# TILLERING DYNAMICS IN MASSAI GRASS FERTILIZED WITH NITROGEN AND GRAZED BY SHEEP

## *DINÂMICA DE PERFILHAMENTO EM CAPIM-MASSAI ADUBADO COM NITROGÊNIO E PASTEJADO POR OVINOS*

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**ABSTRACT:** To evaluate the tillering dynamics of massai grass under rotational sheep stocking and fertilized with nitrogen (control - 0; 400; 800 and 1200 kg ha$^{-1}$ year$^{-1}$), this study was carried out, in a completely randomized design with repeated measures over time. The mob-grazing technique was applied to perform the grazing by employing groups of animals for rapid defoliation. The tiller appearance, survival and mortality rates, tiller biomass, and green/dead tillers ratio, have presented increase responses to nitrogen levels, with the three rates and the tiller biomass varying between evaluation periods. There was a quadratic response for the tiller flowering rate, population density of vegetative and reproductive tillers, reaching maximum values (0.051 tiller 100 tiller$^{-1}$ day$^{-1}$; 4,818 and 35 tillers m$^{-2}$, respectively) under the nitrogen levels of 613.5; 993.5 and 623.9 kg ha$^{-1}$ year$^{-1}$, respectively. For the tiller flowering rate and population density of reproductive tillers, it was verified a fluctuation between periods. The nitrogen fertilization promotes positive changes in tillering dynamics of massai grass, allowing the use of up to 800 kg ha$^{-1}$ year$^{-1}$ for maintaining the pasture stability. The tillering demography of the forage had varied little between assessment periods.

**KEYWORDS:** Nitrogen fertilization. *Panicum maximum x P. infestum*. Tillering stability index. Tiller survival rate.

## INTRODUCTION

Pasture persistence and productivity reflect the synchrony in the tillering dynamics of the grass, which is influenced by abiotic factors such as: light, temperature, water and nutrient supply, especially nitrogen. This nutrient plays a significant role in forage growth and production, result of its benefits, increasing the number of tillers per plant (BAHMANI et al., 2002; LOPES et al., 2011) and consequently the tiller population density. This positive effect of nitrogen on tillering reflects the activation of dormant buds (MATTHEW et al., 2000) and initiation of corresponding tillers, increasing thus the forage biomass.

In this way, nitrogen fertilization combined with grazing effects greatly influence the patterns of tillers appearance and mortality and interfere with the demography of plants populations in the grassland. The pasture with greater appearance and mortality of tillers promotes a greater renewal, increasing the proportion of young tillers, favoring increases in biomass production, once the tiller population stability is not undermined along successive grazing cycles.

The tillering dynamics of forage grasses, defined by the rates of appearance, flowering, mortality and survival of tillers, determines the contribution of tillering for the morphological composition of the pasture, allowing a greater or lesser forage biomass accumulation along the year, according to different seasons (HERNANDEZ GARAY et al., 1997) and management practices.

The massai grass, a natural hybrid between *Panicum maximum x P. infestum* introduced in 2001 by the Embrapa Beef Cattle, has revealed important characteristics like high leaf biomass production, high leaf/stem ratio, and ability to produce leaves and tillers, good ground cover, among others. Although recent studies on morpho-physiological responses of this forage have already shown management strategies for this grass, there is a relative lack of knowledge about the tillering demography of this grass fertilized with nitrogen and grazed by sheep in rotational stocking. Thus, this study evaluated the tillering dynamics in massai

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grass fertilized with nitrogen and managed under rotational stocking with sheep.

## MATERIAL AND METHODS

This experiment was conducted on a pasture of *Panicum maximum x Panicum infestum* cv. Massai, belonging to the Núcleo de Ensino e Estudos em Forragicultura of the Centro de Ciências Agrárias of the Universidade Federal do Ceará - NEEF/DZ/CCA/UFC, in the city of Fortaleza – Ceará State, in 2009.

The city of Fortaleza is located at an average altitude of 21 meters, at geographical coordinates 03° 45' 47'' S, 38° 31' 23'' W, with climate Aw', rainy tropical, according to the Köppen classification. Mean monthly temperatures (mean maximum, mean and mean minimum temperatures), rainfall and insolation relative to the experimental period are presented in the Figure 1.

