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Tillering dynamics in Guinea grass pastures subjected to management strategies under rotational grazing

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ABSTRACT - This study was carried out to analyze the tillering profile of Guinea grass (*Panicum maximum* cv. Tanzania) pastures subjected to two grazing frequencies (time necessary to intercept 90 and 95% of the incoming light) and two post-grazing heights (30 and 50 cm) in the period from November 2005 to October 2006. The experimental design was of completely randomized blocks with three replications, in a 2 × 2 factorial arrangement. At the end of the spring, pastures managed with 90% light interception showed greater tiller appearance rates in relation to pastures managed with 95%, regardless of post-grazing height. In the summer and fall, pastures managed with post-grazing height of 30 cm showed higher tiller appearance rates in comparison with pastures managed at 50 cm, regardless of grazing frequency. Concerning the tiller mortality rates, in the summer, higher values were found for pastures managed at 90/50 and 95/30 (interception/height), intermediate values at 90/30 and lower values in those managed at 95/50. Pastures managed at 90/30, 95/30 and 95/50 in the fall presented greater tiller mortality rates than those managed at 90/50. These differences do not occur in the winter/beginning of spring. The stability index remained above 1 all through the experimental period. All management strategies evaluated are adequate for Guinea grass.

Key Words: grazing frequency, grazing intensity, *Panicum maximum*, plant ecophysiology

Introduction

The tiller is the basic unit of production of forage grasses, which utilize tillering as a form of growth, and above all, survival (Hodgson, 1990). The persistency of a forage grass is associated with the continuous replenishment of tillers, once they present a limited and variable lifespan due to conditions intrinsic to the forage plant (species, vegetative and reproductive stages), to environmental factors (temperature, luminosity, humidity, fertility) (Langer, 1963) and grazing strategy (frequency and intensity) (Matthew et al., 1995).

In Brazil, based on recent studies, it is recommended that the regrowth of Guinea grass be interrupted when the sward reaches 70 cm, which corresponds to 95% of interception of the incoming light by the pasture (Barbosa et al., 2007). Once this defoliation frequency is defined, the flexibility of pasture management can be achieved through variations in the post-grazing height.

Provided it is not very low, which would negatively affect pasture regrowth and persistency (Sousa, 2009), severe defoliation promotes elevated tissue renewal potential, with greater accumulation of leaf blades and effective control of the stem accumulation, which results in greater grazing efficiency and stocking rate, but lower animal performance. In contrast, lenient defoliation results in greater stem accumulation, higher number of grazing cycles during seasons favorable to growth and increase in animal production, but decrease in stocking rate (Difante, 2005).

However, in environments favorable to pasture growth, as in fertilized and/or irrigated pastures, it is common that a greater number of pastures reach the ideal grazing condition in relation to the necessary number (Zanine, 2007). In this scenario, utilizing a grazing management equal to the ideal goal of 95% light interception by the sward could generate management flexibility. However, such studies are still scarce.

Thus, this study was proposed for the evaluation of the tillering patterns of Guinea grass subjected to two frequencies (time to intercept 90 and 95% of light) and two post-grazing heights (30 and 50 cm) under rotational grazing.

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Material and Methods

The study was conducted in an area of the Departamento de Zootecnia of Universidade Federal de Viçosa, Minas Gerais, Brazil (20º 45' S, 42º 51' W and 651 m), with Guinea grass (*Panicum maximum* Jacq. cv. Tanzania), in the period from November 2005 to October 2006. According to the Köppen classification (1948), the climate of the region is subtropical type Cwa, with well-defined dry (in the coldest months) and rainy (in the hottest months) seasons. The climate information (Figure 1) was obtained from a meteorological station located approximately 1,000 m away from the experimental area. The monthly water balance (Figure 2) was calculated utilizing a water holding capacity of 50 mm (Thornthwaite & Mather, 1955).

