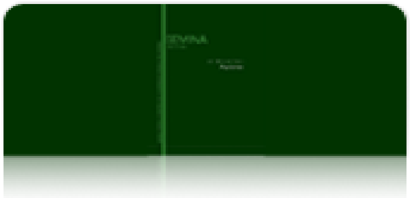

Semina: Ciências Agrárias
ISSN: 1676-546X
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Universidade Estadual de Londrina
Brasil

DOI: 10.5433/1679-0359.2016v37n4p2067

Tifton 85 grass responses to different nitrogen levels and cutting intervals

Características estruturais e composição bromatológica de capim tifton 85 sob doses de nitrogênio e idades de rebrota

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Abstract

The objective of this study was to evaluate the influence of five levels of N and two regrowth intervals on the structural, productive, and nutritional characteristics of Tifton 85 grass (*Cynodon* spp). The experiment was conducted in a hay production field at the State University of West Paraná, planted in 2004 with *Cynodon* spp. cv. Tifton 85. The experiment was established in a randomized block design with factorial treatments of five N fertilization amounts (0, 25, 50, 75 and 100 kg ha^{-1} cut^{-1}) applied as urea after each cut, and two regrowth intervals (28 and 35 d), with four replicates. N application promoted changes in plant structure, such as increased canopy height, stem length, leaf elongation rate, and dry mass (DM) production. The greatest N use efficiency, considering the four harvests, occurred in the plot with 25 kg N ha^{-1} cut^{-1} at the 35-d interval, with a production of 13.79 kg DM kg^{-1} of N applied. A nutritional analysis indicated that 100 kg ha^{-1} of N cut^{-1} promoted higher crude protein (CP) at 28 d, with the highest concentration observed in the fourth cut (208.2 g kg^{-1} DM) and the lowest in the second cut (140.12 g kg^{-1} DM). The content average in the four cuts for CP and LIG at 28 days of regrowth was 175.85 and 104.33 kg^{-1} g MS and at 35 days of regrowth interval was of 164.45 and 118.65 g kg^{-1} DM, respectively. No differences were found between regrowth intervals in the contents of mineral matter and acid detergent fiber (ADF). Environmental factors including the wide variation in precipitation (greater than 200 mm between the peak in December 2010 and the lowest in March 2011) greatly influenced Tifton 85 grass production, affecting DM and the nutritional value of the forage in each cut.
Key words: Biomass. Forage quality. Grazing. Management. Persistence. Stocking.

Resumo

O objetivo do trabalho foi avaliar a influência de cinco doses de nitrogênio (N) em duas idades de rebrota no capim Tifton 85 (*Cynodon* spp.) sobre as características estruturais, produtivas e na composição bromatológica. O experimento foi instalado no campo de produção de feno da UNIOESTE, *campus* de Marechal Cândido Rondon. O delineamento experimental foi em blocos casualizados em esquema fatorial 5x2, sendo cinco doses de nitrogênio (0, 25, 50, 75 e 100 kg ha^{-1}) aplicados em cada corte, aplicadas na forma de uréia, duas idades de rebrota (28 e 35 dias) com quatro repetições e quatro cortes.

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Recebido para publicação 28/05/14 Aprovado em 06/05/16

As doses de nitrogênio promoveram alterações nas características estruturais das plantas, como maior altura do dossel, comprimento de colmo, taxa de alongamento das folhas e produção de MS. A maior eficiência de utilização de N ocorreu na dose de 25 kg N ha^{-1} $corte^{-1}$, com 13,79 kg de MS kg^{-1} de N aplicado na idade de rebrota de 35 dias. Na composição bromatológica a dose de 100 kg N ha^{-1} $corte^{-1}$ promoveu maior teor de proteína bruta na idade de 28 dias, sendo que a maior concentração ocorreu no quarto corte (208,2 g kg^{-1} MS) e a menor no segundo corte (140,12 g kg^{-1} MS). Os teores médios considerando os quatro cortes de proteína bruta e lignina foram de 175,85 e 104,33 g kg^{-1} MS aos 28 dias e de 164,45 e 118,65 g kg^{-1} MS aos 35 dias de intervalo de corte, respectivamente. Não houve diferenças entre idades na concentração de matéria mineral e de fibra em detergente ácido. A grande variação de precipitação (superior a 200 mm entre o mês com maior e menor precipitação) influenciou na produção de MS e na produção total de PB por corte.
Palavras-chave: Biomassa. Lotação. Manejo. Pastejo. Persistência. Qualidade das forrageiras.