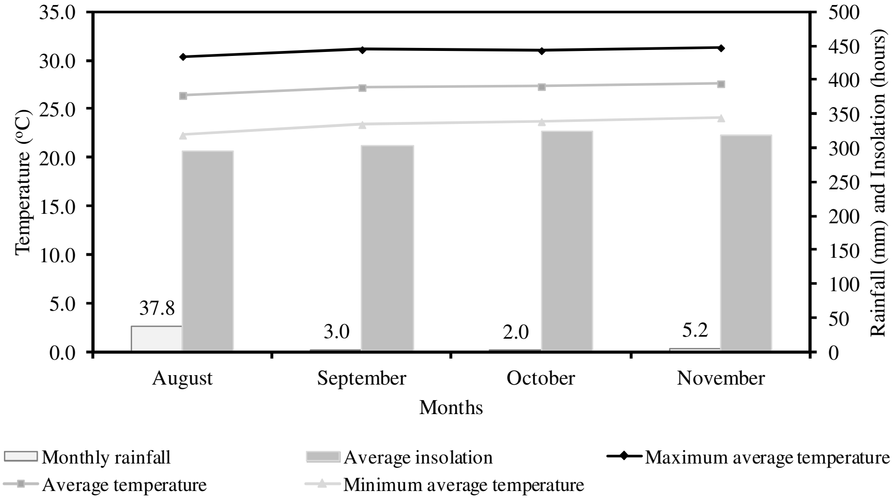

**Figure 1.** Climatic data during the experimental period in the city of Fortaleza – Ceará State, in 2009.

The soil of the experimental area is classified as yellow podzolic soil, whose source materials are sandy-clayey sediments of the barrier formation (EMBRAPA, 1999). The chemical characteristics of the soil revealed by the analysis (0-20 cm depth) performed before the onset of the experiment, are shown in Table 1.

**Table 1.** Chemical characteristics of the soil of the experimental area, at the depth of 0-20 cm, at the onset of the experiment

| P | K | Ca | Mg | Fe | Cu | Zn | Mn | pH | Al | Na | SB | CTCt | MO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mg dm$^{-3}$ | | | | | | | | $H_2O$ | cmol$_c$ dm$^{-3}$ | | | | g kg$^{-1}$ |
| 9.0 | 15.64 | 260.5 | 145.8 | 10.9 | 0.4 | 8.3 | 11.9 | 5.7 | 0.35 | 0.10 | 2.64 | 2.99 | 18.62 |

Font: Soil and Water Laboratory/UFC/FUNCEME. Embrapa method of soil analysis: pH in water, organic matter (MO) = colorimetric method, Ca and Mg = extraction with KCl 1 mol L$^{-1}$, K and P = extraction with Mehlich-1, Al = extraction with KCl 1 mol L$^{-1}$, micronutrients = DTPA method.

From the results of soil analysis, fertilizations followed the recommendation of CFSEMG (1999), for fertility levels suggested for grasses with high yield and production.

Fertilizations of phosphate (simple superphosphate), potassium (potassium chloride) and micronutrients (FTE BR-12), were undertaken based on the results of the soil analysis. The applications of nitrogen (urea) and potassium were split. The nitrogen dose for each treatment was split into two portions, being the first half applied soon after the removal of the animals from the paddock, and the second half applied in the half of the rest period, according to each level evaluated. In all applications of nitrogen, the urea was water-diluted, aiming a better uniformity of application, given the small amount of fertilizer per plot, hindering the application in the solid form, with subsequent irrigation to prevent possible burning of the leaves. In the application it was used a backpack sprayer with spray volume standardized according to the field test previously performed.

The potassium was made available in three applications, the first (160 kg ha$^{-1}$ $K_2O$, corresponding to 132.8 kg K ha$^{-1}$) undertaken at the onset of the experiment along with the first portion of nitrogen. The second and third applications of potassium (160 and 160 kg ha$^{-1}$ $K_2O$, respectively) were performed together with the first dose of nitrogen immediately after the removal of animals at each posterior grazing cycles. The supply of phosphorus (250 kg ha$^{-1}$ $P_2O_5$, corresponding to 110 kg P ha$^{-1}$) was made at once, along with the first portions of potassium and nitrogen, at the onset of the experiment. By this time, micronutrients were also applied (50 kg ha$^{-1}$ FTE BR-12).