The soil of the experimental area is classified as a Red-Yellow Argisol, with clayey-loam texture (EMBRAPA, 2006). Four soil samples were collected at a depth of 0-20 cm for analysis of the chemical characteristics. According to the results of the chemical analysis, the soil presented the following characteristics: pH in H_2O: 6.70; P (Mehlich-1): 1.40 mg/dm^3 and K: 36.00 mg/dm^3; Ca^{2+}: 2.10 cmol$_c$/dm^3; Mg^{2+}: 0.70 cmol$_c$/dm^3; Al^{3+}: 0.00 cmol$_c$/dm^3 (KCl 1 mol/L); H + AL: 1.6 cmol$_c$/dm^3; CEC: 9.9 cmol$_c$/dm^3 and V: 79%. Because of the elevated natural soil fertility, the elevated pH value and absence of exchangeable aluminum, there was no need for correction or fertilization in the area for the implantation of the grass.

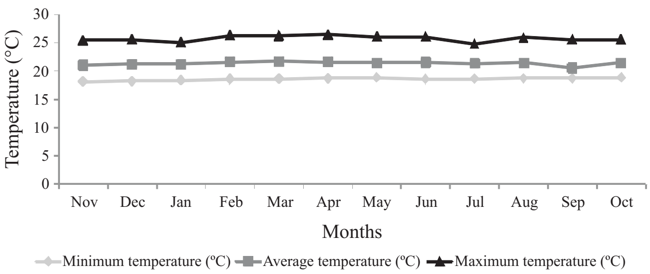


Figure 1 - Monthly meanimum, average and maximum mean temperatures in the period from November 2005 to October 2006.

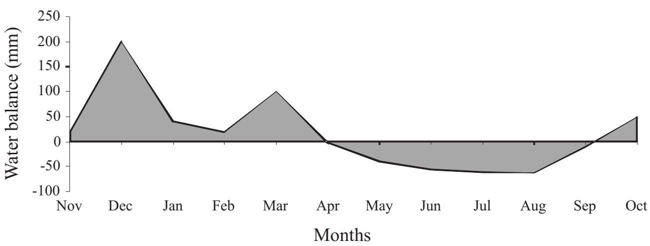


Figure 2 - Monthly water balance during the period from November 2005 to October 2006.

The establishment of the Guinea grass happened in January 2005, by seeding 3 kg pure viable seeds per hectare. In March 2005 the area was subjected to a lenient grazing so as to stimulate plant tillering. After removal of animals from the paddocks, the pasture was fertilized with only 60 kg nitrogen/ha in the form of urea. From this date on, weed control was performed and the area was managed with rotational grazing with crossbred cattle until the beginning of the spring. In the beginning of October 2005, a standardization cut was performed at 35 cm above the soil with a backpack mower. The evaluations started after another cycle of plant growth (11/07/2005) and ended on 10/12/2006.

Combinations between two frequencies (period of time necessary for the sward to reach 90 and 95% of the light interception during regrowth) and two grazing intensities (characterized by post-grazing heights of 30 and 50 cm) were evaluated, in a 2 × 2 factorial arrangement. Thus, treatments corresponded to four grazing management strategies (combination between frequency and intensity): 90/30 (90% light interception and 30 cm post-grazing height), 90/50, 95/30 and 95/50. The grazing management strategies were allocated to the experimental units (144 m^2 paddocks) in a completely randomized block experimental design with three replications.

Grazing was performed by crossbred Nellore × Guzerat cattle of approximately 460 kg body weight. High stocking rates were employed for the grazing not to exceed daytime at the obtainment of the specific residual height of each treatment. After grazing animals remained in a reserve pasture and only returned to the experimental unit when they once again reached the pre-grazing goals established (90 or 95% light interception).

During the experiment 150 kg N/ha were used in the form of urea, divided in three doses of 50 kg/ha after animals left the paddocks. Because the grazing interval and the condition of animal entrance in the paddocks were variable, the application dates were also distinct (Table 1). However, the applications were performed so that all treatments received the same amount of nitrogen by the end of the experimental period.

