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Morphogenetic and structural characteristics of guinea grass tillers at different ages under intermittent stocking

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ABSTRACT - The objective of this research was to assess morphogenetic and structural characteristics of tillers of guinea grass cv. Tanzania at different ages. The pastures of guinea grass were managed in six pasture conditions related to the combination of three frequencies (90, 95, and 99% light interception) and two post-grazing heights (25 and 50 cm). In these six pastures conditions, three tiller ages were evaluated (young, mature, and old). The design was of completely randomized block with three replications. Young tillers exhibited higher leaf appearance rate and leaf elongation rate and, consequently, higher final leaf length and number of live leaves than mature and old tillers, regardless of the pasture condition. On pastures managed with 90 or 95% light interception associated with a post-grazing height of 25 cm, old tillers presented longer leaf lifespan than young and mature ones. There is a progressive reduction in the vigor of growth of pastures of guinea grass cv. Tanzania with advancing tiller age.

Key Words: grazing management, light interception, *Panicum maximum*, sward height

Introduction

Concerning the tiller, the forage production in pastures from tropical climate can be described in terms of the leaf appearance rate, leaf elongation rate, life lifespan (Lemaire & Chapman, 1996), and stem elongation rate (Sbrissia & Da Silva, 2001). Although they are genetically determined characteristics, they can be influenced by environmental variables including temperature (Duru & Ducrocq, 2000), light intensity (Ryle, 1966; Van Esbroeck et al., 1989), water availability (Durand et al., 1997), nutrient availability (Longnecker et al., 1993; Martuscello et al., 2005), defoliation effects (Marcelino et al., 2006; Sousa et al., 2010) and tiller age (Montagner et al., 2011; Paiva et al., 2011), which define rates and duration of processes.

In adequate environmental conditions (day length, temperature, humidity and soil fertility), plants increase their leaf appearance and elongation rates (Marcelino et al., 2006) and tiller appearance rate (Mazzanti et al., 1994; Difante et al., 2008) during regrowth. This pattern makes the forage accumulation be basically composed of leaves (Da Silva & Nascimento Júnior, 2007). As the leaf index increases, the plant starts investing in stem elongation in an attempt to allocate its leaves in the top of the sward (Da Silva, 2004); the quantity and quality of light that penetrates the sward decreases progressively, causing the death of smaller tillers in a process called size/density compensation (Matthew et al., 1995; Sbrissia & Da Silva, 2008). Concomitantly, there is increase in the leaf senescence (Hodgson et al., 1981) and decrease in the leaf lifespan as a way of keeping the number of live leaves per tiller relatively stable (Davies, 1988).

However, because pastures are formed by tillers at different stages of development, they have, simultaneously, tillers at variable vegetative development cycles and also tillers at the reproductive stage (Paiva et al., 2011). So, tillers can respond individually to the management practices employed (e.g., grazing frequency and severity), depending on their stage of development. This research was performed to assess the morphogenetic and structural characteristics of tillers of different ages on pastures of guinea grass cv. Tanzania subjected to rotational grazing strategy.

Material and Methods

The experiment was conducted in Embrapa Gado de Corte - CNPGC, in Campo Grande, MS (20°27' S; 54°37' W; 530 m) during the period from March 12 to May 5, 2004, in a total of 70 days of evaluation. The climate, according to the Köppen classification, is of rainy savannah-tropical

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type, Aw subtype, characterized by irregular annual rain distribution, with a well-defined occurrence of a dry period during the coldest months of the year and a rainy period during summer months.

Rainfall and average temperature data (Figure 1) were recorded by the weather station of Embrapa Gado de Corte, approximately 800 m from the experiment site.

Pastures were planted using 2 kg/ha of pure viable seeds, incorporated in the soil by means of a light harrowing followed by a packing using a tire roll in January 1995. From August of 1995 on, the area was grazed.

Before the initiation of the experiment, 12 soil samples from a 0-10 cm depth were taken from the experimental unit. The soil was classified as a dystrophic Red Oxisol (EMBRAPA, 2006) characterized by clayey texture, acid pH, low saturation for bases and high aluminum concentration. Results of chemical analysis of soil samples revealed a pH of 5.0, base saturation of 44%; phosphorus (Mehlich-1) and potassium concentrations of 4.7 and 122 mg/dm^3. Based on these results, the soil correction was performed with 2,500 kg/ha of dolomitic limestone (PRNT 75%) and maintenance fertility with 300 kg/ha of a 0-20-20 formulation (NPK), divided in three applications, from January to March 2003.

The pastures of guinea grass were managed with three defoliation frequencies (90, 95, or maximum interception of 99% of light during regrowth) and two post-grazing heights (25 and 50 cm), which resulted in six pasture conditions: 90/25, 95/25, 99/25, 90/50, 95/50 and 99/50 (Barbosa et al., 2007). In these six pasture conditions, three tiller ages were evaluated (young, mature and old tillers) (Carvalho et al., 2001). A completely randomized block design with three replications and 0.25 ha experimental units was used.