The massai grass pasture was managed under low pressure fixed sprinkler irrigation (working pressure < 2.0 kgf cm$^{-2}$), with water depth of 7.0 mm day$^{-1}$ at irrigation schedule of 3 days and irrigation time (Ti) of 8 hours, held at night, searching for better uniformity of water depth applied. In order to determine the parameters above mentioned, it was performed an initial assessment of the irrigation system, as worked throughout the experimental period.

The nitrogen levels examined were: control - no nitrogen fertilization; 400; 800 and 1200 kg ha$^{-1}$ year$^{-1}$ nitrogen. The experiment consisted of a completely randomized split plot design, with repeated measures over time along four successive grazing cycles. The nitrogen levels (control - no nitrogen fertilization; 400; 800 and 1200 kg ha$^{-1}$ year$^{-1}$) were studied in the plots, and the evaluation periods, in the subplots.

The adopted rest period was of approximately 1.5 new leaves per tiller, as determined in a pre-trial at the onset of the experiment, providing an interval of 22; 18; 16 and 13 days for the levels 0.0 – control; 400; 800 and 1,200 kg ha$^{-1}$ year$^{-1}$ nitrogen, respectively.

Animals used to lower the pasture height up to the preconized residual height were sheep (½ Morada Nova x ½ SPRD) housed in paddocks of 42.3 m$^2$. The mob-grazing technique (GILDERSLEEVE et al., 1987) was applied to perform the grazing by employing groups of animals for rapid defoliation (duration from 7 to 11 hours), simulating a management under rotational stocking. As animals grazed, the pasture height was monitored using a ruler until the canopy reached the preconized residual height of around 15 cm, corresponding to the residual LAI of the animals' removal from the paddock of approximately 1.5 as determined in a pre-trial for the experiment.

In the evaluation of the tillering dynamics in massai grass pastures were used coated steel rings with 0.0551 m² area at each experimental unit (paddocks with 42.3 m$^2$). The rings were placed in representative locations of each paddock, fixed to the ground by metal clips at representative areas of the pasture, according to visual assessment of the canopy considering height and biomass of forage at the moment of such markings (placement of the rings).

All tillers inside the steel circle were counted and identified with telephone wires of a certain color (1st assessment) and from this, were marked every cycle, in the post-grazing (frequency of assessment according to the nitrogen level: 22; 18; 16 and 13 days for 0; 400; 600 and 1,200 kg ha$^{-1}$ year$^{-1}$, respectively). New tillers emerged between assessment periods, marked with different colored wires, have represented each tiller generation and thus allowed verifying the effects of successive grazing and nitrogen fertilization on the tiller population in massai grass pastures.

Tiller identification was accomplished on the third day after the removal of animals from the paddocks, allowing thus the visualization of new tillers emerged. At this point, it was registered the number of live and dead tillers for each generation in the sampling circles. In this way, the first marking was called generation zero (G0), the second, G1, and so on until the last assessment cycle.

From these measures, the tillers appearance, mortality, survival and flowering rates were estimated, according to Carvalho et al. (2000). The tillering stability index (P1/P0) was calculated as recommended by Bahmani et al. (2003), using the equation: P1/P0 = TSR (1+TAR), where TSR (tillers survival rate) = 1-TMR. It was also determined the population density of vegetative tillers (PDVT, tillers m$^{-2}$), population density of dead tillers (PDDT, tillers m$^{-2}$), population density of reproductive tillers (PDRT, tillers m$^{-2}$), tiller biomass (TB, g tiller $^{-1}$) and vegetative/dead tillers ratio (VT/DT).

Data were subjected to analysis of variance, means comparison test, and regression analysis. The nitrogen fertilization x assessment periods was presented whenever significant (P<0.05) by the F-test. The assessment periods were compared by the Tukey's test (P<0.05). The effect of the levels of nitrogen fertilizers was evaluated by a regression analysis. The choice of the models was based on the significance of linear and quadratic coefficients, by means of a Student's t-test (P<0.05) and on the coefficient of determination. As a tool to assist statistical analysis, it was adopted the MIXED and GLM procedures of SAS statistical software (Statistical Analysis System, version 9.0).

