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Biomass accumulation in mombasa guineagrass plants under different levels of nitrogen supply and plant densities[1]

Vinícius Valim Pereira[2], Dilermando Miranda da Fonseca[2], Janaina Azevedo Martuscello[3], Paulo Roberto Cecon[4], Márcia Vitória Santos[2], Thiago Gomes dos Santos Braz[2]

[1] *Project financed by FAPEMIG.*
[2] *Departamento de Zootecnia - Universidade Federal de Viçosa.*
[3] *Universidade Federal de Alagoas, Campus Arapiraca.*
[4] *Departamento de Estatística - Universidade Federal de Viçosa.*

ABSTRACT - The objective of this study was to evaluate the effect of different levels of nitrogen supply and plants densities in the productivity of mombasa guineagrass (*Panicum maximum*) in the period of establishment. The design was of completely randomized blocks, with 12 treatments and three repetitions, with four nitrogen supplies (absence of application, 80, 160 and 320 kg/ha.year) and three plant densities (9, 25 and 49 plants/m²). The plot was cut at 30 cm from the ground when the sward high intercepted 95% of light. The following items were evaluated: sward height at 95% light interception, interval and number of cuts, dry mass production, total dry mass of leaves, stems and dead material and the morphologic composition. Nitrogen increased the dry mass production and the dry mass of stem in winter and summer, and decreased in the fall. The total dry mass of leaf presented decrease of 19% in the summer between the smallest and biggest densities in the 320 kg/ha. The dry mass of dead material had negative effect of the density in the fall. The leaf percentage increased 88% between the smallest and largest nitrogen level at the plant density of 49 plants/m^2. Only density influenced the sward height in the condition of 95% of light interception. The number of cuts increased with nitrogen levels in the fall, spring and summer, while the interval of cuts decreased with fertilization in the spring and summer. Nitrogen increases the production of mombasa guineagrass in each cycle.

Key Words: height, light interception, productivity

Introduction

The use of arbitrary variables, such as stocking rate, grazing pressure and rest period duration, which have been commonly used as a parameter of grazing management cannot be considered primary determinants of forage production and animal performance, once their effects are not mediated by canopy characteristics that collectively determine the condition and sward structure (sward state) (Hodgson, 1985). For Hodgson & Da Silva (2002), these variables become part of the strategy action that aims at pasture maintenance with an ideal structure for such production system.

Since the year 2000, the part of research that aims to control the conditions and the structure of the sward, for input and output of animals on the pasture has intensified, which has demonstrated good results to improve the management of Tanzania and Mombasa grasses (Da Silva, 2004). Accordingly, light interception, as an object of research to establish management strategy, has shown promising results. In application of these results, a constant relation of sward height and the condition of 95% of light interception was found in several species. Carnevalli et al. (2006), working with Mombasa grass, discovered that the ideal time to interrupt the period of rest was related to the moment that the canopy reached 95% of light interception, a condition that was consistently associated to the canopy high of 90 cm.

However, there is need for further investigations about the effects of nutrients on the relation of 95% light interception versus 90 cm height in Mombasa grass. For example, nitrogen is a nutrient that influences the morphophysiological characteristics of forages and has no effect on the flow of tissue (Garcez Neto et al., 2002), which can influence the canopy height to intercept 95% of light.

Also, the density of plants in the pasture may influence the condition of the pasture or structure, its ability to accumulate biomass and changes in the light interception versus height relation (Souza, 1993). According to Humphreys & Riveros (1986), elevated plant densities usually increase forage production. This study was carried out in order to verify the influence of nitrogen fertilization and densities of Mombasa grass in morphological composition, structure, number of crops, harvest interval

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Corresponding author: viniciusvalim@hotmail.com

and productivity in the canopy height with 95% light interception.

Material and Methods

The experiment was conducted at the Setor de Forragicultura, Departamento de Zootecnia, Universidade Federal de Viçosa, Minas Gerais, from February, 2008 to March, 2009. The city of Viçosa is located in the Forest Zone of Minas Gerais, at an altitude of 651 meters above sea level, in the geographical coordinates 20º45' 40" latitude and 42º51' 40" west longitude. According to the Köppen classification, the climate type is CWA, with annual precipitation of around 1480 mm, 80% relative humidity and maximum and minimum temperatures of 26.6 and 15.9 °C, respectively. During the experimental period, climatic variables (precipitation and temperature) were recorded by the weather station of the Departamento de Engenharia Agrícola, 800 meters away from the experimental area (Figure 1).

