while the highest LAR occurred in the Mulato grass. There was a negative quadratic effect of the N dose on the stem elongation rate (SER; mm/day) and LF. The Mombaça and Tanzania grasses presented the highest SER; however, in just two forages. The production of total dry matter (TDM; kg/ha), leaves (LDM; kg/ha) and stems (SDM; kg/ha) increased linearly and quadratically with the N dose, respectively, for the Mombaça and Tanzania grasses. There was a high positive correlation among DM, LDM and SDM and the Mombaça grass MTW. The dry matter production and morphogenic characteristics were influenced by the nitrogen fertilization as a result of the substantial increase in the flow of tissues stimulated by fertilization, proving the importance of N for forage biomass accumulation.

KEYWORDS: Morphogenic characteristics. Dry matter and nitrogen. Fertilization

INTRODUCTION

Although the feeding of the Brazilian herd can be sustained on tropical pasture grasses, the economic results obtained by most ranchers are far below their potential production (VITOR et al., 2009). One of the reasons for this livestock production deficit is the low fertility of Brasilian soils (SANTOS et al., 2002); this fact, associated with the absence or inefficiency of maintenance fertilization, starts the process of pasture degradation.

In this context, the study of nitrogen fertilizer application on pastures needs to be highlighted, because the low N disponibility in tropical soils is one of the factors that strongly limits forage production (SANTOS et al., 2002). Although the potential production of forage plants may be genetically determined (FAGUNDES et al., 2005), productivity can be stimulated by nitrogen fertilization and may need to be varied in dose with the used species (GARCEZ NETO et al., 2002).

Genetically, the potential production of a pasture is determined by its morphogenetic and structural characteristics. The study of morphogenesis can follow the dynamic development of a pasture, including the emergence and death of leaves and tillers, which are responsible for the production capacity of the pasture (MARCELINO et al., 2006). In addition to the production potential, the morphogenesis and morphophysiological characteristics of the canopy can also respond to nitrogen fertilization (PREMAZZI et al., 2003).

Several papers have been published that include study of the morphogenesis of Brachiaria and Panicum genera grasses subjected to nitrogen fertilization (GARCEZ NETO et al., 2002; LAVRES JR. et al., 2007; MARTUSCELLO et al., 2006; PATÊS et al., 2007; PACIULLO et al., 2011; CASTAGNARA et al., 2011). However, there are no studies in the literature comparing grasses of the genus *Brachiaria* with the genus *Panicum* in terms of morphogenetic changes resulting from nitrogen fertilization, or contemplating the morphonesis characteristics of *Brachiaria* sp. Mulato, especially under field conditions.

Because this information may be crucial for helping farmers choose the Grass to be deployed, or even for proper management of a pasture, we conducted this study to evaluate the morphogenic, structural and productive characteristics of dry

Received: 08/12/11
Accepted: 07/02/14

Panicum maximum cv. Mombasa and Tanzania, and *Brachiaria* sp. Mulato grasses.

MATERIAL AND METHODS

The study was conducted under field conditions in Oxisol at coordinates: 24º 33 '22" South latitude, 54º 03'24" West longitude, and 400 m altitude. The local climate is Cfa, subtropical with well-distributed rainfall during the year and hot summers (IAPAR, 2007). During the experimental period the average monthly rainfall was 31.0 mm and average temperatures were 19.1º minimum, 31.3º maximum and 24.5 ° C on average.

The chemical characteristics of the soil in the experimental area obtained by chemical analysis (PAVAN et al., 1992), performed in October 2008 on the 0–20 cm layer, were as follows: pH in H_2O: 5.0; P (Mehlich): 4.18 g/dm³; K (Mehlich-1): 115 $cmol_c/dm^3$; Ca^{+2} (KCl 1.0 mol/L): 3.99 $cmol_c/dm^3$; Mg^{+2} (KCl 1.0 mol / L): 2.39 $cmol_c/dm^3$ and Al^{+3} (KCl 1.0 mol/L): 0.05 cmolc/dm³, H+Al (calcium acetate 0.5 mol/L): 7.20 $cmol_c/dm^3$; SB: 6.57 $cmol_c/dm^3$, V: 47.71%, organic matter (Boyocus Method): 31.44 g/dm³.

The experiment design was a randomized block in a 3 x 4 factorial scheme, with three tropical grasses (*Panicum maximum* cvs. Tanzania and Mombasa, and *Brachiaria* sp. cv. Mulato), four N doses (0, 40, 80 and 160 kg/having urea as font) and three replicates, totaling 36 experimental units, each with a 12 m² area, which amounted to an experimental area of 432 m².

The establishment of fodder was performed in September 2006 after elevating the soil base saturation to 60% and applying phosphate and potassium fertilizer according to the soil analysis. Seeding was performed manually in rows spaced 0.4 m apart using 7.0 kg /ha of viable seeds. The pastures remained under periodic cleaning cuts to ensure establishment. A uniformity cut was made in December 2008 with the aid of the brushcutter, with 15 cm of soil heigth, with subsequent cleaning of the area and nitrogen fertilizer application.

Marking the tillers was performed on the seventh day after the standardization cut through the random choice of three tillers per experimental unit, which were identified with colored ribbons, totalizing 108 tillers. In these were recorded, during 42 days, three times per week, the day of appearance of the leaf apex, the ligule exposure day, the pseudostem length, the expanded leaf blade length, the expansion leaf blade length, the number of leaves per tiller and the senesced leaf blade length.