During the experiments, the pastures received fertilization with an equivalent of 200 kg/ha of nitrogen, which was consistently applied in portions as urea after the animals had left the paddocks after each grazing cycle. Because the grazing interval and the conditions for animal entry into the pastures were not fixed, the amount of fertilizer that was applied to each paddock at each grazing cycle varied. Thus, 200 kg/ha of nitrogen were divided by the period of grass growth (November-March) to obtain the daily amount to be applied to each paddock. The amount of fertilizer that was effectively applied was calculated by multiplying the daily amount by the rest period that occurred in each experimental unit. Therefore, by the end of each experiment, every pasture had received the same amount of nitrogen (200 kg/ha). Fertility was monitored annually with the objective of keeping base saturation between 50 and 70%, phosphorous (Mehlich-1) content between 8 and 12 mg/dm^3 and potassium content between 80 and 100 mg/dm^3.

Light interception was monitored with canopy light analyzer AccuPAR Linear PAR / LAI ceptometer, Model PAR –80 (DECAGON Devices), and readings were taken at six sampling points for each experimental unit (Carnevalli et al., 2006). At every point, three readings above the forage canopy and three at soil level (each measure was the average of five instantaneous readings) were performed.

From April to June 2003, standardization grazing session and weed control were performed. In July 2003, the pastures underwent management according to the six imposed conditions (frequency/post-grazing height: 90/25, 95/25, 99/25, 90/50, 95/50 and 99/50) (Barbosa et al., 2007). On this date, the first tiller tagging occurred. In each experimental unit, four clumps were tagged in the sward average height to monitor the tillering pattern of the pastures. In these clumps, it was possible to monitor the tiller from the tagging of new emerged tillers in the post-grazing condition at each regrowth cycle. The tillering was watched in until March

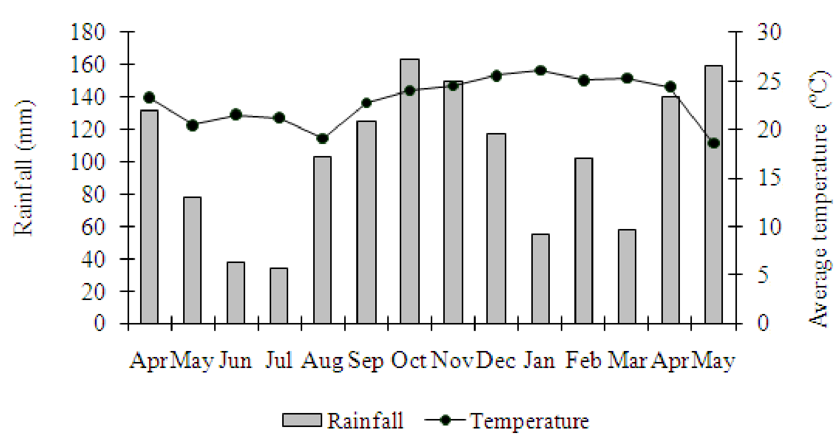

Figure 1 - Rainfall distribution and average temperature during the experimental period (April 2003 to May 2004).

1st, 2004, when it was possible to obtain three tiller categories in all the experimental units: young tillers (less than 2 months), mature tillers (between 2 and 4 months), and old tillers (more than 4 months) (Carvalho et al., 2001). Thus, this date marked the beginning of the evaluations, which were extended to May 10, 2004, in a total of 70 evaluation days.

In each of the four clumps per experimental unit that were utilized for measuring tiller demography, nine tillers, three of each age, were selected for a total of 12 young, 12 mature, and 12 old tillers. As there were only three grazing cycles for the condition of 99/25, it was not possible to obtain tillers from the old category. Evaluations were performed between March 1, 2004 and May 10, 2004, in a total of 70 days.

The morphogenetic and structural characteristics were performed twice a week by measuring the lengths of leaf blade and stem (stem+leaf sheaths). These evaluations made it possible to calculate the leaf appearance rate (leaves/tiller.day), number of emerging leaves per tiller divided by the number of days of the evaluation period; the leaf elongation rate (cm/tiller.day), sum of the all leaf elongation per tiller divided by the number of the days of the evaluation period; the leaf lifespan (days), period of time between the leaf appearance until its death, estimated by the following equation proposed by Lemaire & Chapman (1996): leaf lifespan = number of live leaves × (1/leaf appearance rate); the final leaf length (cm), average leaf length of all the leaves present in the tiller, measuring the leaf apex until the ligule; and the number of live leaves (leaves/tillers), average number of leaves per tiller, regardless of the leaves that presented more than 50% of their senescent length.