The monitoring of light interception by swards was done with sward analyzer AccuPAR Linear PAR/LAI ceptometer, Model PAR–80 (DECAGON Devices). During regrowth, the evaluations happened at every seven days, until values close to 90 and 95% were reached. From this moment, the interval between evaluations was reduced to two days, until the pre-grazing goals were achieved. Readings were done in sixteen sampling points per experimental unit, in between the tussocks, following a pre-determined path at

Table 1 - Date of application of nitrogen fertilizer in each experimental unit during the experimental period

Treatment[1]	Block	Date	1st dose (kg/ha)	Date	2nd dose (kg/ha)	Date	3rd dose (kg/ha)	Total (kg/ha)
90/30	I	11/07	50	12/28	50	02/03	50	150
90/30	II	11/07	50	12/28	50	02/03	50	150
90/30	III	11/07	50	12/28	50	02/03	50	150
95/30	I	11/07	50	01/28	50	03/01	50	150
95/30	II	11/07	50	01/28	50	03/01	50	150
95/30	III	11/07	50	01/28	50	03/01	50	150
90/50	I	11/07	50	12/20	50	02/23	50	150
90/50	II	11/07	50	12/20	50	02/23	50	150
90/50	III	11/07	50	12/20	50	02/23	50	150
95/50	I	11/07	50	01/06	50	02/09	50	150
95/50	II	11/07	50	01/06	50	02/09	50	150
95/50	III	11/07	50	01/06	50	02/09	50	150

[1] Light interception (%)/grazing intensity (cm).

the beginning of the experimental period (zigzag). In each point, one reading was performed above and another below the sward, utilizing the soil level as reference.

For the evaluation of the tillering demographic patterns, three tussocks were tagged per experimental unit at points representing the average pasture height. At the beginning of the experimental period all tillers belonging to the tussocks were counted and tagged with plastic-coated wires of a specific color. After each grazing session, all tillers tagged were recounted; new tillers were tagged with a different color from that utilized at the previous taggings and the wires of dead tillers were removed. In this way it was possible to estimate the tiller population of all generations and to calculate the rates of tiller appearance {[(new tillers/total live tillers in the previous tagging) × 100]/ days of regrowth} and mortality {[(dead tillers/total live tillers in the previous tagging) × 100]/ days of regrowth}(Carvalho et al., 2000).

The tiller population stability index was calculated according to the methodology described by Bahmani et al. (2003), using the expression: stability index = tiller survival rate (1 + tiller appearance rate). The tiller survival rate was calculated as: (1 – tiller mortality rate).

Because of the variable nature of the grazing intervals of the treatments, the data were grouped per time of the year. For so, the weighted means were calculated by considering the number and duration of the grazing cycles for each repetition, and the results were grouped in the following times of the year: end of the spring (November and December 2005); summer (January to March 2006); fall (April to June 2006); and winter/beginning of spring (July to October 2006). The dataset was tested to make sure that the basic prerogatives of variance analysis were met, without the need for data transformation. The data grouped so were subjected to variance analysis utilizing procedure GLM of statistical package SAS (Statistical Analysis System*,* version 6.4). The comparison of means, whenever necessary, was performed by the Tukey test, adopting 10% as significance level.

Results

Tiller appearance rate was influenced by the interaction of post-grazing height × light interception × time of the year ($P<0.10$) (Table 2). At the end of the spring, pastures managed at 90/30 and 90/50 presented higher tiller appearance rates in relation to those managed at 95/30 and 95/50. In the summer and fall, pastures managed at 90/30 and 95/30 showed higher values in comparison with pastures managed at 90/50 and 95/50. In the winter/beginning of spring, pastures managed at 95/30 presented lower tiller appearance rates in comparison with pastures managed at 90/30, 90/50 and 95/50 (Table 2). Overall, tiller appearance rate was greater in the summer in relation to the end of the spring, fall and winter/beginning of spring.

Tiller mortality rate was not affected by the post-grazing height × light interception × time of the year interaction ($P<0.10$) (Table 3). The tiller mortality rate was also not affected by the combination between frequency (90 and 95% light interception) and post-grazing heights (30 and 50 cm) at the end of the spring. In the summer, higher values were recorded for pastures managed at 90/50 and 95/30, intermediate in those managed at 90/30 and lower in those managed at 95/50. Pastures managed at 90/30, 95/30 and 95/50 in the fall presented greater tiller mortality rate in comparison with those managed at 90/50. These differences disappeared in the winter/beginning of spring (Table 3). Overall, the tiller mortality rates increased in the summer, reduced in the fall and reached minimum values in the winter/beginning of spring and end of spring.