From the data obtained were calculated the following variables: leaf appearance rate (LAR); phyllochron (Phil), leaf elongation rate (LER), number of live leaves per tiller (NLT), leaf lifetime (LL), estimated by the equation proposed by Lemaire; Chapman (1996), leaf senescence rate (LSR), stem elongation rate (SER), final leaf length (FLL), and average weight of tillers (AWT).

At 42 days of regrowth, we proceeded with destructive evaluations to determine the tiller density (TD) and dry matter production (DMP). TD was obtained through random placement of two metal squares (0.5 mx 0.5 m) in each experimental unit with a manual count of all tillers contained inside. After counting, we proceeded to vegetative material cutting and weighing to determine the production of green matter per hectare. To determine the DMP of leaves (LDM) and stems (SDM), a representative sample of approximately 400 g was removed, which was manually separated into leaf blades and stems plus sheaths, and dried in an oven with forced air ventilation at 55 ° C. TDM was then calculated from LDM and SDM.

The data obtained were submitted to variance analysis (ANOVA) and tested by Fisher`s F test (PIMENTEL-GOMES, 2009). To determine the significance of the factors studied, the forages were compared by Tikey test at a 5% probability level, while the N levels were studied by means of regression analysis, testing the linear (Grade 1º) and quadratic (Grade 2º) and considering the lack of significance of the regression deviations. For the choice of model the highest coefficient of determination (R²) s considered. The significance of the coefficients of equations 1º (b1) and Grade 2º (b1 and b2) in the regression models selected for each variable was tested by Student's t test (PIMENTEL-GOMES, 2009).

To analyse correlations among the studied traits we adopted a linear correlation, and correlation coefficients had their significance estimated and tested by Student's t test (PIMENTEL-GOMES, 2009).

RESULTS AND DISCUSSION

The interaction between N dose and the grasses was not significant for the rate of leaf appearance. However, there was a statistically significant difference among the grasses, since the leaf appearance rate for Mulato grass (0.12 leaves/day/tiller) was higher than for the Tanzania and Mombasa grasses (0.07 and 0.07 sheets/day/tiller, respectively) (Table 1).

Table 1. Morphogenetic and structural characteristics of Tanzania, Mombasa and Mulato grasses

Grasses	Variables									
	LAR	Phil	LER	FLL	LL	LSR	NLT	SER	TD	ATW
Tanzania	0,07b	14,81a	45,74a	65,64a	41,67a	4,43a	2,89b	5,10a	688,67b	2,13a
Mombasa	0,07b	14,82a	46,39a	66,71a	40,99a	2,85a	2,81b	4,98a	612,67b	2,31a
Mulato	0,12a	8,46b	11,70b	11,68b	40,29a	7,32a	4,81a	1,70b	1447,67a	0,43b

* Averages followed by same tiny letter in columns do not differ statistically among themselves by Tukey test at 5% probability. LAR: leaf appearance rate (leaves/day), Phil: phyllochron (days/leaf), LER: leaf elongation rate (mm/day), FLL: final leaf length (cm), LL: lifetime leaf (days), LSR: leaf senescence rate (mm/day), NLT: number of leaves per tiller, SER, stem elongation rate (mm/day), TD: tiller density (tillers/m²) and ATW: average weight of tillers (g).

Alexandrino et al. (2004), and Martuscello et al. (2005) also found a linear effect of N dose on the leaf appearance rate in the Marandu and Xaraes grasses, respectively. Lopes et al., (2013), working with *Panicum Maximumm* cv. Massai, also observed a linear increase in the leaf elongation rate in response to increasing doses of N.

Mesquita and Neres (2008) evaluated the Mombasa, Tanzania and Milenio grasses under different nitrogen rates (0, 100, 200, 300 and 400 kg/ha) and obtained a quadratic and positive response of the leaf appearance rate to nitrogen fertilization, due to higher doses used.

We were unable to detect a significant interaction of factors for phyllochron, but the Tanzania and Mombasa grasses presented a longer phyllochron than Mulato grass (Table 01), because the latter has a shorter final leaf length. The phyllochron decreased linearly with the N dose (Table 2), agreeing with the results obtained by Martuscello et al. (2006), and Alexandrino et al. (2004) working with nitrogen fertilization on the Massai and Marandu grasses, respectively.

Table 2. Morphogenetic, structural and productive characteristics of Tanzania, Mombasa and Mulato grasses under increasing N doses

Characteristics	Regression equation	R^2	CV (%)
LAR	$\hat{Y}$= 0,0836+0,000088**x	0,81	9,08
Phil	$\hat{Y}$= 13,6398-0,013461*x	0,78	15,50
LER	$\hat{Y}$= 30,2600+0,062131**x	0,98	18,46
FLL	$\hat{Y}$= 42,6760+0,1639**x-0,000731*x^2	0,99	9,94
NLT	$\hat{Y}$= 3,2656+0,003345**x	0,87	10,00
SER	$\hat{Y}$= 2,4813+0,0278**x-0,000103*x^2	0,99	17,30
DP	$\hat{Y}$= 791,1960+4,1278*x-0,019501*x^2	0,98	15,63
ATW	$\hat{Y}$= 1,0531+0,008150**x	0,97	30,04
Tanzania			
TDM	$\hat{Y}$= 9281,2485+141,3027**x-0,5962*x^2	0,87	
LDM	$\hat{Y}$= 7061,0606+93,1076**x-0,3946*x^2	0,82	20,81
SDM	$\hat{Y}$= 2220,4485+48,1927**x-0,1916*x^2	0,95	
Mombasa			
TDM	$\hat{Y}$= 7133,6667+92,5826**x	0,95	
LDM	$\hat{Y}$= 5641,8667+64,2840**x	0,96	21,14
SDM	$\hat{Y}$= 1491,8000+28,2969**x	0,93	