The treatments consisted of a combination of four levels of nitrogen supply (0, 80, 160 and 320 kg/ha) and three plant densities (9, 25 and 49 plants/m^2), with a 4 × 3 factorial arrangement in a randomized blocks design with three replications, totaling 36 experimental units with 9 m^2 each. In the experimental area, before demarcation of plots, samples of soil were taken for chemical and physical characterization and subsequent correction of acidity and fertilizer application. For greater precision in the density of established plants, 9, 25 and 49 m^2, the sowing of Mombasa grass was conducted in a greenhouse, in trays containing commercial substratum, where they remained until the seedlings reached about 10 cm, when they were transplanted to the plots.

The soil of the experimental area is classified as Red-Yellow Podzolic (EMBRAPA, 1999), with loamy texture.

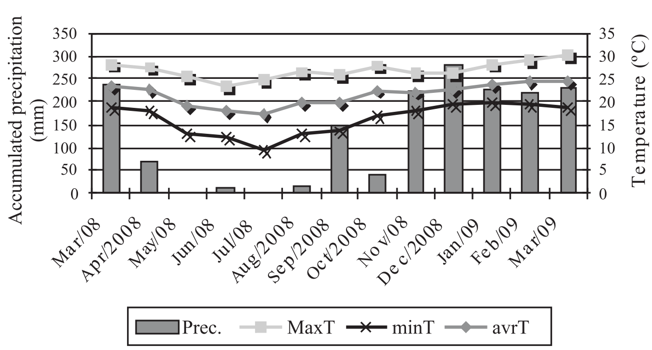


Figure 1 - Average monthly accumulated precipitation (Prec.) and maximum (maxT), average (avrT) and minimum (minT) temperatures observed during the experimental period.

The results of chemical analysis of the soil sample, in the 0-20 cm layer were: pH in H_2O: 6.30; P: 2.10 (Mehlich) and K: 132.00 $mg.dm^{-3}$; Ca^{+2}: 2.80, Mg^{+2}: 1,00 and Al^{+3}: 0.00 $cmol_c.dm^{-3}$ (KCl 1 $mol.L^{-1}$); CTC (T): 4.14 $cmolc.dm^{-3}$, sum of bases: 4.14 $cmolc.dm^{-3}$, H + Al: 3.80 $cmolc.dm^{-3}$ and 1.30 $dag.kg^{-1}$ of organic matter and 20.35 P-rem.

Based on the soil analysis results, superphosphate was applied at 667 kg/ha. The nitrogen supplies were divided into three applications: the first after the unification cut, done on February 2008, and the others after the second and third cuts. 150 kg/ha of K_2O were applied in two sessions: one after the uniformity cut and the second after the second cut. The sources of nitrogen and potassium were urea (46% N) and potassium chloride (60% K_2O).

In February, 2008, uniformity cut was done at 30 cm height, when the monitoring of light interception and canopy height began, with seven days of interval. However, when the light interception levels were close to the target (95% light interception), monitoring was performed every day. In the evaluations of the light interception, canopy analyzer unit AccuPAR Linear PAR/PARENT captometer, model 80 (Decagon Devices®) was used, with which readings were taken at three points of each experimental plot. In each plot, three readings were taken above the canopy and three at ground level. Canopy height was measured with a ruler graduated in centimeters, and it was measured in ten points of each experimental unit.

When the canopy light interception reached 95%, the plants were harvested at 30 cm above the ground level (Carnevalli et al., 2006), regardless of height and treatment. The sample, taken in a rectangle of 0.60 × 1.3 meters, was weighed and separated into leaf, stem and dead material, packed in paper bags and placed in an oven with forced ventilation at 65 °C until achieving constant weight. The masses were obtained to estimate the total dry mass production (TDM), leaf dry mass (LDM), dry mass of pseudostems (DMPS), dry mass of dead material (DMDM) and percentages of leaves, pseudostems and dead material.

The biomass dry mass (DM) was pooled in order to obtain the total dry mass in each treatment throughout the experimental period.

All the data were submitted to regression analysis, according to the nitrogen supply level and plant density, selecting the equations by the coefficient of determination (R^2) and 10% of significance (of the coefficients according to the T test). The regression equations were adjusted by the average of variables by treatment, with the R^2 as SQReg/SQtrat.

Results and Discussion

The total dry mass (TDM) was influenced negatively (P<0.10) by the density of plants, with a linear response in the winter, with no observed effect of fertilization and density in the spring (P>0.10). There was a positive linear effect for fertilization in the fall and summer (P<0.10) and a linear effect (P <0.05) for density in the summer (Table 1).

The TDM was lower in the winter (Table 1), and the limitation or reduction of temperature, water availability and photoperiod probably would have been responsible for lower production of Mombasa grass. Under favorable conditions to the development of plants, the nitrogen fertilization increases dry mass production of *P. maximum*, because it accelerates growth, increases the size of the leaves, the appearance and development of tillers - factors directly related to production (Davis et al., 2005; Martuscello et al., 2006), increasing the number of harvests.