Introduction

Balanced N fertilization can increase pasture productivity and sustainability and reduce environmental impacts by limiting pasture degradation especially if fertilizer is applied in a species-specific manner. Grazing systems must be carefully managed according to the carrying capacity of the pasture to maintain dry matter (DM) production and sustain the system (MOREIRA et al., 2015); management may include increasing the supply of nutrients and possibly integrating crops and livestock (SOLLENBERGER, 2008). N limits biomass production and influences the amount of other nutrients necessary to sustain production. It also influences the nutritional value of forage, plant health, and plant recovery after grazing, and may affect animal performance (SOLLENBERGER, 2008; SILVA et al., 2013).

N fertilizer must be applied regularly because the amount available in the soil is insufficient to support high productivity and forage quality (REZENDE et al., 2015). When applied regularly according to the cycling capacity of the forage crop and with respect to soil permeability and drainage, N can increase the productivity and concentration of animals per unit area, resulting in lower methane emissions per kilogram of milk or meat as slaughter age is reduced and milk production is increased (PEDREIRA; PRIMAVESI, 2006). More than three times the fossil fuel energy is required to provide the same energy to ruminants from soybean and corn compared to forage (TAMMINGA, 1996).

N fertilizer must be applied appropriately to enhance plant recovery, reduce runoff, and prevent the formation of nitrous oxide (N_2O) (FERRÃO et al., 2010). More frequent but smaller doses reduce losses from volatilization, denitrification, and leaching, enabling better plant growth and maintenance (SILVA et al., 2013). Quaresma et al. (2011) found that biomass of Tifton 85 was markedly reduced after N application at an estimated dose of 155 kg ha^{-1}.

Sustainable production systems for Tifton 85 (*Cynodon spp*.) and Tifton 68 (*Cynodon nlemfuensis*) require soils with abundant nutrient levels. Tifton 85 is more tolerant of grazing because its rhizomes have many lateral buds and can store energy (SOLLENBERGER, 2008). It is more resistant to cold, frost, and drought than other cultivars of bermudagrass and can grow 6-8 months during the year, producing abundant and highly digestible forage (MONTEIRO et al., 2008), but this growth requires high N, potassium, and soil moisture availability (ANDERSON et al., 2008). In the winter, pastures with Tifton 85 can be seeded with oats, providing year-round forage with a high protein content and digestibility (NERES et al., 2011).

After grazing, the regrowth interval affects the quality and morphogenesis of Tifton 85. The leaf to stem ratio (LSR) reaches a maximum between 28 and 35 d and then decreases, owing to a decrease in the leaf appearance rate (LAR) and an increase in phyllochron and leaf senescence and death

(PEREIRA et al., 2011). Moreira et al. (2015) found that the total tiller number (TN) m^{-2} also increased as tiller weight (TW) decreased with increasing N application of 0-223 kg ha^{-1}.

The daily leaf elongation rate (LER) and leaf length (LL) are associated with the DM accumulation rate of leaf blades, which is higher in the summer. However, the LAR and the number of leaves per tiller are higher in spring (VILELA et al., 2005), and N influences these characteristics, contributing to increased DM yield, turf height, and crude protein (CP) content, and reducing the neutral detergent fiber (NDF) content (QUARESMA et al., 2011).

N applications in Tifton 85 also increase the CP content (VENDRAMINI et al., 2008b) and digestibility (VENDRAMINI et al., 2008a). Therefore, a low N fertilization rate reduces the CP and rumen degradable protein (RDP) contents of grasslands, which can limit the performance of ruminants with higher CP requirements. Although a RDP supplement can be added to the animals' diet, even fertilization and appropriate grazing intervals are equally effective (SOLLENBERGER, 2008).