**, *: Significant at 1 and 5% respectively by t test. Regression equations (Y), coefficients of determination (R^2), coefficients of variation (% CV). LAR: leaf appearance rate (leaves/day), Phil: phyllochron (days/leaf), LER: leaf elongation rate (mm/day), FLL: final leaf length (cm), NLT: number of leaves per tiller, SER, stem elongation rate (mm/day), DP: tiller density (tillers/m²) and ATW: average weight of tillers (g), TDM: total DM yield (kg/ha), LDM: leaves DM yield (kg/ha), SDM: stem DM yield (kg/ha).

Correlation analysis revealed a negative linear correlation between the leaf appearance rate and phyllochron for the grasses (Table 3). According to Martuscello et al. (2006), a shorter phyllochron results from the more rapid leaf appearance rate promoted by N.

The leaf elongation rate was influenced only by the type of grass (p<0.01), with the Tanzania and Mombasa grasses having a faster leaf elongation rate (45.74 and 46.39 mm/day, respectively) than the Mulato grass (11.70 mm/days) (Table 1). This difference is due to genotypic characteristics of the species, because grasses belonging to the genus *Brachiaria* Mulato have a smaller size, with consequent shortening of the sheath length, which in turn makes the leaves shorter and the leaf elongation rate slower. *Panicum* genus grasses, due to their habit of growing on tussocks, favor the formation of clumps with advancing age of the pasture, resulting in increased length of the sheath, with a consequent increase in the length of the leaves.

The higher N increased the leaf elongation rate from 30.17 mm/day (0 kg/ha) to 39.90 mm/day (160 kg/ha), representing an increase of 25% (Table 2).

Table 3. Estimates of the coefficients of simple Pearson linear correlation between the morphogenesis and productive characteristics Tanzania, Mombasa and Mulato grasses

	Phil	LER	FLL	LLS	LSR	NLT	SER	TD	ATW	TDM	LDM	SDM
Tanzania												
LAR	-0,90**	0,29ns	0,00ns	-0,49*	0,35ns	1,00**	0,23ns	-0,34ns	0,45ns	0,30ns	0,28ns	0,22ns
Phil		-0,47ns	-0,24ns	0,81**	-0,40ns	-0,90**	-0,21ns	0,05ns	-0,36ns	-0,38ns	-0,40ns	-0,32ns
LER			0,46ns	-0,48ns	0,64*	0,30ns	0,51*	-0,03ns	0,46ns	0,45ns	0,44ns	0,42ns
FLL				-0,36ns	0,22ns	0,00ns	0,41ns	0,51*	0,22ns	0,60*	0,59*	0,56*
LL					-0,32ns	-0,49ns	0,00ns	-0,30ns	-0,08ns	-0,30ns	-0,33ns	-0,24ns
LSR						0,35ns	-0,03ns	-0,04ns	0,02ns	-0,07ns	-0,04ns	-0,13ns
NLT							0,23ns	-0,34ns	0,45ns	0,27ns	0,28ns	0,22ns
SER								-0,11ns	0,62*	0,63*	0,58*	0,66**
TD									-0,34ns	0,05ns	-0,03ns	0,51*
ATW										-0,47ns	0,20ns	0,29ns
TDM											0,76**	0,69**
LDM												0,84**
Mombasa												
LAR	-0,99**	0,58*	0,47ns	-0,68**	0,00ns	0,54*	0,18ns	0,11ns	-0,04ns	0,00ns	-0,01ns	0,06ns
Phil		-0,59*	-0,48ns	0,75**	-0,01ns	-0,54*	-0,27ns	-0,13ns	0,00ns	-0,07ns	-0,04ns	-0,13ns
LER			0,31ns	-0,28ns	-0,28ns	0,38ns	0,30ns	0,11ns	0,45ns	0,56*	0,57*	0,53*
FLL				-0,19ns	0,24ns	0,42ns	0,75**	-0,19ns	0,24ns	0,21ns	0,20ns	0,23ns
LL					0,12ns	-0,34ns	-0,32ns	-0,37ns	0,19ns	0,06ns	0,10ns	-0,03ns
LSR						-0,02ns	0,14ns	-0,02ns	0,28ns	0,24ns	0,22ns	0,27ns
NLT							0,32ns	0,14ns	-0,12ns	-0,07ns	-0,06ns	-0,10ns
SER								-0,14ns	0,50*	0,52*	0,50*	0,56*
TD									-0,40ns	-0,06ns	-0,04ns	-0,11ns
ATW										0,94**	0,93**	0,95**
TDM											1,00**	0,98**
LDM												0,97**
Mulato												
LAR	-0,99**	0,68**	0,53*	-0,03ns	0,14ns	1,00**	0,74**	0,84**	-0,13ns	0,65*	0,72**	0,44ns
Phil		-0,70**	-0,57*	0,10ns	-0,19ns	-0,99**	-0,72**	-0,85**	0,12ns	-0,66**	-0,74**	-0,44ns
LER			0,91**	-0,11ns	0,51*	0,68**	0,68**	0,49ns	0,29ns	0,61*	0,62*	0,53*
FLL				-0,03ns	0,62*	0,53*	0,66*	0,41ns	0,43ns	0,63*	0,62*	0,58*
LL					-0,19ns	-0,03ns	0,23ns	0,09ns	0,36ns	0,30ns	0,21ns	0,45ns
LSR						0,14ns	-0,02ns	0,14ns	0,32ns	0,32ns	0,30ns	0,33ns
NLT							0,74**	0,84**	-0,13ns	0,65*	0,72**	0,44ns
SER								0,48ns	0,32ns	0,61*	0,61*	0,55*
TD									-0,14ns	0,79**	0,85**	0,59*
ATW										0,49ns	0,38ns	0,66**
TDM											0,98**	0,93**
LDM												0,84**