Thus, nitrogen acts as a controlling factor of the different processes of growth and development of plants, providing increased biomass by fixing carbon (Nabinger & Pontes, 2001). The results observed in this experiment confirm those of Quadros et al. (2002), who observed that the increase in forage production with the application of nitrogen was linear and crescent. Still on the effects of nitrogen fertilization, Souza et al. (2005), studying the effects of irrigation and fertilization on the forage mass of cultivars of *P. maximum*, observed that as they increased the fertilization, there was an increase in the production of forage mass. The linear relation between nitrogen and dry mass production is indicative of great potential response of Mombasa grass to this nutrient.

The effect of plant densities on dry mass production of Mombasa grass suggests that plants occupy empty spaces, through tillering, in the period of establishment. Magalhães et al. (2011) also observed the effect of plant densities in the establishment of Tanzania grass. In this experiment with Mombasa grass, the largest number of plants per unit area resulted in the shortest period of plant growth to reach 95% of the lowest densities in relation to light interception. However, at lower densities, the death of tillers is reduced, which contributes to greater TDM.

For total dry mass of leaf (TDML) there was no effect of nitrogen levels or densities in the fall, winter and spring, with mean values of 242.35, 275.61 and 404.53 g/m^2, respectively. However, there was a positively linear increase (P<0.05) to fertilization and a negatively linear increase to densities (P<0.05) in the summer ($\hat{Y}$ = 428.538-2.44123 + 0.367413 * N * D, R^2 = 0.56).

The highest TDML observed in the summer, in higher doses of nitrogen, is related to the increase in total dry mass production. This result is due to the fact that a bigger number of cycles results in a bigger number of harvests, considering that most frequently defoliated plants tend to prioritize the recovery of the photosynthetic apparatus, favoring, in this case, the deposition of new leaves. The dry mass production of tropical grasses, based on the managed light interception, tends to have high percentage of leaves.

It was observed that at the lowest densities there was higher production of TDML in the summer; the same for the nitrogen level, 320 kg/ha; but, with different densities, 9 and 49 plants/m^2, production was 524.14 and 426.49 g/m^2 respectively - a 19% drop. Plants grown at lower densities have more spaces between the clumps, increasing their lateral growth, promoting greater accumulation of leaf.

It should be stressed, yet, that the influence of the seasons in TDML, where climatic conditions was favorable to plant development, associated with the management of 95% light interception, promoted increased production, resulting in a greater and better forage crop.

The total dry mass of pseudostems (TDMPS) had no effect of nitrogen levels or plant densities in the spring, with an average value of 59.44 g/m^2. There was a negatively linear response (P<0.05) to fertilization and a negatively quadratic response to plant densities (P<0.05) in the fall. In the winter, there was a positively linear response of fertilization (P<0.05) and negatively linear to densities (P<0.05). In the summer, nitrogen fertilization influenced linearly and positively the production of TDMPS (P<0.05), with quadratic effect of plant densities observed for this characteristic (Table 2).

With the forage harvest at 95% light interception, it was expected that if the elongation of pseudostems was reduced, the dry weight of this component would also reduce.

Table 1 - Equations for total dry mass in Mombasa grass, according to plant densities and nitrogen levels in the seasons of the year

Season	Adjusted equations	R^2
Fall	$\hat{Y}$ = 625.616-15.3815*D+0.204616*D^2+0.140193°N	0.61
Winter	$\hat{Y}$ = 384.692-3,72660°D	0.29
Spring	$\hat{Y}$ = 479.29	-
Summer	$\hat{Y}$ = 541.340-3,07250*D+0.205072°N	0.41

* P<0.05 and ° P<0.10.

Table 2 - Equations for total dry mass of pseudostems in plants of Mombasa grass, according to plant density and nitrogen levels in the seasons of the year

Season	Adjusted equations	R^2
Fall	$\hat{Y}$ = 320.651-10.2416*D+0.114068°D^2-0.1985573*N	0.77
Winter	$\hat{Y}$ = 49.8350-0.612074*D+0.0893857*N	0.32
Summer	$\hat{Y}$ = 9.83498+7.20553°D-0.141741*D^2+0.225654*N	0.54

* P<0.05 and ° P<0.10.

However, the higher frequency of cuts in higher doses may have influenced the pseudostems rate of elongation, because plants from plots that received higher dose of nitrogen sprouted and developed their morphological components faster, staying longer in a position of shading themselves, thereby increasing the total dry mass of pseudostems. Greater accumulation of TDMPS with nitrogen was also observed by Martuscello et al. (2004) in Massai grass and by Magalhães et al. (2011), in Tanzania grass.