## RESULTS AND DISCUSSION

There was a significant interaction ($P<0.05$) between nitrogen levels x assessment periods for the appearance rate (TAR) and mortality rate (TMR) of tillers. In the assessment periods 1 and 3, higher values ($P<0.05$) of TAR were registered for nitrogen fertilized-pastures, but without difference ($P>0.05$) between the levels for the period 1 (Table 2).

A reduction ($P<0.05$) was observed for TAR from the assessment period 1 to 3, in non-fertilized pastures and supplied with 400 kg ha$^{-1}$ year$^{-1}$ nitrogen (Table 2), showing the depletion of soil nitrogen under the absence of fertilization, and the lack of nitrogen supply at low doses for the grass to keep the TAR over assessment periods. In the dose equivalent to 800 kg ha$^{-1}$ year$^{-1}$ nitrogen, no difference ($P>0.05$) was found for the TAR between assessment periods, proving the nitrogen dose as responsible for best balancing the appearance of tillers in massai grass pastures throughout the experiment.

Importantly, regardless of the nitrogen level, the TAR in the period 1 was higher ($P<0.05$) than the period 3, except for the nitrogen dose equivalent to 800 kg ha$^{-1}$ year$^{-1}$ (Table 2), which had no difference ($P>0.05$) in the TAR between periods, despite the downward trend ($P\leq0.173$) from the period 1 to the period 3 due to the improvement in the light at the base of the canopy, once at the beginning of assessments the pasture presented a structural arrangement and morphological composition more favorable to the light penetration in lower strata, which admittedly promotes the differentiation of axillary buds and the potential emergence of new tillers (MATTHEW et al., 2000; DIFANTE et al., 2008), especially basal tillers, since the competition between tillers mainly occurs for light (SACKVILLE-HAMILTON et al., 1995).

**Table 2.** Tillering dynamics in pastures of *Panicum maximum x P. infestum* cv. Massai fertilized with nitrogen and grazed by rotational sheep stocking

| Assessment period | Nitrogen levels (kg ha$^{-1}$ year$^{-1}$) | | | | | Equations (Nitrogen effect) |
|---|---|---|---|---|---|---|
| | 0 | 400 | 800 | 1200 | Mean | |
| | Tillers appearance rate (TAR, tillers 100 tillers$^{-1}$ day$^{-1}$) | | | | | |
| 1 | $0.84^{Ab}$ | $2.15^{Aa}$ | $1.68^{Aa}$ | $1.93^{Aa}$ | 1.65 | $TAR = 0.9496 + 0.000579^{**}N$;<br>$R^2 = 0.36$ |
| 2 | $1.11^{Aa}$ | $1.02^{Ca}$ | $1.20^{Aa}$ | $1.55^{ABa}$ | 1.22 | |
| 3 | $0.57^{Bb}$ | $1.31^{Ba}$ | $1.33^{Aa}$ | $1.35^{Ba}$ | 1.14 | |
| | Tillers mortality rate (TMR, tillers 100 tillers$^{-1}$ day$^{-1}$) | | | | | |
| 1 | $1.42^{Ab}$ | $2.28^{Aa}$ | $1.79^{Bb}$ | $2.21^{Aa}$ | 1.92 | $TMR = 1.545 + 0.000486^{**}N$;<br>$R^2 = 0.34$ |
| 2 | $1.62^{Abc}$ | $1.35^{Bc}$ | $1.87^{Bbc}$ | $2.00^{ABab}$ | 1.71 | |
| 3 | $1.23^{Ac}$ | $1.99^{Ab}$ | $2.41^{Aa}$ | $1.63^{Bbc}$ | 1.81 | |
| | Tillers flowering rate (TFR, tillers 100 tillers$^{-1}$ day $^{-1}$) | | | | | |
| 1 | 0.000 | 0.000 | 0.025 | 0.000 | $0.0063^{B}$ | $TFR = 0.0055 + 0.000147^{**}N - 0.0000001198^{**}N^2$;<br>$R^2 = 0.37$ |
| 2 | 0.010 | 0.080 | 0.055 | 0.025 | $0.043^{A}$ | |
| 3 | 0.010 | 0.045 | 0.070 | 0.000 | $0.031^{A}$ | |
| | Tillers survival rate (TSR, tillers 100 tillers$^{-1}$ day $^{-1}$) | | | | | |
| 1 | 3.76 | $5.04^{c}$ | 6.10 | 7.35 | $5.56^{B}$ | $TSR = 4.138 + 0.00264^{**}N$;<br>$R^2 = 0.93$ |
| 2 | 4.48 | 5.09 | 5.69 | 7.64 | $5.72^{AB}$ | |
| 3 | 4.51 | 5.39 | 6.13 | 7.54 | $5.89^{A}$ | |
| | Tillering stability index of (TSI) | | | | | |
| 1 | $1.15^{ABb}$ | $1.21^{Aab}$ | $1.24^{Aa}$ | $1.20^{Aab}$ | 1.20 | $TSI = 1.17 \pm 0.06$ |
| 2 | $1.20^{Aa}$ | $1.08^{Bb}$ | $1.17^{Aa}$ | $1.19^{Aa}$ | 1.16 | |
| 3 | $1.12^{Bbc}$ | $1.20^{Aa}$ | $1.19^{Aab}$ | $1.09^{Bc}$ | 1.15 | |