The main objective was to compare the tiller categories in each pasture condition; therefore, the comparisons between pasture conditions were not made. The data were analyzed utilizing the GLM procedure of the SAS package (Statistical Analysis System, version 6.4), for Windows. RANDOM and TEST commands were used for identification and performance of appropriate tests. Comparison of means was made through appropriate contrasts, adopting 10% of significance level.

Results

Young tillers presented higher leaf appearance rate (P<0.10) than mature and old tillers in all pasture conditions (90/25, 95/25, 90/50, 95/50 and 99/50), except on pastures managed at condition of 99/25, in which there was no difference (P>0.10) between young and mature tillers (Table 1).

In the pasture condition of 90/25, 95/20 and 90/50, higher leaf elongation rates were obtained in young tillers, intermediate rates were observed in mature tillers, and lower rates were obtained in old tillers. Young tillers presented higher value than mature and old tillers in the pasture

Table 1 - Morphogenetic and structural characteristics of tillers of different ages on pastures of guinea grass subjected to rotational grazing strategies

Tiller age	Pastures condition					
	90/25	95/25	99/25	90/50	95/50	99/50
	Leaf appearance rate (leaves/tiller.day)					
Young tiller	0.096a	0.079a	0.060a	0.083a	0.069a	0.062a
Mature tiller	0.083b	0.069b	0.059a	0.067b	0.056b	0.057ab
Old tiller	0.077b	0.064b	-	0.059b	0.054b	0.052b
	Leaf elongation rate (cm/tiller.day)					
Young tiller	2.85a	2.49a	2.02a	2.57a	2.26a	2.34a
Mature tiller	2.25b	1.81b	2.22a	1.73b	1.51b	1.76b
Old tiller	1.65c	1.43c	-	1.30c	1.37b	1.53b
	Leaf lifespan (days/leaf)					
Young tiller	28.0b	37.0ab	40.0a	30.0a	36.0a	43.0a
Mature tiller	29.0ab	34.0b	37.0a	30.0a	37.0a	44.0a
Old tiller	32.0a	39.0a	-	31.0a	36.0a	41.0a
	Final leaf length (cm)					
Young tiller	30.0a	34.5a	40.0a	30.7a	34.6a	42.3a
Mature tiller	31.0a	28.5b	40.3a	25.9b	31.3ab	34.4b
Old tiller	21.8b	22.1c	-	21.7c	28.7b	32.7b
	Number of live leaves (leaves/tiller)					
Young tiller	2.6a	2.9a	2.5a	2.5a	2.4a	2.7a
Mature tiller	2.3b	2.4b	2.2a	2.0b	1.9b	2.5a
Old tiller	2.3b	2.5ab	-	1.8b	2.0ab	2.2a

For each characteristic, means followed by the same letter in the column do not differ significantly by Tukey's test (P>0.10).

conditions of 95/50 and 99/50. In the pasture condition of 99/25, there was no difference in the leaf elongation rate between young and mature tillers (Table 1).

In the pasture conditions of 90/25 and 95/25, the leaf lifespan was greater (P<0.10) in old tillers in comparison with young and mature tillers. In the other pasture conditions (99/25, 90/50, 95/50 and 99/50) there was no difference in the leaf lifespan between the evaluated tiller ages (Table 1).

In the pasture conditions of 95/25, 90/50 and 95/50, young tillers presented higher (P<0.10) final leaf length, mature tillers presented intermediate value, and old tillers presented lower value. Young and mature tillers presented higher final leaf length in relation to old tillers in the condition of 90/25. However, in the condition of 99/50, young tillers presented higher value in relation to the mature and old ones. There was no difference (P>0.10) between young and mature tillers in the condition of 99/25 (Table 1).

Young tillers presented higher number of live leaves per tiller in comparison with mature and old tillers in the pasture conditions of 90/25, 95/25, 90/50 and 95/50. The number of live leaves was not influenced (P>0.10) by tiller age in the pasture conditions of 99/25 and 99/50 (Table 1).

Discussion

It was not possible to obtain old tillers (more than 4 months) for the pasture condition of 99/25. This fact occurred because of the longer necessary time for the pastures managed at 25 cm post-grazing height to reach 99% of light interception (Barbosa et al., 2007), which reduced the pasture tillering. Thus, the morphogenetic and structural characteristics for old tillers could not be estimated in this pasture condition.