The reduction in the production of TDMPS with the increase of density was contrary to the results described in the literature, since higher densities result in increased stem elongation of plants, because of bigger competition for light. The fall season is the time of intense flowering of Mombasa grass, when the elongation of stems is accelerated. Still, there was reduction in TDMPS with the higher densities in this season.

The dry mass of dead material (DMDM) showed no effects of nitrogen fertilization or density in the winter, spring and summer, with mean values of 9.19, 15.31 and 15.81, respectively, but showed a negatively linear response (P<0.01) to density in the fall ($\hat{Y}$ = 49.4584-0.754148 D **, R^2 = 0.52).

In the winter, DMDM value was lower than those of previous seasons, due to the reduced number of cuts, since in this time of year there is reduction in the growth rates of forage due to low precipitation and luminosity. In the fall, the high values are due to the flowering period when there is increased deposition of dry dead mass.

In the fall, the DMDM was more significant in the density of 9 plants/m^2 because of flowering, when elongation of the stem occurs, causing reduction of incoming light at the bottom of the canopy and thereby increasing the amount of senescent tissue. It should be stressed that this period can be characterized as a "rainy-dry" transition period, when there is a decrease in precipitation and temperature, favoring the deposition of dead material.

In other seasons, the absence of significant effects can be attributed to the harvest in 95% light interception, because there was a predominance of pseudostems and green leaves. According to Braz et al. (2011), the lack of effect of nitrogen and densities on dead material can be explained by the established strategy of the cuts at 95% light interception. This management aims to increase the rate of liquid accumulation of DM by the maintenance of pasture in critical leaf area index, thus reducing forage losses due to senescence.

The morphological composition of Mombasa grass, regardless of the evaluated season, with harvest of plants at 95% of light interception favors and minimizes the deposition of dead material of pseudostems and provides the predominance of leaf (Figure 2). In the fall, there was a bigger accumulation of pseudostems because of the Mombasa grass flowering and stem elongation, resulting in bigger participation of this component, even in the handling of 95% light interception. In winter, it should be noted that the cuts were made early in the season, so there was no accumulation of dead material, either. In the spring, these results were due to the accumulation of dead material in winter, resulting in the following season (spring). In the summer there was a low percentage of dead material because of the adopted management under the 95% light interception, which favored a higher percentage of green leaves.

With the management of 95% light interception of Mombasa grass, rest periods were variable, so the use of fixed rest periods for grazing, or harvesting, can be a non-optimized use, since the productive capacity of the pasture which is modified, which influences its structure according to the season, densities, fertilization and stage of development, which may cause losses in yield and quality of forage produced.

The leaf percentage was not influenced by nitrogen or densities in the winter (P>0.10), but in the spring, the response to density was quadratic (P<0.05). In the summer there was only effect of nitrogen (P<0.05), which was positively linear. In the fall, leaf percentage responded to both nitrogen levels (P<0.05) and density (P<0.01), with no interaction between factors (Table 3).

In the absence of nitrogen application in the fall with 49 plants/m^2, the leaf percentage was 74.47; with the use of 320 kg/ha of N with the same plant density, it increased to 88%. The positive response of the nitrogen in leaf percentage in the fall and summer was due to the significant influence of this nutrient for biomass in general, including both the leaves as pseudostems.