ns: Not significant; *,**: Significant at 5 and 1% respectively by t test; LAR: leaf appearance rate (leaves/day), Phil: phyllochron (days/leaf), LER: leaf elongation rates (mm/day), FLL: final leaf length (cm), LL: leaf lifetime (days), LSR: leaf senescence rate (mm/day), NLT: number of leaves per tiller, SER : stem elongation rate (mm/day), TD: tiller density (tillers/m²), ATW: average tiller weight (grams), TDM: total DM yield of shoots (kg/ha), LDM: DM yield of leaves (kg/ha), SDM: stem DM production (kg/ha).

The results are similar to Fagundes et al. (2006), studying the application of N to *Brachiaria decumbens*. The leaf elongation rate was positively correlated with the leaf appearance rate and with the phyllochron in Mombasa and Mulato grasses (Table 3), in agreement with the results of Garcez Neto et al. (2002) obtained with Mombasa grass. According to the authors, besides acting on the phyllochron, increasing the production of new cells, N can still cause changes in leaf elongation rate. The leaf elongation rate is a variable of great importance in analysing the flow of plant biomass, since the proportion of leaves and, consequently, the photosynthetically active leaf area both increase as the rate of leaf elongation increases, resulting in greater biomass accumulation (LOPES et al., 2013).

The Tanzania and Mombasa Grasses had longer final leaf lengths, 65.64 and 66.71 cm, respectively, compared to Mulato grass (11.68 cm), while with nitrogen fertilization the final leaf length was adjusted to the quadratic regression model, with a maximum final leaf length at a dose of 112 kg/ha of N, and the largest increase (0.15 cm) achieved with a dose of 40 kg/ha of N compared with no N (Table 2).

There was a positive linear correlation of the final leaf length with the rates of leaf appearance and oeaf elongation, and a negative correlation with the phyllochron for Mulato grass (Table 3), in agreement with Mazzanti and Lemaire (1994). This behavior is a example of the relationship between the morphogenetic and structural characteristics of the pasture. In vegetative tillers, due to increased sheath length with increasing pasture heigth, greater will be the way to go until the leaf becomes fully expanded , with consequent increases in the leaf elongation rate and leaf lifetime. The reduction in the phyllochron with the increase in final leaf length may be related to the boost provided by the N to the leaf elongation rate, because even with a longer route being traveled by the leaves, the increase in the leaf elongation rate caused by N favors maintenance of the values for the leaf appearance rate and phyllochron.

The leaf lifetime and rate leaf senescence were not affected by the studied factors. The leaves' average lifetime was 40.98 days, approaching values obtained in other studies (MARCELINO et al. 2006; GARCEZ NETO et al., 2002). According to Gastal and Nelson (1994), the leaf lifetime appears to be little affected by N disponibility, but it is an important criterion in the management of pastures under rotational grazing (GRANT et al., 1988) because it allows the loss of leaf tissue due to senescence to be minimized through adjusting the stocking rate and duration of the grazing and resting periods. With regard to the leaf senescence rate, Fagundes et al. (2006) also saw no significant changes with the dose of N, indicating that there was no competition for nutrients and metabolites between young and old leaves (GOMIDE; GOMIDE, 2000).

The leaf senescence rate was positively correlated with the leaf elongation rate for the Tanzania and Mulato grasses, and the final leaf length for the Mulato grass (Table 3). This result can be linked to the greater leaf area promoted by the increases in leaf elongation rate and final leaf length. These characteristics can promote the senescence of older leaves due to shading promoted by younger leaves, as with stabilization of the genetically determined number of sheets for each grass. This result justifies the association of morphogenetic characteristics with growth indices for determinations of pasture management (CALBO et al., 1989).

The interaction between the grasses and the nitrogen dose was not significant for the number leaves per tiller, but the superiority of Mulato grass (4.81 leaves) compared with the Tanzania (2.89 leaves) and Mombasa (2.81 leaves) grasses was observed (Table 1). These results are similar to those obtained by Gomide and Gomide (2000), who reported that the number of green leaves for Mombasa grass was stable at three leaves per tiller. The N doses were adjusted to a positive linear regression model (Table 2), agreeing with Garcez Neto et al. (2002), Martuscello et al. (2006) and Batista and Monteiro (2006). This result confirms the positive effect of nitrogen fertilization on pastures. The slowing of the aging process, the greater leaf elongation rate and the higher final leaf length promoted by N may all have contributed to the increase in the number of leaves per tiller.