N = nitrogen level; means followed by the same letter, in the column (upper case) and in the row (lower case) are not significantly different ($P>0.05$) by Tukey's test; significant at 1% (**).

It was verified a similarity ($P>0.05$) in the TMR between assessment periods for pastures non-fertilized with nitrogen. The mortality of tillers has varied ($P<0.05$) between periods in the nitrogen levels equivalent to 400; 800 and 1200 kg ha$^{-1}$ year$^{-1}$, accounting for the dynamics of plant communities in pastures under grazing (Table 2). This variation in the TMR between periods for the fertilized pastures had no defined up or downward pattern along the periods, but a characteristic change in tiller mortality, reflecting the dynamic process of pastures under grazing, as previously mentioned. The nitrogen fertilization influenced ($P<0.05$) the TMR in all periods (Table 2).

The increase in nitrogen fertilization promoted a positive linear response ($P<0.05$) on the TAR and TMR, with estimates from 0.95 to 1.64 (TAR) and from 1.54 to 2.13 tillers 100 tiller$^{-1}$ day$^{-1}$ (TMR) in the doses equivalent to 0.0 and 1,200 kg ha$^{-1}$ year$^{-1}$, respectively (Table 2). The greater appearance of tillers in response to increased availability of nitrogen evidences the activation of dormant buds (MATTHEW et al., 2000) and initiation of corresponding tillers, increasing the emergence of new tillers.

The pattern of response observed for tiller mortality rate in massai grass supplied with increasing levels of nitrogen supports the behavior of this variable in studies with *Brachiaria decumbens* subjected to nitrogen fertilization (MORAIS et al., 2006), which can be related to the activity of this nutrient to promote a higher density of plants, resulting in a more dense pasture. In this way, it reduces the light penetration and favor a greater shading, which increases the tiller death in pasture due to the lack of carbon supply generated by the competition for light.

It is noteworthy the indirect effect of nitrogen on tiller mortality in the pasture (AUDA et al., 1966), triggering a stronger competition for nutrients in general, which stimulates the turnover of tissues, as observed by Moreira et al. (2009), leading to the death of older tillers, which will contribute with the appearance of new ones through the remobilization of nutrients.

The higher tiller mortality at higher levels, offset by the high appearance rate (Table 2) promoted a renewal of tillers in the pasture, with proven importance for maintaining the tiller population, especially for the stability of plant populations in pasture ecosystems.

In this context, tiller mortality in a pasture can be result of diverse causes, but mainly from the elimination of the apical bud by the grazing animal (LEMAIRE & CHAPMAN, 1996). Another significant cause for tiller death in a pasture made up by high plant density is the lack of carbon supply produced by the competition for light. According to Davies et al. (1983), in a shaded plant community, a greater amount of photoassimilates is taken to the growth of the already present tillers rather than the formation of new tillers.