The first generation corresponded to the number of existing tillers in the beginning of the experimental period;

Table 2 - Tiller appearance rate (tiller/100.tiller.day) in Guinea grass subjected to grazing strategies under rotational grazing

Post-grazing height (cm)	Light interception (%)	
	90	95
	End of the spring	
30	1.10Aa	0.45Ba
	(0.202)	(0.205)
50	0.85Aa	0.45Ba
	(0.873)	(0.277)
	Summer	
30	1.92Aa	2.33Aa
	(0.326)	(0.370)
50	1.66Ab	1.40Ab
	(0.408)	(0.449)
	Fall	
30	1.10Aa	1.30Aa
	(0.152)	(0.395)
50	0.79Ab	0.70Ab
	(0.113)	(0.216)
	Winter/beginning of the spring	
30	1.21Aa	0.69Ba
	(0.271)	(0.243)
50	1.08Aa	0.98Aa
	(0.103)	(0.178)

Numbers in parentheses correspond to the standard error of the mean. For each time, means followed by the same uppercase letter in the row and lowercase letter in the column do not differ by the Tukey test (P>0.10).

Table 3 - Tiller mortality rate (tiller/100.tiller.day) in Guinea pastures subjected to grazing strategies under rotational grazing

Post-grazing height (cm)	Light interception (%)	
	90	95
	End of the spring	
30	0.34Aa	0.30Aa
	(0.160)	(0.230)
50	0.38Aa	0.49Aa
	(0.180)	(0.301)
	Summer	
30	2.20Ab	2.35Aa
	(0.440)	(0.850)
50	2.69Aa	1.65Bb
	(0.090)	(0.850)
	Fall	
30	1.20Aa	1.02Aa
	(0.080)	(0.190)
50	0.61Bb	0.95Aa
	(0.110)	(0.150)
	Winter/beginning of the spring	
30	0.18Aa	0.29Aa
	(0.090)	(0.033)
50	0.51Aa	0.19Aa
	(0.112)	(0.093)

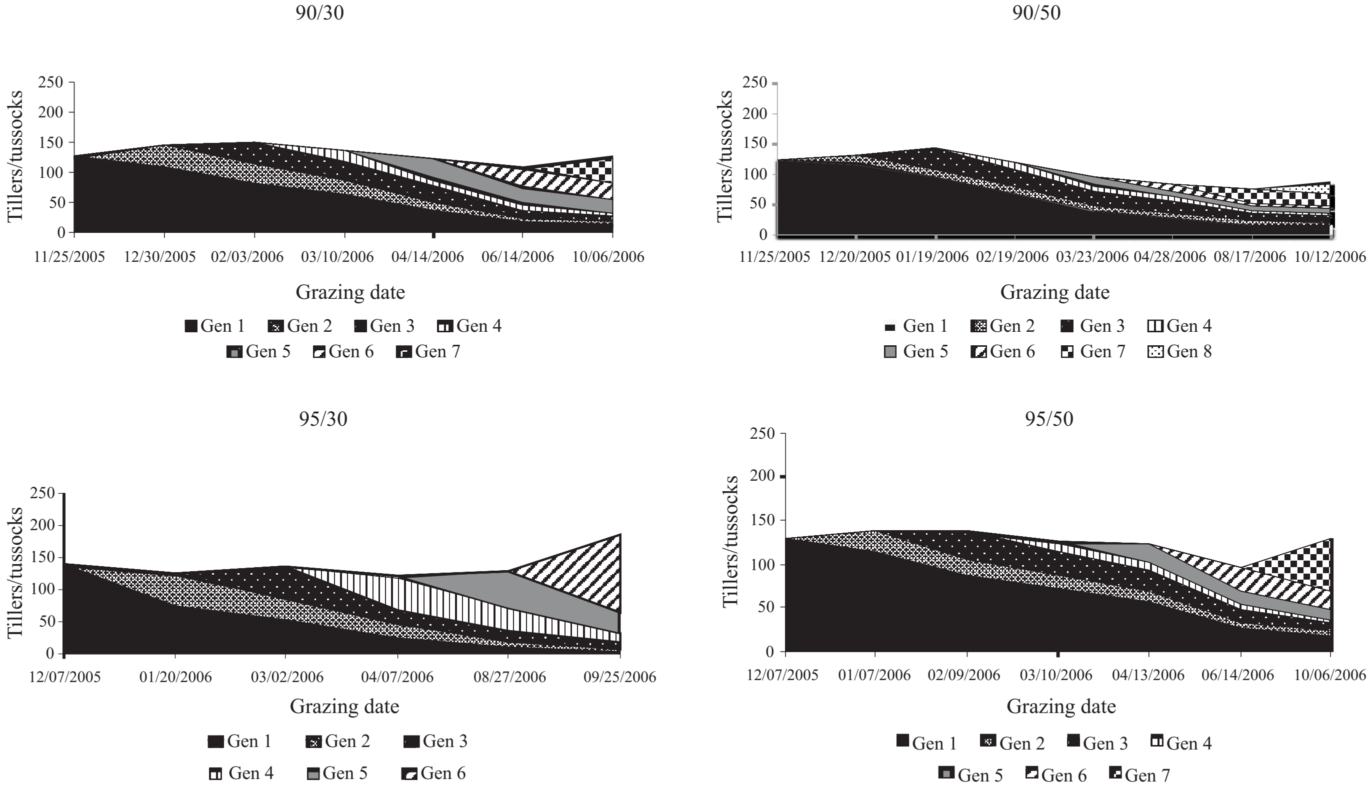
Numbers in parentheses correspond to the standard error of the mean. For each time, means followed by the same uppercase letter in the row and lowercase letter in the column do not differ by the Tukey test (P>0.10).