The livestock production systems in Brazil are constantly evolving and encompass a range of techniques, but intensive forage systems that use strategic supplementation have benefitted from the multidisciplinary knowledge of new professionals who are providing management improvements (LOBATO et al., 2014), and making production more sustainable (LATAWIEC et al., 2014). Demand for dairy cattle production has increased and could be met with carefully managed Tifton 85.

The objective of this study was to evaluate the influence of five N treatments on the structural characteristics, productivity, chemical and bromatological composition, and digestibility of Tifton 85 harvested at two regrowth intervals.

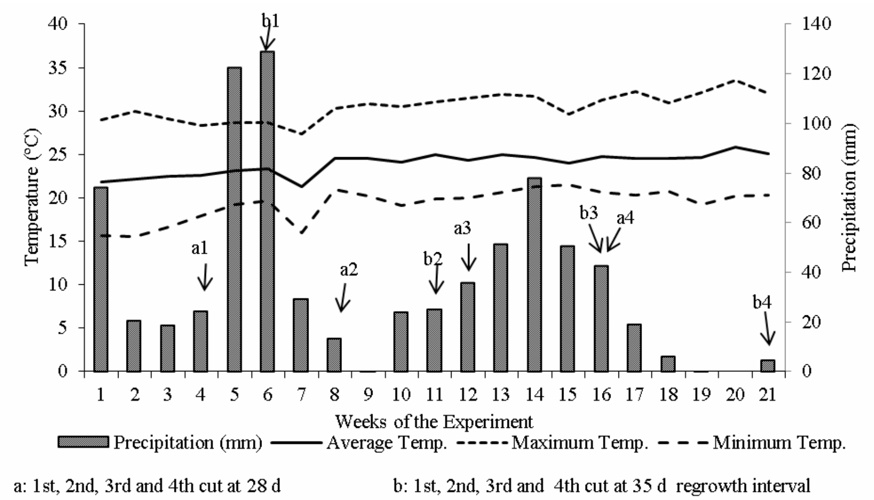
Material and Methods

The experiment was conducted under field conditions at the Experimental Farm "Antonio Carlos dos Santos Pessoa," which belongs to the State University of West Paraná, Marechal Cândido Rondon campus (latitude: 24°33′40″ S; longitude: 54°04′12″ W; altitude: 420 m above sea level). The local climate is classified according to Koppen as the Cfa type, subtropical with well-distributed rainfall during the year and hot summers (CAVIGLIONE et al., 2000). The average temperature varies between 17 and 18 °C for the coldest quarter and between 28 and 29 °C for the warmest quarter, with an annual temperature between 22 and 23 °C. The average annual rainfall ranges from 1660 to 1800 mm, with quarterly totals ranging from 400 to 500 mm (CAVIGLIONE et al., 2000). The climatic conditions during the experiment are shown in Figure 1.

The soil in the experimental area is classified as a eutrophic red latosol (ERL) (EMBRAPA, 2006) and has the following chemical characteristics: P (Mehlich extractor) 8.15 mg dm^{-3}; OM 23.92 g dm^{-3}; pH ($CaCl_2$) 0.01 mol L^{-1}; H + Al = 4.30 $cmol_c$ dm^{-3}; Al^{3+} = 0.05 $cmol_c$ dm^{-3}; K = 0.23 $cmol_c$ dm^{-3}; Ca^{2+} = 3.62 $cmol_c$ dm^{-3}; Mg^{2+} = 1.69 $cmol_c$ dm^{-3}; SB = 5.54 $cmol_c$ dm^{-3}; CTC = 9.84 $cmol_c$ dm^{-3}; V = 56.30%; Al = 0.89%; Cu = 6.30; Mn = 1.4; Zn = 63.00; Fe = 25.10; clay = 650 g kg^{-1}.