There was no interaction ($P>0.05$) between nitrogen levels x assessment periods for the flowering (TFR) and survival rate (TSR) of tillers. It was observed a quadratic response ($P<0.05$) for the TFR with increasing levels of nitrogen, reaching a maximum value (0.051 tillers 100 tiller$^{-1}$ day$^{-1}$) at the nitrogen level equivalent to 613.5 kg ha$^{-1}$ year$^{-1}$ (Table 2).

The increase in the TFR up to the maximization of the dose previously presented is due to the effect of this nutrient on the plant growth and development, result of the improvement in the soil fertility, especially the nitrogen supply, allowing tillers to persist in the plant community in response to their better structure, with a well-developed root system compared with non-fertilized pastures, favoring thus an increase in the flowering rate. The reduction of the TFR at higher doses reflects the lower luminosity inside the canopy (SOARES et al., 2009) due to a more horizontally and vertically dense pasture, provided by the higher leaf biomass.

Higher values ($P<0.05$) of TFR were detected in the assessment periods 2 and 3 (Table 2), owing the greater density of plants with more advanced age in the last periods, persisting until reaching the reproductive phase.

The lack of interaction between levels and periods contradicts the hypothesis of cumulative effect of nitrogen levels along periods on the older tillers, which could entail a higher flowering rate in the higher levels and in the last periods. Possibly the high renewal of tillers observed in this pasture has annulled this possible cumulative effect over periods.

The increase in nitrogen levels has promoted an increase ($P<0.05$) in the TSR, with values estimated at 4.14 and 7.31 tiller 100 tiller$^{-1}$ day$^{-1}$ in the doses equivalent to 0.0 and 1,200 kg ha$^{-1}$ year$^{-1}$, respectively (Table 2). A slight change was observed in the TSR ($P<0.05$) over assessment period, with higher values in the last periods (2 and 3), due to the adjustment to successive grazing, favoring the superiority in the population of live tillers in the anterior generation compared with the number of live tillers in the evaluated generation (current generation), and hence increasing tiller survival in the pasture.

The survival of tillers in plant community is determinant on persistence and productivity of the pasture, and in agreement with Matthew et al. (2000), although it is a genetically determined trait, the influence of factors such as rainfall, temperature, light, and nutrient availability, along with management strategies can greatly modify that characteristic of the pasture.

In a plant community with a continuous tiller renewal, it is possible that non-significant differences in terms of low rates of appearance and mortality can, when combined, result in significant variations in population density, reason why it is important to examine the combined effect of both variables (DIFANTE et al., 2008). This evaluation can be done through the stability index of tiller population (BAHMANI et al., 2003).

When the tillering stability index is below 1.0, indicates that the survival rate combined with the appearance rate of tillers was not enough to offset the mortality rate and the plant population in the pasture ecosystem tends to decrease. Instead, a stability index higher than 1.0 (Table 2) points an inverse situation, and value equal to 1.0 indicates a stable tiller population, where the number of tillers in the pasture hardly varies, despite being a result of a dynamic balance in the pasture (BAHMANI et al., 2003).

It was observed an interaction ($P<0.05$) between the factors (nitrogen levels x assessment periods) for the tillering stability index (TSI) (Table 2). The nitrogen fertilization has changed ($P<0.05$) the TSI of the massai grass, but no response ($P>0.05$) was detected in the regression analysis, revealing a mean value of 1.17 ± 0.06.

The stability index of the massai grass remained above 1.0 throughout the experiment, regardless of nitrogen levels and assessment periods. Nevertheless the values of this index have reduced slightly in non-fertilized pastures and supplied with doses equivalent to 1,200 kg ha$^{-1}$ year$^{-1}$ as advanced the experimental period, which can be ascribed to the lower TAR in the last period for the non-fertilized pastures, and those receiving 1,200 kg ha$^{-1}$ year$^{-1}$ nitrogen (Table 2), modifying the relationships between the appearance and mortality rates of tillers in the pasture.

In the dose equivalent to 800 kg ha$^{-1}$ year$^{-1}$ nitrogen was not observed difference ($P>0.05$) in the TSI between the assessment periods (Table 2), proving the nitrogen dose as responsible for best balancing the rates of appearance, mortality and survival of tillers in massai grass pastures throughout the experiment, confirming the relevance of nitrogen fertilization for the pasture stability over successive grazing cycles.