it was not possible to identify the date of their appearance, so it was more numerous. Regardless of the management strategy utilized (grazing frequency and post-grazing height), tillers emerging during the summer (generations 2 and 3) showed more longevity and consequently higher contribution to the maintenance of the tiller population, in comparison with those that emerged during the fall and winter. Overall, there was a reduction in tillering during the winter, which increased again with the beginning of the spring. Pastures managed at 95/30 showed a more stable tillering in relation to pastures managed at 90/30, 90/50 and 95/50 (Figure 3).

The high stability index of the tiller population of the Guinea grass remained above 1.0 all through the experimental period, regardless of the management strategy evaluated (defoliation frequency and post-grazing height) (Figure 4). After the first grazing cycle, the tiller population increased in the period corresponding to the end of spring and summer, decreasing in the winter and rising again in the beginning of spring.

Discussion

At the beginning of the experimental period, i.e., at the end of spring, pastures managed with 90% light interception presented greater tiller appearance rate compared with pastures managed at 95%, regardless of the post-grazing height assessed (Table 1). The tillering potential of a genotype is related to its capacity of emitting leaves, once each leaf formed corresponds to the formation of a new axillary bud, capable of generating another tiller. In theory the appearance of new leaves results in opportunity for appearance of new tillers (Skinner & Nelson, 1992). Thus, the greater tiller appearance rates in the pastures managed with 90% of light interception by the sward can be related to greater leaf appearance rate, which was, on average 32% (0.1785 *vs* 0.135 leaves/tiller.day) higher in these pastures in comparison with those managed at 95% light interception. This pattern can be a response to the lower competition for light associated with the lower grazing (30 cm) at the beginning of the experimental period. The more intensive grazing removes more quantity of forage, which reduces the dead forage mass and the amount of accumulated stems during the winter. According to Paiva et al. (2011), management actions that reduce the amount of dead material during the winter favor tillering and reestablishment of pasture growth at the beginning of the new growth season (spring). Moreover, pastures managed with 90% light interception present even lower pre-grazing forage mass (6,400 kg/ha DM) in relation to those



Gen - generation.

Figure 3 - Demographic pattern of tillering in Guinea grass pastures managed with frequencies (time to intercept 90 and 95% of the light) and post-grazing heights (30 and 50 cm).