Correlation analysis revealed a positive linear correlation between the number leaves per tiller with the leaf appearance rate and a negative corrolation with Phyllochron for the Tanzania, Mombasa and Mulato grasses. The number of leaves per tiller presented a positive correlation with the leaf elongation rate and the final leaf length for the Mulato grass (Table 3). By enabling a higher number of leaves per tiller to be maintained, nitrogen fertilization provides a greater photosynthetically active area per tiller, boosting the leaf appearance rate, with consequent reduction in the phyllochron. Depending on the grass, these positive effects may also act on the leaf elongation rate and increase the final leaf length. Stabilization of the number of leaves per tiller is suggested as a criterion for defining the duration of the rest period in pasture under rotational grazing (FULKERSON et al., 1999).

For the stem elongation rate, there was a significant effect in the quadratic regression model only for the N dose. Maximum elongation occurred at a dose of 135 kg/ha N. Patês et al. (2007), working with Tanzania grass under 100 kg/ha N, also reported an increase in the stem elongation rate. The stem elongation rate was positively correlated with the leaf elongation rate in the Tanzania, Mombasa and Mulato grasses. For the Mulato grass significant correlations of the leaf appearance rate were found with the stem elongation rate, phyllochron, final leaf length and number of leaves per tiller (Table 03). The stem elongation rate affects the leaf appearance rate and final leaf length due to the increased production of new cells (GARCEZ NETO et al., 2002) at faster rates, and to the increase in the leaf route inside the pseudostems (SKINER; NELSON, 1995), with consequent effects on the phyllochron and number of leaves per tiller. These results can be explained by the nitrogen fertilization, because the tiller can accelerate the leaf elongation rate due to the maintenance of such genotypic characteristics as the leaf appearance rate and number of leaves per tiller associated with a higher intake of available N.

The Mulato grass presented a tiller density above those of the Tanzania and Mombasa grasses (Table 1), without significant interaction of the factors. The N doses promoted a quadratic effect on the tiller density, with maximum tillering at an estimated N dose of 106 kg/ha. Similar results were obtained by Colozza et al. (2000) with Aruana grass, Braga et al. (2004) in Mombasa grass, and Silveira e Monteiro (2007) in Tanzania grass. The positive response of tillering to nitrogen fertilization may be associated with growth stimulation and multiplication of vegetal cells by N (OLIVEIRA et al., 2007). The tiller density showed a positive linear correlation with the final leaf length of the Panicum maximum grass. For the Mulato grass positive linear correlations were found between tiller density and leaf appearance rate as well as the number leaves per tiller, and a negative correlation with phyllochron (Table 3). Garcez Neto et al. (2002) and Martuscello et al. (2006) also showed significant linear correlation of tiller density with leaf appearance rate and the number leaves per tiller. According to Garcez Neto et al. (2002), tillering in grasses is a structural determinant characteristic of the morphogenic plasticity of forage plants influenced by combinations of nutritional, environmental and management factors impacting on the morphogenic characteristics.

The Mulato grass presented average tiller weights below those of the Mombasa and Tanzania grasses (Table 1), while the N dose promoted a linear increase in the weight of the tillers (Table 2). There was a correlation between the average tiller weight with the stem elongation rate in the Tanzania and Mombasa grasses, confirming the importance of the stem fraction for tiller productivity and consequently that of the pasture.

Significant effect of N levels were observed on total dry matter, on grasses and interaction. The total dry matter of the Guinea grass was adjusted to the quadratic regression model (Table 2) and the estimated maximum yield (17800 kg/ha) was obtained with a dose of 120 kg/ha N. For the Panicum maximum grass, the total dry matter was adjusted to the linear regression model, while for the Mulato grass the total dry matter did not fit any of the studied models (Table 02). Similar results were obtained by Mesquita and Neres (2008), who obtained the total dry matter adjusted to the quadratic model of regression working with Tanzania grass under different nitrogen levels. Martuscello et al. (2006) working with Massai grass, Vitor et al. (2009) working with elephant grass, and Santos et al. (2009) working with *Brachiaria decumbens* also found linear increases in total dry matter with increasing N levels. For Guinea grass, positive linear correlations of the total dry matter with the final leaf length and the stem elongation rate were found, while for Mombasa, the total dry matter was positively correlated with leaf elongation, the stem elongation rate and the average weight of tillers. In the Mulato grass, the total dry matter was significantly correlated with the leaf appearance rate, phyllochron, leaf elongation rate, final leaf length, number of leaves per tiller, stem elongation rate and dry matter production (Table 3). Garcez Neto et al. (2002) and Costa et al. (2009) also found a significant linear correlation of leaf elongation rate with dry matter production, because an increase in leaf elongation rate provides increased dry matter production. Singly, the leaf elongation rate appears to be the morphogenic variable that correlates best with the total dry matter (HORST, 1978).

For leaf dry matter as well as for stem dry matter it was possible to detect the significance of the N dose, of the forage and of interacting factors. The Tanzania grass adjusted to the quadratic regression model (Table 2) and the Mombasa grass to the positive linear model (Table 2), while the Mulato grass did not fit any of the studied models.

The high values in relation to stem dry matter and leaf dry matter agree with Pinto et al. (1994), who reported that this effect can be attributed to the senescence and death of basal leaves in tillers. Most leaf dry matter associated with the addition of N is due to the tissue flux (DURU; DUCROCQ, 2000).