The experiment was conducted in a hay production field planted in 2004 with *Cynodon* spp. cv. Tifton 85. The experimental design was a completely randomized 5 × 2 factorial arrangement, with five N treatments (0, 25, 50, 75, and 100 kg ha^{-1} cut^{-1}) and two regrowth intervals (28 and 35 d), with four replicates and four crops (cuts). Experimental plots were 3 m × 5 m. The experiment began on October 30, 2010 with a uniform cut to within 5 cm of the soil and with fertilization of 40 kg ha^{-1} K_2O in the form of potash and 40 kg ha^{-1} P_2O_5 chloride in the form of superphosphate, following IAPAR (2003) recommendations for fodder fertilization.

Figure 1. Temperature (°C) (mean, maximum, and minimum) and precipitation (mm rainfall) during the experimental period (Marechal Cândido Rondon, October 30, 2010 to March 21, 2011).



Source: UNIOESTE, adapted by author.

Plots with a regrowth interval of 28 d were cut on November 26 and December 26, 2010, and January 21 and February 18, 2011. Plots with a regrowth interval of 35 d were cut on December 6, 2010, and January 10, February 14, and March 21, 2011. Within five d after the initial and subsequent cuts, the plots were fertilized with urea. Three robust tillers were also selected and scored in each plot.

. After each cut, the following characteristics were evaluated: LAR, phyllochron (Phy), LER, plant height (PH), leaf stem ratio (LSR), tiller mass (TM), stem length (SL), stem diameter (SD), average leaf length (LL), tiller number per square meter (TN), and DM yield.

The LAR, LER, and LL were obtained by measuring the sheets every four d during the experimental period and Phy was calculated from the LAR. PH was measured in millimeters with a ruler before every cut and LSR was measured from 30 tillers that were separated into leaf blade and stem after cutting and then dried in an oven with forced air circulation at 55 °C for 72 hours. The LSR was calculated from the ratio between the dry weight of the leaves and the dry weight of the stems. SL was measured in millimeters with a ruler from the same 30 tillers used for LSR, and SD was measured with calipers. DM yield was calculated from a random 50 cm × 50 cm area (0.25 m^2) within each experimental plot. After cutting, the forage was placed in bags, transported to the laboratory, and immediately weighed and dried at 55 °C for 72 hours. Samples were weighed again to calculate DM yield ha^{-1}. TN per square meter was calculated by multiplying the fresh mass of each 0.25 m^2 area by four and dividing by the average weight of each tiller from the same area.

After drying, the samples were ground in a Willey mill with a 30 mesh sieve and stored in labeled plastic bags prior to bromatological analysis of dry matter (DM), mineral matter (MM), NDF, acid detergent fiber (ADF), CP, lignin (LIG), cellulose (CEL) and hemicellulose (HEM), following the methods of Silva and Queiroz (2009).

Data were evaluated with an analysis of variance, and the effect of regrowth interval was assessed with a Tukey test, while N application was examined with regression analysis. The choice of models was based on the coefficients of determination (R^2) and the significance (at a 5% level) of the partial regression coefficients was calculated with a Student's t-test. The significance of the factors included in the initial statistical model was respected. All analyses were conducted in the statistical program Sisvar (FERREIRA, 2011).

Results and Discussion

There were significant differences ($p < 0.05$) between regrowth intervals for canopy height (PH), DM yield (DMY), average mass per tiller (TM), LSR, SL, SD, LL, LAR, Phy, LER, and TN (Table 1). There was no interaction between N and interval in the variables listed, except in the 3rd cut, at 28 d ($\hat{Y} = 17.20 + 0.0045875*X$, CV = 17.19%, R^2 = 65.88%).

Table 1. Height of plants, dry matter yield (DMY), average tiller mass (TM), leaf stem ratio (LSR), stem length (SL), stem diameter (SD), size of leaves (LL), leaf appearance rate (LAR), phyllochron (Phy), leaf elongation rate (LER), and tiller number (TN) at the regrowth ages on the day of cutting.