No interaction ($P>0.05$) was observed between nitrogen levels x assessment periods (Table 3) for the vegetative tiller population density (VTPD), dead tiller population density (DTPD) and reproductive tiller population density (RTPD). The VTPD and RTPD revealed a quadratic response ($P<0.05$) with maximum point (4,818 and 35 tillers m$^{-2}$, respectively) at nitrogen levels equivalent to 993.5 and 623.9 kg ha$^{-1}$ year$^{-1}$, respectively. The DTPD remained similar ($P>0.05$), regardless of nitrogen levels (332 ± 45 tillers m$^{-2}$) and assessment periods (331 ± 55 tillers m$^{-2}$) (Table 3), despite the effect of nitrogen fertilization on the tiller mortality rate.

**Table 3.** Tillering patterns in pastures of *Panicum maximum x P. infestum* cv. Massai fertilized with nitrogen and grazed by rotational sheep stocking

| Variables | Assessment period | | | Equations (Nitrogen effect) |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| VTPD | $4174^{a}$ | $4262^{a}$ | $4360^{a}$ | $VTPD = 3288.2 + 3.08^{**}N – 0.00155^{**}N^2$; $R^2 = 0.71$ |
| DTPD | $254^{a}$ | $362^{a}$ | $378^{a}$ | DTPD = 332 ± 45 |
| RTPD | $5^{b}$ | $29^{a}$ | $23^{a}$ | $RTPD = 3.725 + 0.0997^{**}N – 0.0000799^{**}N^2$; $R^2 = 0.33$ |
| VT/DT | $17.1^{a}$ | $12.2^{a}$ | $11.6^{a}$ | $VT/DT = 8.83 + 0.00706^{**}N$; $R^2 = 0.31$ |
| TB | $1.62^{b}$ | $1.81^{a}$ | $1.84^{a}$ | $TB = 1.288 + 0.000778^{**}N$; $R^2 = 0.79$ |

Vegetative tiller population density (VTPD, tillers m$^{-2}$), dead tiller population density (DTPD, tillers m$^{-2}$), reproductive tiller population density (RTPD, tillers m$^{-2}$), vegetative/dead tiller ratio (VT/DT), tiller biomass (TB, g tiller$^{-1}$); N = nitrogen level; means followed by the same letter in the row are not significantly different ($P>0.05$) by Tukey's test; significant at 1% (**).

The similarity between assessment periods for the DTPD is partially explained by the rigorous management of grazing in terms of residual condition of the pasture along successive grazing cycles, neutralizing the difference between periods according to the death of tillers by decapitation (apical bud removal by animal grazing), and also by the low flowering rate of tillers in pastures of massai grass (Table 2), not changing the DTPD between studied periods.

The similarity in the DTPD regardless of nitrogen levels, even with this nutrient influencing the TMR, can be attributed to the positive effect of nitrogen fertilization in the balance between rates of survival and appearance of tillers, i.e., in the tillering patterns of the grass, defining according to

Hirata & Pakiding (2001) and Bahmani et al. (2003), the stability of tiller population in the pasture.

Tiller appearance and flowering rates (Table 2) have responded to nitrogen fertilization with increases of 72.6 and 827.3%, respectively, for the pastures supplied with nitrogen levels of 1,200 and 613.5 kg ha$^{-1}$ year$^{-1}$ in comparison with those non-fertilized, was a basic determinant for the increase in the VTPD and RTPD (Table 3) up to the maximization in the previously mentioned doses. The RTPD was higher ($P<0.05$) in the last two assessment periods (Table 3), responding by the superiority of TFR in the periods 2 and 3 (Table 2).

The increase in vegetative tiller population until reaching the maximum value reflects an increase in the number of tillers per plant proportioned by the nitrogen (BAHMANI et al., 2002; LOPES et al., 2011), justified by its effect on the activation of dormant buds (MATTHEW et al., 2000) and on the initiation of corresponding tillers.

The nitrogen, as presented in this study (Table 2) and reported in literature (MORAIS et al. 2006; BASSO et al., 2010), promotes significant increases in tiller appearance, resulting in a plant population constantly renewed and with high production potential (FAGUNDES et al., 2005), since new emerged tillers have a higher responsiveness to stimulation from the environment (BULLOCK et al., 1994).