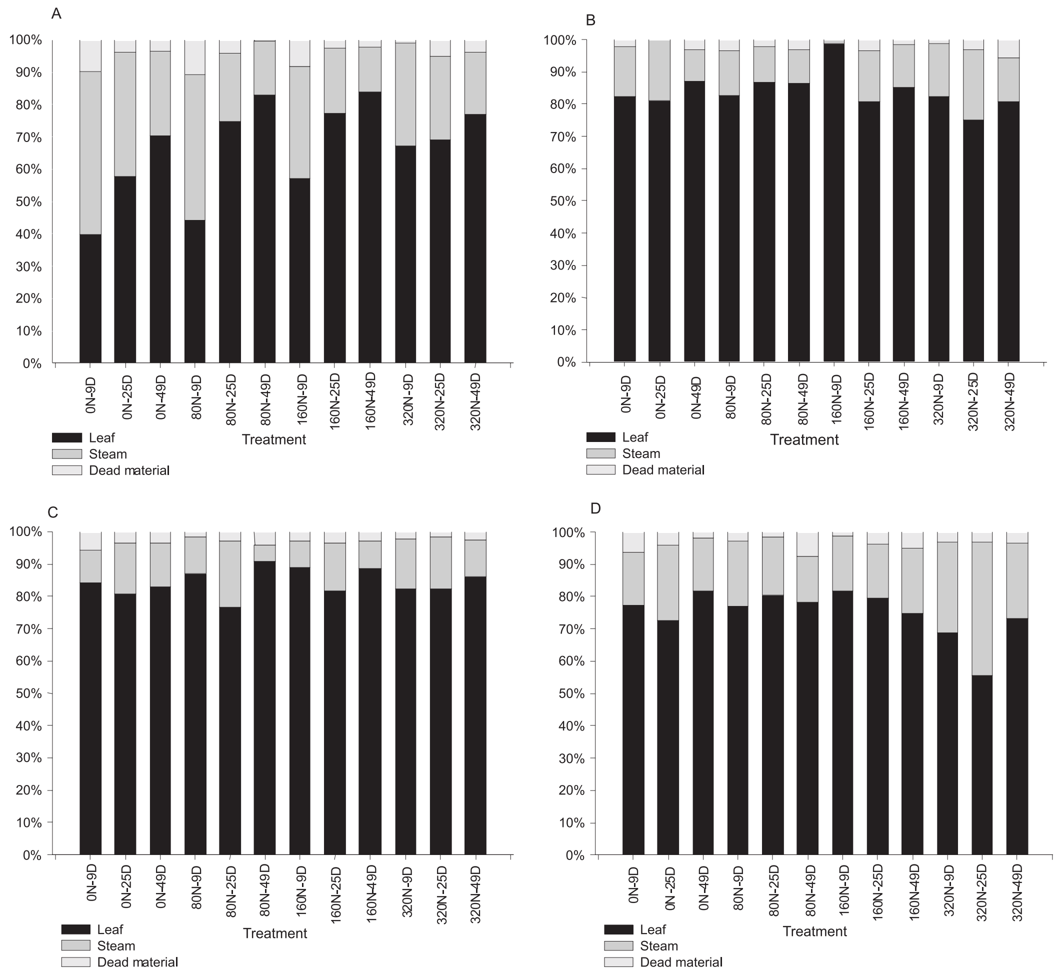


Figure 2 - Morphological composition of Mombasa grass with nitrogen levels (kg/ha) and plant densities (number of plants/m^2) in the fall (A), winter (B), spring (C) and summer (D).

Table 3 - Equations of the leaf percentage of Mombasa grass, according to the densities and levels of nitrogen in the seasons of the year

Season	Adjusted equations	R^2
Fall	$\hat{Y}$ = 43.1967+0.63833**D+0.0423165*N	0.71
Winter	$\hat{Y}$ = 62.35	-
Spring	$\hat{Y}$ = 91.6337-0.848423*D+0.0152657**D^2	0.55
Summer	$\hat{Y}$ = 86.7344+0.0380540*N	0.61

** P<0.01 and * P<0.05.

The largest leaf percentage observed in the higher doses of nitrogen can also be explained by the impact of application of this nutrient in anticipation of the development of the sward, which may have caused higher production of leaves and increased shading of tillers. The lack of effect of fertilization in the winter is attributed to unfavorable climatic factors, while in the spring, the lack of response to nitrogen may be due to mineralization of organic mass providing nitrogen, or the possible mobility of a portion of the nutrient from one area to another, due the slope of the experimental area. The increase in leaf percentage with the biggest densities can be attributed to the higher leaf elongation rate (LER), which results in greater light interception and most frequent harvests.

In the winter, the percentage of pseudostems was positively and linearly influenced by nitrogen fertilization (P<0.10) and in the spring, the density effect was quadratic (P<0.05) (Table 4). In the fall, percentage of pseudostems was linear and negatively influenced by both fertilization (P<0.05) and density (P<0.01). The percentage of pseudostems was quadratically influenced by density (P<0.10) and linear and positively by fertilization (P<0.01) in the summer. In the fall, it was observed that the response to nitrogen was different (negative), compared with the other seasons.

Nitrogen, in general, when promoting more frequent harvests, contributed to reducing the elongation of pseudostems, which delays flowering, thus reducing their percentage in the forage. In fact, the plots where the plants were harvested after the flowering period in the same season had lower percentage of pseudostems, because the nitrogen influenced the number of crops for the period and decreased the accumulation of pseudostems, compared with lower doses of nitrogen that had fewer harvests. This is due to the increase in the cutoff frequency, promoted by the largest accumulation of forage on pastures fertilized with higher doses of nitrogen.

Hoeschl et al. (2007) also observed an increase in the percentage of green forage with nitrogen supplies applied, and concluded that this occurred primarily due to increase of the green pseudostems participation in pastures that received higher doses of nitrogen.