Regrowth age	Height (cm)	DMY (kg ha^{-1})	TM (g)	LSR	SL (cm)	SD (mm)	LL (cm)	LAR	Phy	LER (mm day^{-1})	TN (m^{-2})
1st Cut											
28 d	20.50 b	3904.7 b	0.18 b	1.16 a	11.12 b	1.67 a	9.45 a	0.32 a	3.70 b	9.30 a	3846 a
35 d	45.80 a	4940.7 a	0.46 a	1.10 a	22.16 a	1.61 a	10.10 a	0.29 b	4.21 a	9.00 a	2667 b
CV (%)	15.60	15.51	25.99	21.35	13.11	11.93	10.89	10.86	9.96	12.20	20.08
2nd Cut											
28 d	46.60 a	5590.8 a	0.16 b	1.02 b	20.87 a	1.42 b	14.65 b	0.28 a	4.23 b	17.10 a	3652 a
35 d	26.28 b	2919.7 b	0.21 a	1.41 a	13.60 b	1.84 a	15.90 a	0.28 a	4.77 a	15.10 b	1253 b
CV (%)	10.29	15.11	31.89	17.26	17.19	12.50	9.89	12.20	11.64	13.43	16.55
3rd Cut											
28 d	26.05 b	3336.1 b	0.15 b	1.56 a	11.66 b	1.50 a	15.15 b	0.30 a	3.93 a	16.10 a	2525 a
35 d	36.88 a	4070.8 a	0.23 a	1.14 b	21.48 a	1.54 a	16.4 a	0.31 a	3.67 a	17.00 a	2049 b
CV (%)	11.83	16.02	29.39	9.14	15.65	10.45	8.62	11.50	14.71	13.07	26.86
4th Cut											
28 d	29.75 a	2995.0 a	0.24 a	1.27 b	18.48 a	1.70 a	17.05 a	0.35 a	3.28 b	19.8 a	14.39 b
35 d	16.14 b	2383.6 b	0.13 b	1.62 a	8.92 b	1.35 b	14.00 b	0.31 b	3.99 a	13.50 b	2036 a
CV (%)	8.67	11.71	30.27	12.82	11.39	9.38	11.37	15.17	10.71	16.32	3.20

Values followed by the same letter in each column and cut do not differ at 5% probability with Tukey's test.

The canopy height, DMY, and SL were significantly higher ($p < 0.05$) at 35 d of regrowth on the 1st and 3rd cuts and at 28 d on the 2nd and 4th cuts (Table 1). It is likely that the low rainfall of 195.4 mm between the 6th to the 10th week of the experiment against 293.2 mm from 5th to 8th week of the experiment (Figure 1) reduced canopy height, DMY, and shorter SL for the 2nd cut at 35 d (10 weeks) compared to the 2nd cut at 28 d (8 weeks), respectively. In the 4th cut, a similar pattern was observed, with lower rainfall during the 16th to 21th weeks (46.0 mm) than during the 13th to 16th weeks (225.0 mm) (Figure 1).

N application affected canopy height in each cut except the 3rd (Figure 2). There was a linear effect on the 1st and 4th cuts and a quadratic effect on the 2nd cut. Oliveira et al. (2010) reported greater canopy height as a function of N fertilizer on Tifton 85, which varied as a function of N levels and rainfall. Quaresma et al. (2011) found an average increase of 0.052 cm in Tifton 85 for each kg N ha^{-1} applied every 30 d over a 120 d period, a value similar that seen from the 4th cut of this experiment. N fertilization linearly increased the DMY on the 1st and 4th cuts (Figure 3), consistent with previous findings (OLIVEIRA et al., 2010; QUARESMA et al., 2011). The highest average DMY in the four cuts was observed with 400 kg N ha^{-1} at 28 d of regrowth, and the lowest was observed with no added N at 35 d of regrowth (Table 1). The average total DMY was 3956.71 kg ha^{-1} at 28 d of regrowth and 3578.75 kg ha^{-1} at 35 d of regrowth. These differences are attributable to the distribution of rainfall during the 28-d interval (137 mm, 293 mm, 85.4 mm, and 222 mm) compared to the 35-d interval (388 mm, 92 mm, 257.8 mm, and 30 mm) (Figure 1).