In all the pasture conditions, except for the condition of 99/25, young tillers presented higher leaf appearance and elongation rates in relation to mature and old tillers (Table 1). These higher growth rates recorded for young tillers are likely to be linked to their greater photosynthetic capacity. Carvalho (2002), evaluating guinea grass cv. Tanzania and guinea grass cv. Mombasa subjected to cutting heights revealed that young tillers presented higher photosynthetic capacity than old tillers. The effects of tiller age upon the morphogenetic and structural characteristics were also evaluated for guinea grass cv. Mombaca subjected to three post-grazing heights (Montagner et al., 2011) and for Marandu palisadegrass managed with different doses of nitrogen under continuous stocking (Paiva et al., 2011). The results followed the same pattern related by Carvalho (2002), in which there was reduction in the growth rates with the elevation of tiller ages. According to Carvalho et al. (2006), young tillers also present lower carbon retention, suggesting that the photosynthetic capacity of these tillers exceeds their capacity of use to maintenance, growth, and stocking capacity. Therefore, young tillers would be the "source" of photoassimilates for older tillers (Taiz & Zeiger, 2009). This reduction in the tiller photosynthetic rate with increase in the age possibly occurred because of the anatomical and physiological changes in the leaves (Carvalho, 2002), like the increase in the proportion of conducting and mechanic tissues of plants and tillers (Pinto et al., 1994) and the increase in the specific leaf area with and without the increase in tiller age (Carvalho, 2002).

In the conditions of 90/25 and 95/25, young and mature tillers presented shorter leaf lifespan than the old ones. These pasture conditions result in lower intraspecific competition for light inside the sward (Da Silva & Nascimento Júnior, 2007). In this context, the processes of growth and senescence in young and mature tillers provided a higher tissue renewal. For presenting lower photosynthetic metabolism, and, therefore, lower rates of growth and development (Carvalho et al., 2006), old tillers possibly presented higher leaf lifespan as a way of keeping their leaf area for a longer period. Therefore, as described by Silveira (2010), it is observed that the tissue production in tillers, besides being ruled by environmental features, by management, and by pasture characteristics (tiller density), is also influenced by the tiller characteristics themselves (tiller age), and the interaction between these features determines the morphogenetic patterns of the plants.

In this study, no statistical comparison of the tiller ages between the diverse existing pasture conditions was made. This decision was due to the short evaluation period of this experiment (70 days), which could generate confusion of the responses found. Nevertheless, decrease in the growth vigor of the young tillers in relation to the old ones with the elevation in grazing frequency can be observed, especially on pastures managed at 50 cm post-grazing height. This way, young tillers presented superior leaf appearance rates at 40.7, 28.8 and 19.2% in the conditions of 90/50, 95/50 and 99/50, respectively; and superior leaf elongation rates at 90.7, 65.0 and 52.9% in the conditions of 90/50, 95/50 and 99/50, respectively, in comparison with old tillers. Less frequent grazing sessions (99% light interception) increase the regrowth time of the pasture in relation to more frequent grazings (90% light interception) (Barbosa et al., 2007); consequently, they increase the intraspecific competition for light inside the sward (Da Silva & Nascimento Júnior, 2007). This situation reduces the leaf accumulation, increases the stem and the death material accumulation (Carnevalli et al., 2006; Da Silva et al., 2009), and decreases the rates of sward growth and development (Barbosa et al., 2011). Possibly, this reduction in the grazing frequency also decreases the rates of young tiller growth and development in relation to the old ones as reported above. However, this is just a hypothesis that in order to be validated needs to be analyzed in studies with a greater extent of the experimental period in different seasons of the year.

The forage plant expresses genetic potential through the morphogenetic characteristics such as leaf appearance and elongation rates, leaf lifespan (Lemaire & Chapman, 1996), and stem elongation rate (Sbrissia & Da Silva, 2001). These characteristics, influenced by the environmental conditions, determine the structural characteristics (plant phenotype), such as leaf length and number of live leaves (Lemaire & Chapman, 1996). Overall, young tillers presented higher growth rates, characterized by higher leaf appearance and elongation rates, in relation to mature and old tillers. Consequently, young tillers also presented higher leaf length and number of live leaves than mature and old ones. In addition to this, the lower final leaf length in old tillers in comparison with the young ones may be a result of the shorter distance traveled by the new leaf inside the pseudo-stem (Duru & Ducroq, 2002), in response to the elevation of the apical meristem (Hodgson, 1990) in old tillers. The higher number of leaves and the longer final leaf length effectively represent greater participation of the leaves per tiller, which results in higher leaf area to perform the photosynthesis. Additionally, the higher number of leaves and the longer final leaf length may represent forage with more quality, once the leaf is the morphologic component of greatest nutritional value (Van Soest, 1994).

The results indicate that the tiller age affects the morphogenetic and structural characteristics in pastures of guinea grass. Thus, grazing management strategies that allow higher tiller population renewal, contributing to a younger profile of the plants on pasture, may result in increases of production in addition to improvement in the nutritional value of the forage produced (Santos et al., 2006).

Conclusions

Tiller age alters the morphogenetic and structural characteristics of guinea grass cv. Tanzania, once young tillers present increased growth vigor compared with both mature and old ones.

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