This effect of nitrogen accelerating the development of forage and shading of tillers, promotes increases in elongation rate of pseudostems, to expose part of the more active photosynthetic apparatus (younger leaves) to light. This response pattern highlights the importance of proper management of the pasture when fertilized with high doses of nitrogen. The accumulation of pseudostems is generally undesirable because of the expense of energy for growth and maintenance of this fraction, which besides hindering the proper recess and uniformity of the pastures, where animals are used for harvesting, instead of mechanical cutting (Carnevalli et al., 2006), further reduces the nutritional value of forage produced, also hindering the apprehension of forage by grazing animals, which can affect the voluntary consumption.

The largest share of pseudostems in the composition of forage produced reduces the leaf:pseudostem ratio in the canopy with an adverse effect on the efficiency of use of pasture, negatively influencing the selective grazing of animals (Carvalho et al., 2001). Therefore, the management, using 95% of light interception, is an effective strategy to offer better-quality forage (Carnevalli et al., 2006).

The percentage of dead material had no effect of density or nitrogen in the winter and summer (P>0.10). There was a negatively linear effect of density in the fall (P<0.05) and of nitrogen in the spring (P<0.05) (Table 5).

The absence of effect of density and fertilization on the accumulation of dead material in winter and summer was due to the fact that management with plants harvested at 95% light interception favors and minimizes the deposition of this component in forage harvested at 30 cm. With this post-harvest waste, the amount of dead tissue harvested was negligible in all seasons, which means favorable conditions for improving the quality of forage. For this, there needs to be a rate adjustment in stocking grazing, because, according Nabinger & Pontes (2001), when nitrogen fertilization increases and this adjustment is not made, there will be exaggerated increase of senescence, accumulation of dead material and drop in the growth rate of the forage.

The height of the sward at 95% light interception was not influenced by nitrogen fertilization (P>0.10) but there was effect of density (P<0.10) without interaction between those factors (P>0.10). The data were adjusted according to the simple exponential model of two parameters (height and light interception), involving the values measured during the year. With 95% light interception, greater heights were observed in the canopy established with low density (9 plants/m^2).

Table 4 - Equations for percentage of pseudostems in plants of Mombasa grass, according to densities, or levels of nitrogen in the seasons of the year

Seasons	Adjusted equations	R^2
Fall	$\hat{Y}$ = 47.8298-0.518224**D-0.0348041*N	0.72
Winter	$\hat{Y}$ = 9.60644+0.0199527°N	0.22
Spring	$\hat{Y}$ = 4.03367-0.893458*D+0.0161080**D^2	0.57
Summer	$\hat{Y}$ = 8.88061+0.768981°D-0.0143987°D^2+0.0411606**N	0.59

** P<0.01; * P<0.05 and ° P<0.10.

Table 5 - Equations for the percentage of dead material in Mombasa grass, according to density and nitrogen levels in the seasons of the year

Seasons	Adjusted equations	R^2
Fall	$\hat{Y}$ = 8.97345-0.120108*D	0.52
Winter	$\hat{Y}$ = 2.01	-
Spring	$\hat{Y}$ = 3.82387-0.00579476*N	0.44
Summer	$\hat{Y}$ = 3.61	-

* P<0.05.

The estimated values according to the regression equations were: 111, 106 and 101 cm (Figure 3), for densities of 9, 25 and 49 plants/m^2, respectively. In this study, it was observed that, as density increased, the time to intercept 95% of incident light decreased. This difference in the effects of density highlights the variation in canopy structure of Mombasa grass during the establishment period and after the establishment (Figure 3). The observed heights, greater than 90 cm, can be related mainly to the time of flowering of Mombasa grass (fall), in which the canopy structure was modified, the arrangement and leaf angle were changed and the forage modified its strategy, prioritizing the emission of panicle and seed production.