Stem dry matter and leaf dry matter correlated positively with stem elongation rate and total dry matter in all the studied grasses (Table 3), agreeing with Alexandrino et al. (2004). According to the author, increasing the dose of N increases the contribution of the stem to the total forage mass produced due to stretching of the same. The positive correlation of the leaf dry matter with the stem elongation rate can be explained by the effects of stem elongation on leaf blade length (SKINER; NELSON, 1995) because increasing the route of the leaf inside the pseudostem until it becomes expanded, besides promoting an increase in the final leaf length, may also affect the overall proportion of leaves in the forage produced. The leaf dry matter correlated positively with the leaf elongation rate in the Mombasa and Mulato grasses (Table 3), agreeing with the results found by Braga et al. (2000) working with *Cynodon* spp. cv. Tifton 85 and its response to the dose of N.

Was also found a positive linear correlation between the stem dry matter and the average tiller weight in the *Panicum maximum* and Mulato grasses (Table 3). The increase in production and stems with increasing N rates can be explained by the increase in the number of tillers per unit area and the greater weight of the tiller. Heavier tillers have more developed stems to guarantee the leaves are supported (SANTOS et al., 2009).

CONCLUSION

Nitrogen fertilization altered the morphogenesis, structural and production characteristics of Mombasa, Tanzania and Mulato grasses, providing substantial increases in the tissue flow and contributing to greater accumulation of forage biomass.

RESUMO: O experimento foi conduzido sob o delineamento em blocos completos ao acaso em esquema fatorial 4x3 para avaliar a aplicação de doses de nitrogênio (N) (0, 40, 80 e 160 kg/ha) sobre as características morfogênicas e a partição de matéria seca (MS) de três gramíneas forrageiras (*Panicum maximum cvs*. Mombaça e Tanzânia e Brachiaria sp. híbrida Mulato). As taxas de aparecimento (TapF; folhas/dia) e alongamento de folhas (TalF; mm/folha), o número de folhas verdes por perfilho (NFVP) e o peso médio de perfilhos (PMP; g) apresentaram resposta linear positiva às doses de N enquanto o filocrono (Fil; dias/folha) apresentou resposta linear negativa. Os capins Tanzânia e Mombaça apresentaram maiores TalF, Fil e comprimento final de folhas (CFF; cm) enquanto o capim Mulato apresentou maior TapF. As produções de matéria seca total (PMST; kg/ha) de folhas (PMSF; kg/ha) e de colmos (PMSC; kg/ha) aumentaram de forma quadrática e linear com as doses de N, respectivamente, para os capins Mombaça e Tanzânia. Houve alta correlação positiva entre as PMST, PMSF e PMSC e o PMP da forrageira Mombaça. A produção de matéria seca e as características morfogênicas foram influenciadas pela adubação nitrogenada, como resultado do aumento substancial do fluxo de tecidos estimulado pela adubação, o que comprova a importância do N para o acúmulo de biomassa da forragem.

PALAVRAS–CHAVE: Características morfogênicas. Fertilização. Matéria seca e nitrogênio.

REFERENCES

ALEXANDRINO, E.; NASCIMENTO JUNIOR, D.; MOSQUIM, P. R.; REGAZZI, A. J.; ROCHA, F. C. Características morfogênicas e estruturais na rebrotação da *Brachiaria brizantha* cv. marandu submetida a três doses de nitrogênio. **Revista Brasileira de Zootecnia**, Viçosa - MG, v. 33, n. 6, p. 1372-1379, jun., 2004.

BATISTA, K.; MONTEIRO, F. A. Respostas morfológicas e produtivas do capim-marandu adubado com doses combinadas de nitrogênio e enxofre. **Revista Brasileira de Zootecnia**, Viçosa - MG, v. 35, n. 4, p. 1281-1288, abr., 2006.

BRAGA, G. J.; LUZ, P. H. C.; HERLING, V. R.; LIMA, C. G. Resposta do capim-mombaça a doses de nitrogênio e a intervalos de corte. **Acta Scientiarum. Animal Sciences**, Maringá, v. 26, n. 1, p. 123-128, jan./mar., 2004.

BRAGA, G. J.; PINEDO, L. A.; HERLING, V. R.; LUZ, P. H. C.; LIMA, C. G. Produção de matéria seca e fluxo de tecidos de *Cynodon spp*. cv. Tifton 85 em resposta a doses de nitrogênio. **Acta Scientiarum**, **Animal Sciences**, Maringá, v. 22, n. 3, p. 851-857, jul/set., 2000.

CALBO, A. G.; SILVA, W. L. C.; TORRES, A. C. Comparação de modelos e estratégias para análise de crescimento. **Revista Brasileira de Fisiologia Vegetal**, Campinas, v. 1, n. 1, p. 1-7, jan./abr., 1989.

CASTAGNARA, D. D.; ZOZ, T.; KRUTZMANN, A.; UHLEIN, A.; MESQUITA, E. E.; NERES, M. A.; OLIVEIRA, P. S. R. Produção de forragem, características estruturais e eficiência de utilização do nitrogênio em forrageiras tropicais sob adubação Nitrogenada. **Semina: Ciências Agrárias**, Londrina, v. 32, n. 4, p. 1637-1648, out./dez. 2011.