Figure 2. Canopy height as a function of nitrogen applied after each cut of Tifton 85.

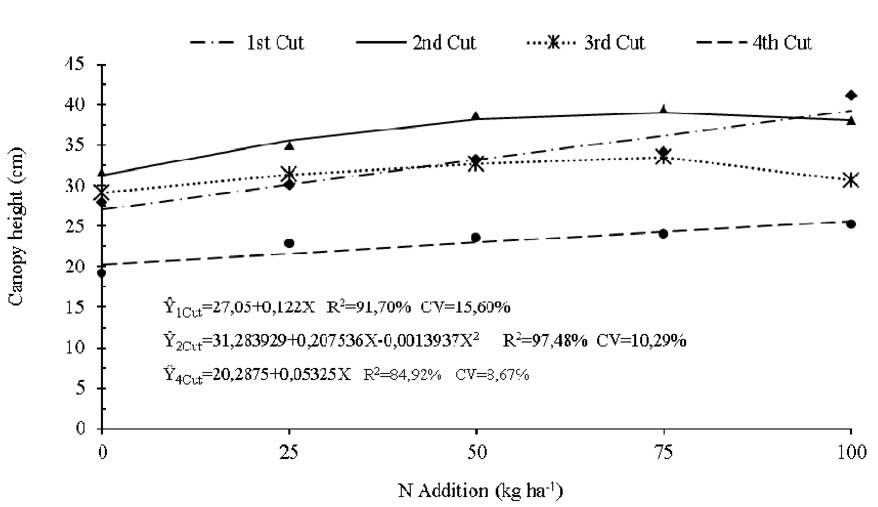
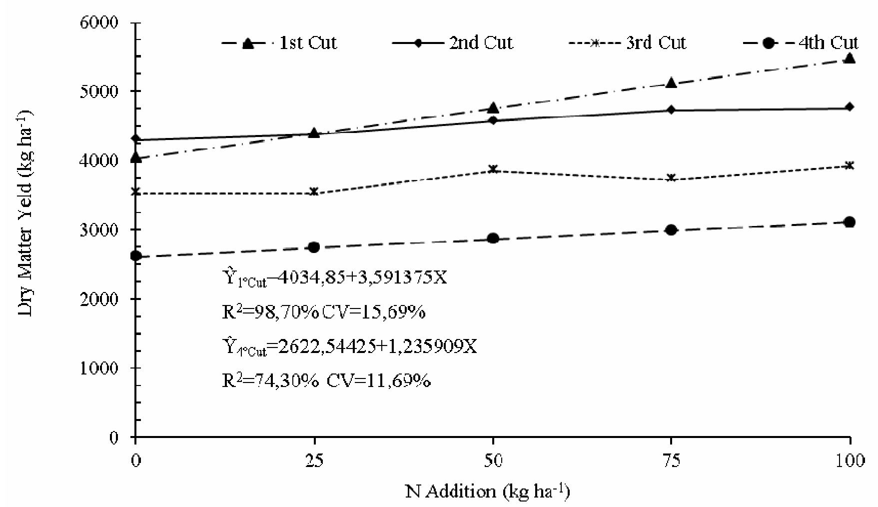


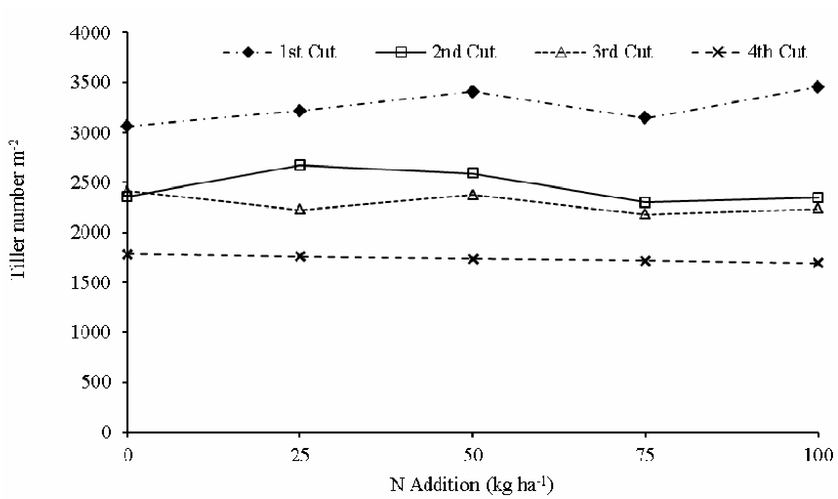
Figure 3. Effect of nitrogen on the dry matter yield (DMY) ha^{-1} in each cut of Tifton 85.