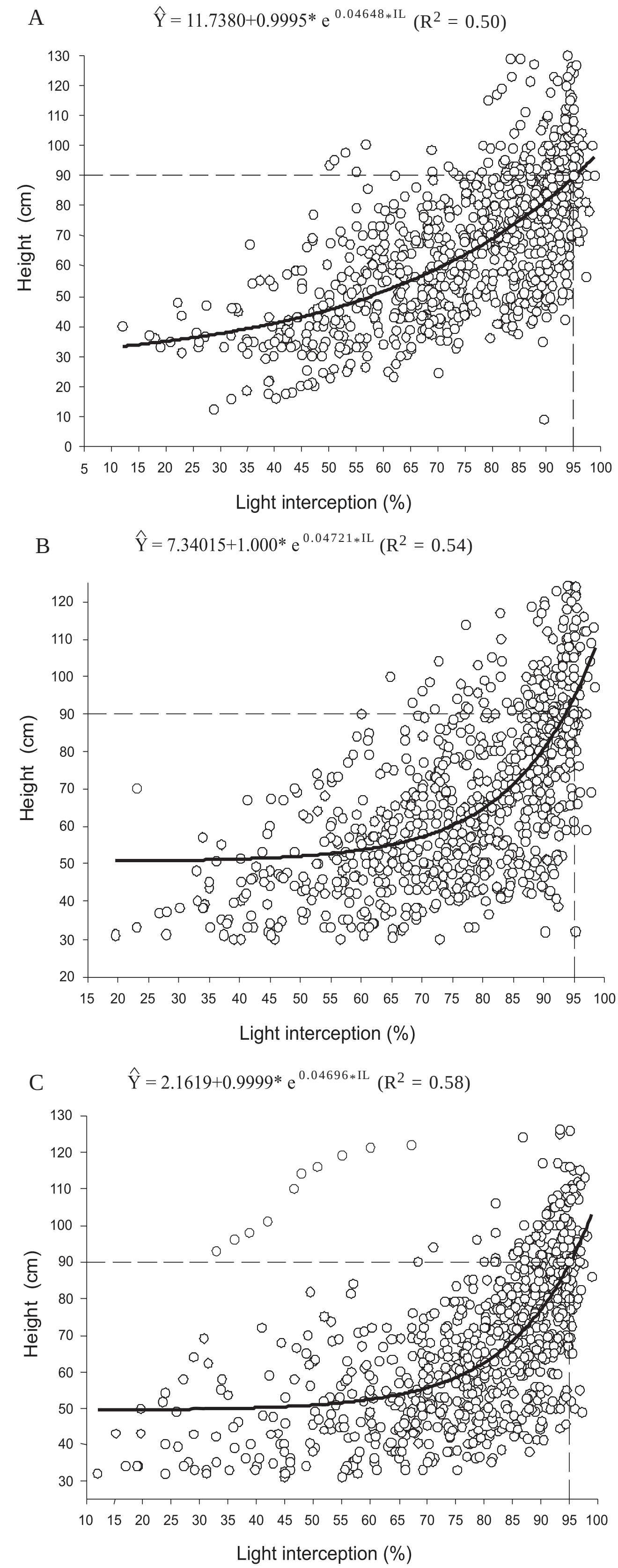
According to Da Silva et al. (2008), at 95% of light interception, canopy height of 90 cm was observed only in the second year of experiment with Mombasa grass. Furthermore, in accordance with the findings of Carnevalli et al. (2006), discrepancies in the height of the plant at 95% light interception are the result of the transition to the new pasture system.

In studies of Mello & Pedreira (2004) and Carnevalli et al. (2006), the sward height was highlighted as a reliable management feature on rotational grazing. However, the results of this study indicate that the height corresponding to 95% of light interception can vary with densities of Mombasa grass in establishment, which suggests the need for further studies to confirm this assertion.

Lopes (2006) noted that in Mombasa grass forage, the canopy height correlated with 95% light interception ranged between grazing intensities evaluated. The pre-grazing heights were 70.2, 72.0 and 72.3 cm for residues of 30, 50 and 50-30 cm, respectively. Such differences were also observed in Mombasa grass by Uebele (2002), with values of 86.0 cm to 30-cm residues and 93 cm to 50-cm residues.

Overall, in this experiment with Mombasa grass, the 95% light interception was achieved with heights below and above 90.0 cm. Lopes (2006), evaluating Mombasa grass in an area that had no control of the process of grazing, found areas of empty spaces and amplitudes of clumps of considerable size, contributing to a great variability of canopy structure. By monitoring the light interception of pastures where 95% would be the management goal, the author observed values of 65.0 cm, lower than the results reported by Carnevalli (2006). Therefore, the variations found in this study are probably a consequence of the transition, formation and adaptation of the pasture.

The number of harvest is the number of cuts made in each season. In this experiment, in the winter, the number of Mombasa grass harvests showed no response to nitrogen fertilization or plant density (P>0.10), but in the spring



Density of 9 plants/m^2 (A), 25 plants/m^2 (B), and 49 plants/m^2 (C).

Figure 3 - Relation of light interception (LI) and height in Mombasa grass harvested at 95% of light interception.

(P<0.01) and summer (P<0.05), there was linear and positive effect of nitrogen fertilization (Table 6). In the fall, there was effect of fertilization (P<0.01) and density (P<0.05).

In the spring and summer, nitrogen promoted higher numbers of harvests; 1.38 and 2.19 harvests were conducted in the absence of fertilization and with 320 kg/ha, respectively. This response is due the increase in leaf appearance rate, increasing biomass accumulation, thus anticipating the interception of light at 95%, and consequently increasing the number of harvests.