COLOZZA, M. T.; KIEHL, J. C.; WERNER, J. C.; SCHAMMASS, E. A. Respostas de *Panicum maximum* cultivar aruana a doses de nitrogênio. **Boletim da Indústria Animal**, Nova Odessa, v. 57, n. 1, p. 21-32, jan./abr., 2000.

COSTA, N. L., PAULINO, V. T., MAGALHÃES, J. A.; TOWNSEND, C. M.; PEREIRA, R. G. A. Rendimento de forragem, composição química e morfogênese de *Panicum maximum* cv. Vencedor em diferentes idades de corte. **PUBVET**, Londrina, v. 3, n. 12, dez., 2009.

DURU, M.; DUCROCQ, H. Growth and senescence of the successive leaves on a Cocksfoot tiller. Effect of nitrogen and cutting regime. **Annals of Botany**, Oxford, v. 85, n. 5, p. 645-653, may., 2000.

FAGUNDES, L. J.; FONSECA, D. M.; GOMIDE, J. A.; NASCIMENTO JUNIOR, D.; VITOR, C. M. T.; MORAIS, R. V.; MISTURA, C.; REIS, G. C.; MARTUSCELLO, J. A. Acúmulo de forragem em pastos de *Brachiaria decumbens* adubadas com nitrogênio. **Pesquisa Agropecuária Brasileira**, Brasília, v. 40, n. 4, p. 397-403, abr., 2005.

FAGUNDES, L. J.; FONSECA, D. M.; MISTURA, C.; MORAIS, R. V.; VITOR, C. M. T.; GOMIDE, J. A.; NASCIMENTO JUNIOR, D.; CASAGRANDE, D. R.; COSTA, L. T. Características morfogênicas e estruturais do capim-braquiária em pastagem adubada com nitrogênio avaliadas nas quatro estações do ano. **Revista Brasileira de Zootecnia**, Viçosa, v. 35, n. 1, p. 21-29, jan., 2006.

FULKERSON, W. J.; SLACK, K.; HAVILAH, E. The effect of defoliation interval and height on growth and herbage quality of kikuyu grass (*Pennisetum clandestinum*). **Tropical Grassland**, Saint Lucia, v. 33, n. 3, p. 138-145, jul./set., 1999.

GARCEZ NETO, A. F.; NASCIMENTO JUNIOR, D.; REGAZZI, A. J.; FONSECA, D. M.; MOSQUIM, P. R. GOBBI, K. F. Respostas morfogênicas e estruturais de *Panicum maximum* cv. mombaça sob diferentes níveis de adubação nitrogenada e alturas de corte. **Revista Brasileira de Zootecnia**, Viçosa, v. 31, n. 5, p. 1890-1900, set./out., 2002.

GASTAL, F.; NELSON, C. J. Nitrogen use within the growing leaf blade of tall fescue. **Plant Physiology**, Rockville, v. 105, p. 191-197, 1994.

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

GRANT, S. A., BARTHRAM, G. T., TORVELL, L.; KING, J.; ELSTONJ, D. A. Comparison of herbage production under continuous stocking and intermittent grazing. **Grass and Forage Science**, Oxford, v. 43, n. 1, p. 29-39, jan., 1988.

HORST, G. L., NELSON, C. J., ASAY, K. H. Relationship of leaf elongation to forage yield of tall fescue genotypes. **Crop Science**, Madison, v. 18, n. 5, p. 715-719, may.,1978.

IAPAR. **Cartas climáticas do Paraná**. Disponível em: <http://200.201.27.14/Site/Sma/CartasClimáticas/ClassificacaoClimáticas.htm>. Acessado em: 30 outubro 2011.

LAVRES JR., J.; FERRAGINE, M. D. C.; GERDES, L.; RAPOSO, R. W. C.; COSTA, M. N. X.; MONTEIRO, F. A. Yield components and morphogenesis of Aruana grass in response to nitrogen supply. **Scientia Agricola**, Piracicaba, v. 61, n. 6, p. 632-639, jun., 2007.

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

LOPES, M. N.; CÂNDIDO, M. J.; POMPEU, R. C. F. F.; SILVA, R. G.; LOPES, J. W. B.; FERNANDES, F. R. B.; LACERDA, C. F.; BEZERRA, F. M. L. Fluxo de biomassa em capim-massai durante o estabelecimento e rebrotação com e sem adubação nitrogenada. **Revista Ceres,** Viçosa, v. 60, n.3, vol.60, n.3, p. 363-371, may., 2013.

MARCELINO, K. R. A.; NASCIMENTO JUNIOR, D.; SILVA, S. C.; EUCLIDES, V. P. B.; FONSECA, D. M. Características morfogênicas e estruturais e produção de forragem do capim-marandu submetido a intensidades e freqüências de desfolhação. **Revista Brasileira de Zootecnia**, Viçosa, v. 35, n. 6, p. 2243-2252, jun., 2006.

MARTUSCELLO, J. A.; FONSECA, D. M.; NASCIMENTO JUNIOR, D.; SANTOS, P. M.; RIBEIRO JUNIOR, J. I.; CUNHA, D. N. F. V.; MOREIRA, L. M. Características morfogênicas e estruturais do capim-xaraés submetido à adubação nitrogenada e desfolhação. **Revista Brasileira de Zootecnia**, Viçosa, v. 34, n. 5, p. 1475-1482, mai., 2005.