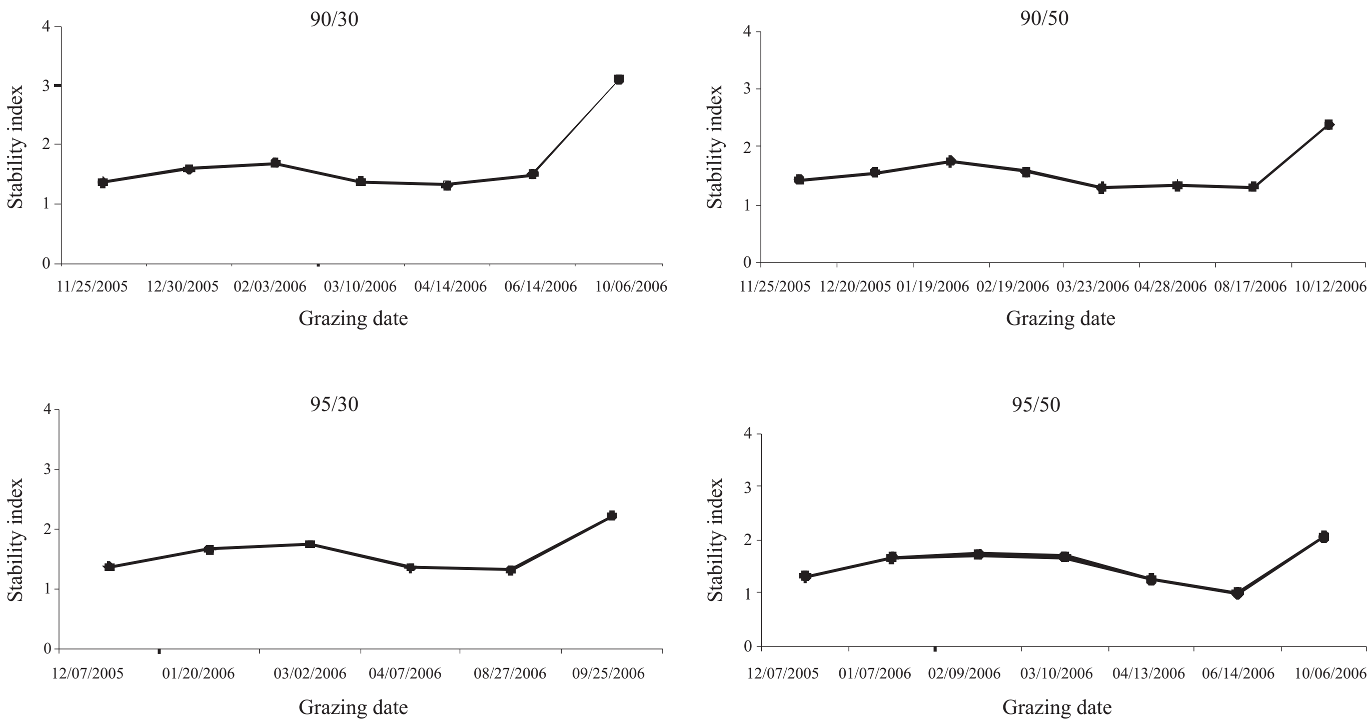


Figure 4 - Stability index in Guinea grass pastures managed with frequencies (time to intercept 90 and 95% of the light) and post-grazing heights (30 and 50 cm).

managed with 95% light interception (7,270 kg/ha DM) (Zanine, 2007), which also caused a greater competition for growth factors, especially light.

The more intense grazing can increase the decapitation of apical meristems (Korte & Harris, 1987), which would also stimulate tillering. Thus, for reaching the grazing condition earlier, pastures managed at 90% light interception show greater tiller appearance, possibly due to the conditions of lower light interception at the beginning of the experimental period and also to the decapitation of apical meristems.

Tiller mortality rate, in turn, did not vary ($P<0.10$) among the management strategies assessed at the beginning of spring. The tiller population is closely linked to a dynamic and harmonic balance between the processes of appearance and death of tillers (Da Silva et al., 2008). Thus, the elevation in the tiller appearance rate (Table 2) associated with the relatively constant mortality rate in this period resulted in elevation in the number of tillers in the sward (Figure 3), regardless of the management strategy evaluated (grazing frequency and intensity).