In the fall, plant density and nitrogen fertilization had a positively effect for number of harvests. Thus, setting the highest level of fertilizer (320 kg/ha of nitrogen) with 9 plants/m^2, the number of harvests estimated was 1.73, and with 49 plants/m^2; that number increased to 2.87 in the fall.

The most pronounced effects on the number of crops was observed in the spring and summer (Table 6). However, inelastic results were observed in seasons of fall and winter.

Still, increments were observed in the number of crops in all seasons when using the highest dose of nitrogen (320 kg/ha), which caused an increase in the number of crops. Thus, it was observed that fertilization increased the number of harvests when the management was done with 95% light interception.

In this experiment, the harvest intervals (Figure 4), which are the number of days elapsed between each cutting stations, were analyzed. To harvest interval, no significant effect (P>0.10) was observed for fertilization or density in the fall and winter seasons. In the summer, there was a linear and negative effect of nitrogen (P<0.10) and there was no significant effect of density. In the spring, there was a positive and linear effect of density (P<0.05) and a linear effect of fertilization (P<0.01) (Table 7).

Decrease was observed in the interval of harvest with fertilization and the decrease in plants/m^2. In the spring, with the fertilization of 320 kg/ha at the highest density, the range of harvest was 29 days, resulting in a difference of 66 days. This was due to the biggest number of crops, bigger accumulation of total biomass and reduced losses. In the summer, the response to fertilization was higher because of better water availability and temperature; in the absence of nitrogen harvest interval of 56 days, and with 320 kg/ha, 26 days was observed. These results show the difference and the influence of abiotic factors in the period of rest of the forage used for grazing management with 95% light interception.

Magalhães et al. (2011) observed the effect of density on dry mass production of Tanzania grass during the establishment period. According to the author, the greater increase in the accumulated production of dry mass with the higher number of plants per unit area was due to the shorter growing period for plants to reach 95% of light interception, for lower densities, which resulted in a greater number of growth cycles. This fact occurs due to the situation of low intraspecific competition established. In this case, the

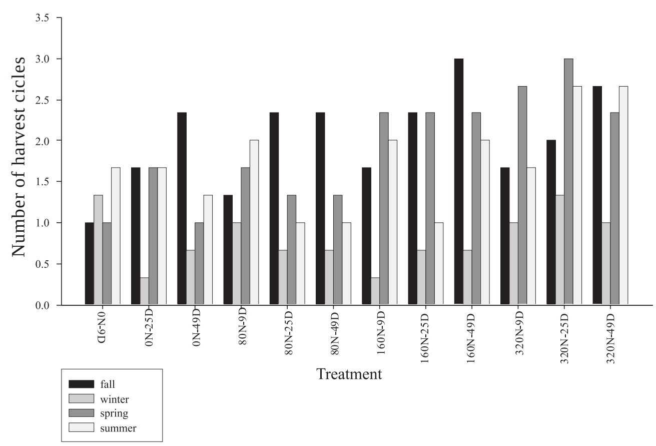


Figure 4 - Number of harvest cycles in Mombasa grass in the four seasons.

Table 6 - Equations for the number of crop in Mombasa grass, according to density and nitrogen levels in the seasons of the year

Season	Adjusted equation	R^2
Fall	$\hat{Y}$ = 1.05570+0.00130952**N+0.0285088*D	0.79
Winter	$\hat{Y}$ = 0.77	-
Spring	$\hat{Y}$ = 1.38096+0.00480159**N	0.80
Summer	$\hat{Y}$ = 1.37125+0.00277778*N	0.34

** P<0.01; * P<0.05 and ° P<0.10.

Table 7 - Equations for range of crops in Mombasa grass, according to density and nitrogen levels in the seasons of the year

Season	Adjusted equations	R^2
Fall	$\hat{Y}$ = 31	-
Winter	$\hat{Y}$ = 78	-
Spring	$\hat{Y}$ = 89.6394+0.564650*D-0.203742**N	0.82
Summer	$\hat{Y}$ = 55.8828-0.094503°N	0.27

** P<0.01; * P<0.05 and ° P<0.10.

canopy is favored by available resources such as nutrients, water, light, among others, causing a tradeoff between size and density, which reflects the production capacity of the canopy to intercept the incident light and affects the range and number of harvest cycles.

Conclusions

Nitrogen contributes to greater productivity of Mombasa grass by increasing production per cycle and the number of harvest cycles, although it influences the structure of the canopy due to higher accumulation of leaves and stem. The canopy height of Mombasa grass at establishment to intercept 95% of incident sunlight is proportional to the plant density.

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