MARTUSCELLO, J. A.; FONSECA, D. M.; NASCIMENTO JUNIOR, D.; SANTOS, P. M.; RIBEIRO JUNIOR, J. I.; CUNHA, D. N. F. V.; MOREIRA, L. M. Características morfogênicas e estruturais de capim-massai submetido a adubação nitrogenada e desfolhação. **Revista Brasileira de Zootecnia**, Viçosa, v. 35, n. 3, p. 665-671, mar., 2006.

MAZZANTI, A.; LEMAIRE, G. Effect of nitrogen fertilization on herbage production of tall fescue continuously grazed by sheep. II. Consumption and herbage efficiency utilization. **Grass and Forage Science**, Oxford, v. 49, n. 3, p. 352-359, mar., 1994.

MESQUITA, E. E.; NERES, M. A. Morfogênese e composição bromatológica de cultivares de *Panicum maximum* em função da adubação nitrogenada. **Revista Brasileira de Saúde e Produção Animal**, Belo Horizonte, v. 9, n. 2, p. 201-209, fev., 2008.

OLIVEIRA, A. B.; PIRES, A. J. V.; MATOS NETO, U. CARVALHO, G. G. P.; VELOSO, C. M.; SILVA, F. F. Morfogênese do capim-tanzânia submetido a adubações e intensidades de corte. **Revista Brasileira de Zootecnia**, Viçosa, v. 36, n. 4, p. 1006-1013, abr., 2007.

OLIVEIRA, A. B.; PIRES, A. J. V.; MATOS NETO, U.; CARVALHO, G. G. P.; VELOSO, C. M.; SILVA, F. F. Morfogênese do capim-tanzânia submetido a adubações e intensidades de corte. **Revista Brasileira de Zootecnia**, Viçosa, MG, v. 36, n. 4, p. 1006-1013, ago., 2007.

PACIULLO, D. S. C.; FERNANDES, P. B.; GOMIDE, C. A. M.; CASTRO, C. R. T.; SOUZA SOBRINHO, F.; CARVALHO, C. A. B. The growth dynamics in *Brachiaria* species according to nitrogen dose and shade. **Revista Brasileira de Zootecnia**, Viçosa, v. 40, n. 2, p. 270-276, fev., 2011.

PATÊS, N. M. S.; PIRES, A. J. V.; SILVA, C. C. F.; SANTOS, L. C.; CARVALHO, G. G. P.; FREIRE, M. A. L. Características morfogênicas e estruturais do capim-tanzânia submetido a doses de fósforo e nitrogênio. **Revista Brasileira de Zootecnia**, Viçosa, v. 36, n. 6, p. 1736-1741, dez., 2007.

PAVAN, M. A.; BLOCH, M. de F.; ZEMPULSKI, H. da C.; MIYAZAWA, M.; ZOCOLER, D.C. Manual de análise qíimica de solo e controle de qualidade. Londrina: IAPAR, 1992. 39 p. (IAPAR. Circular, 76).

PIMENTEL-GOMES, F. P. **Curso de Estatística Experimental.** 15ª Ed., FEALQ, Piracicaba. 2009. 451p.

PINTO, J. C.; GOMIDE, J. A.; MAESTRI, M. Crescimento de folhas de gramíneas forrageiras tropicais, cultivadas em vasos, com duas doses de nitrogênio. **Revista Brasileira de Zootecnia**, Viçosa, v. 23, n. 3, p. 327-332, mar., 1994.

PREMAZZI, L. M.; MONTEIRO, F. A.; CORRENTE, J. E. Perfilhamento em Capim Capim bermuda cv. Tifton 85 em resposta a doses e ao momento de aplicação do nitrogênio após o corte. **Scientia Agrícola**, Piracicaba, v. 60, n. 3, p. 565- 571, mar., 2003.

SANTOS, I. P. A.; PINTO, J. C.; SIQUEIRA, J. O.; MORAIS, A. R.; SANTOS, C. L. Influência do fósforo, micorriza e nitrogênio no conteúdo de minerais de *Brachiaria brizantha* e *Arachis pintoi* consorciados. **Revista Brasileira de Zootecnia**, Viçosa, v. 31, n. 2, p. 605-616, fev., 2002.

SANTOS, M. E. R.; FONSECA, D. M.; BALBINO, E. M.; MONNERAT, J. P. I.; SILVA, S. P. Capim-braquiária diferido e adubado com nitrogênio: produção e características da forragem. **Revista Brasileira de Zootecnia**, Viçosa, v. 38, n. 4, p. 650-656, abr., 2009.

SILVEIRA, C. P.; MONTEIRO, F. A. Morfogênese e produção de biomassa do capim-tanzânia adubado com nitrogênio e cálcio. **Revista Brasileira de Zootecnia**, Viçosa, v. 36, n. 2, p. 335-342, fev., 2007.

SKINNER, R. H., NELSON, C. J. Elongation of the grass leaf and its relationship to the phyllochron. **Crop Science**, Madison, v. 35, n. 1, p. 4-10, jan., 1995.

VITOR, C. M. T.; FONSECA, D. M.; CÓSER, A. C.; MARTINS, C. E.; NASCIMENTO JUNIOR, D.; RIBEIRO JUNIOR, J. I. Produção de matéria seca e valor nutritivo de pastagem de capim-elefante sob irrigação e adubação nitrogenada. **Revista Brasileira de Zootecnia**, Viçosa, v. 38, n. 3, p. 435-442, mar., 2009.