The end of the spring and summer are characterized by better conditions for plant growth, markedly by higher temperatures, rainfall (Figures 1 and 2) and luminosity, as well as greater nutrient availability caused by fertilization (Table 1). Thus, in these seasons plants increase their tiller growth and development rates (Sousa, 2009) and renewal (Sbrissia et al., 2010; Caminha et al., 2010). This was observed in this experiment, in which higher tiller appearance rates (Table 1) and tiller mortality (Table 2) occurred during the summer, which resulted in lower tiller survival (Figure 3). The greater renewal of tillers results in younger tillers on the pasture (Sbrissia et al., 2010); these tillers present newer leaves, and consequently greater photosynthetic capacity (Carvalho et al., 2006) and thus greater growth and development rates in relation to older tillers (Paiva et al., 2011).

In the summer and fall, pastures managed at 90/30 and 95/30 presented higher tiller appearance rates in relation to pastures managed at 90/50 and 95/50. The number of tillers of a pasture is maintained by a size/density compensation mechanism (Matthew et al., 1995; Sbrissia et al., 2003), in which the increase in the weight (size) of the tiller is compensated by reduction in their number, as a way to keep the leaf area index of the pasture relatively constant within a period of the year. This process is especially controlled by the intraspecific competition for light (Matthew et al., 1995). In this sense, pastures managed with post-grazing height of 50 cm presented greater forage mass and leaf area index at the beginning of regrowth in comparison with those managed at 30 cm (Zanine, 2007). This pattern decreases the quantity and quality of light that reaches the inner part of the sward, reducing the activation of dormant buds and consequently reducing the tiller appearance (Matthew et al., 2000). Furthermore, the more intensive grazing (30 cm) removes more forage, which may result in greater elimination of apical meristems, which might also stimulate tillering, once there is removal of the source of auxin that inhibits the development of lateral buds (Langer, 1979).

As a way to keep the tiller population density relatively constant in a growth season (Da Silva et al., 2008), the higher appearance rates during the summer and fall in pastures managed at 90/30 and 95/30 (Table 1) were compensated by greater tiller mortality rates (Table 2). However, to better analyze the effects of significant variations in the tiller appearance and mortality rates one can utilize the stability index (Bahmani et al., 2003). In general, values inferior to 1.0 indicate that the survival and appearance of new tillers are not enough to compensate the mortality rates, so the population would tend to diminish. Numbers higher than 1.0 suggest the opposite situation, whereas values close to 1.0 indicate a stable tiller population, in which the number of tillers almost does not change (Bahmani et al., 2003).

Regardless of the management strategy utilized (frequency and post-grazing height), the stability index remained above 1 during all the experimental period (Figure 4). These results demonstrate that the management strategies evaluated did not compromise the tiller population stability of the Guinea grass, suggesting that all combinations between grazing frequencies and intensities were appropriate for the management of the Guinea grass. Because of the better growth conditions (temperature, luminosity, soil moisture) starting from the end of spring, the stability index rose until reaching a peak in the summer, indicating increase in the tiller population. The summer was marked by greater tiller appearance and mortality rates, indicating elevated capacity of renewal of the tillers of the pasture, but without compromising pasture stability.

The fall, and especially the winter, are seasons with restrictive conditions of plant growth and development. Thus, there was decrease in tiller appearance (Table 2) and mortality (Table 3) during these times of the year. As a consequence, there was reduction in the number of tillers (Figure 3) and in the stability index (Figure 4) for all management strategies.

The differences of tiller appearance and mortality among the pastures conditions evaluated (90/30, 90/50, 95/30 and 95/50) during the winter were reduced or disappeared. In fact, this period occurred because of the lower growth conditions in the winter and the flowering of the Guinea grass at the end of the fall. Reaching maturity (flowering), tillers complete their life cycle, the appearance and elongation of leaves cease and the tiller dies. However, because of the more limiting environmental conditions, these tillers are not replaced by new ones (Sbrissia et al., 2010), which resulted in lower tissue renewal and even stoppage of growth.

The improvement in the environmental conditions (light, temperature and rainfall) at the end of winter and beginning of spring resulted in marked tillering, demonstrating the capacity of Guinea grass to renew its tillers and the importance of ensuring, via management, proper conditions to the tillering of pastures at the beginning of the new growth season.

Conclusions

The time necessary for the sward to reach 90 or 95% light interception, as well as the post-grazing residues of 30 or 50 cm, alter the tillering pattern of Guinea grass under rotational grazing without compromising the stability of the tiller population of the Guinea grass pastures.

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