The VTPD did not differ ($P>0.05$) between assessment periods, with a mean value of 4265 tiller m$^{-2}$ (Table 3), due to the low flowering rate between periods, showing thus the judicious management adopted over the successive grazing cycles.

In agreement with Matthew et al. (2000), the tillering is a relevant mechanism of adjustment and optimization of the leaf area index of the pasture, which plays an essential role in the forage recovery after defoliation, greatly influencing the production of forage biomass. In this way, any factor working positively on the production of new tillers favors the growth and development of pastures (HIRATA & PAKIDING, 2003) and accumulation of forage in the pasture.

No interaction ($P>0.05$) was found between nitrogen levels x assessment periods on the vegetative/dead tillers ratio (VT/DT) and tiller biomass (TB) (Table 3). The nitrogen fertilization promoted a positive linear response ($P<0.05$) on the VT/DT and TB, with estimates from 8.8 to 17.3 (VT/DT) and 1.29 to 2.22 g tiller$^{-1}$ (TB) in the nitrogen levels equivalent to 0.0 and 1,200 kg ha$^{-1}$ year$^{-1}$, respectively (Table 3).

There was no difference ($P>0.05$) between assessed periods for the VT/DT, with mean of 13.6 ± 2.5. The tiller biomass revealed higher values ($P<0.05$) for the periods 2 and 3 (Table 3), indicating the formation of more developed tillers in the pasture.

The similarity in the VT/DT between assessed periods and its increase with nitrogen fertilization is consequence of responses already observed for the VTPD and DTPD, where the first responded only to the fertilization, with a quadratic effect, and the second was not affected either by the fertilization or periods. The variable VT/DT indicates the quality of forage in the pasture. The lower the number of dead tillers in relation to vegetative tillers, the wider is this ratio and better is the forage quality, responding to the higher production of green biomass, compared with the presence of dead forage.

The increase in tiller biomass with nitrogen fertilization is explained by the increase in length of leaves and stems (data not shown), resulting in more developed tillers, and therefore longer and heavier, supporting the nitrogen effect on the tiller biomass and consequently on the increase of biomass production.

## CONCLUSIONS

The nitrogen fertilization promotes positive changes in tillering dynamics of massai grass, allowing the use of up to 800 kg ha$^{-1}$ year$^{-1}$ for maintaining the pasture stability.

The tillering demography of the forage had varied little between assessment periods.

**RESUMO:** Objetivou-se avaliar a dinâmica de perfilhamento do capim-massai sob lotação rotativa com ovinos e adubado com nitrogênio (controle - 0; 400; 800 e 1200 kg ha$^{-1}$ ano$^{-1}$), em um delineamento inteiramente casualizado com medidas repetidas no tempo. A técnica de "mob-grazing" foi usada para a realização dos pastejos, empregando-se grupos de animais para desfolhações rápidas. As taxas de aparecimento, sobrevivência e mortalidade de perfilhos, biomassa do perfilho e relação perfilhos vegetativos/perfilhos mortos responderam crescentemente às doses de nitrogênio, com as três taxas e a biomassa do perfilho variando entre os períodos de avaliação. Constatou-se resposta quadrática para a taxa de florescimento de perfilhos, densidade populacional de perfilhos vegetativos e densidade populacional de perfilhos reprodutivos, alcançando valores máximos (0,051 perf 100 perf$^{-1}$ dia$^{-1}$; 4818 e 35 perfilhos m$^{-2}$, respectivamente) nas doses de nitrogênio de 613,5; 993,5 e 623,9 kg ha$^{-1}$ ano$^{-1}$, respectivamente. Para a taxa de florescimento e densidade populacional de perfilhos reprodutivos, verificou-se oscilação entre os períodos de avaliação. A adubação nitrogenada proporciona mudanças positivas na dinâmica de perfilhamento do capim-massai, podendo-se utilizar uma dose de nitrogênio de até 800 kg ha$^{-1}$ ano$^{-1}$ para a manutenção da estabilidade do pasto. A demografia do perfilhamento da referida forrageira oscila entre os períodos de avaliação.

**PALAVRAS-CHAVE:** Adubação nitrogenada. *Panicum maximum x P. infestum*. Índice de estabilidade de perfilhamento. Taxa de sobrevivência de perfilhos.

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