Total DM production (kg ha^{-1}) was 14 675, 15 066, 16 197, 16 246, and 16 949 for the 28-d interval and 12 490, 13 870, 14 105, 15 432, and 15 678 for the 35-d interval at doses of 0, 100, 200, 300, and 400 kg ha^{-1} N, respectively. The corresponding N use efficiency values were 3.91, 7.61, 5.24, and 5.68 kg DM kg^{-1} N for the 28-d interval and 13.80, 8.07, 9.81, and 7.97 kg DM kg^{-1} N for the 35-d interval, respectively, with 100, 200, 300, and 400 kg ha^{-1} of N. The highest N use efficiency occurred with 100 and 200 kg N ha^{-1}, possibly owing to an increased N use efficiency 30 d after N application between 150 and 300 kg ha^{-1} (OLIVEIRA et al., 2010). Quaresma et al. (2011) reported N use efficiency of 22.67 kg DM kg^{-1} of applied N in a very fertile soil, and Rocha et al. (2000) reported N use efficiency of 10.30, 8.05, and 5.15 kg DM with N applications of 100, 200, and 400 kg ha^{-1}, respectively.

The average mass of each tiller in the first three cuts was significantly higher ($p < 0.05$) at 35 d of regrowth and in the 4th cut at 28 d of regrowth (Table 1). The other cuts at both intervals might have had lower average mass per tiller because they had higher DMY. Premazzi et al. (2003) reported an inverse relationship between TN and mass, as greater numbers of taller tillers compete to assimilate nutrients, thereby reducing individual tiller mass; increasing N availability may lead to taller tillers. There was no significant variation in TN with respect to cutting interval and N level (Figure 4). There was no effect of N application ($p > 0.05$) on TM (Figure 5), nor on LSR (Figure 6). TN and TM determine forage productivity (MOREIRA et al., 2015), and this is evident in the higher TN and lower TM in the 2nd cut of the 28-d interval, which had a greater DMY.

Figure 4. Effect of nitrogen application on the tiller number m^{-2} in each cut of Tifton 85.



LSR did not differ between intervals in the 1st cut, but it was significantly higher ($p < 0.05$) at 35 d in the 2nd and 4th cuts and at 28 d in the 3rd cut (Table 1). When height and DMY are greater, LSR is smaller, but this was not observed in the 4th cut. Dittrich et al. (2005) found LSRs of 1.79 and 1.75 for Tifton 85 plants that were 12 and 25 cm tall. A LSR of approximately 1.2 contains about two thirds of total DM is available in leafs. As tillers age, LSR decreases owing to stem elongation; the stem has a higher fiber content and less protein (CUTRIM JUNIOR et al., 2014; MARCHESAN et al., 2013). However, LSR also varies with the season (MOREIRA et al., 2015). In general, as N application increased, the stem length also increased (Figure 7), although only the 2nd and 4th cuts were significantly higher ($p < 0.05$), with similar results at canopy height.

SD was significantly greater ($p < 0.05$) in the 2nd cut at the 35-d interval and in the 4th cut at the 28-d interval (Table 1). In the 4th cut, the difference was likely due to less rainfall during the 35 d growing period (Figure 1, Table 1). Larger diameter stems retain more water, so forage cut for hay takes longer to dry. There was no significant difference ($p > 0.05$) in SD between regrowth intervals in the 1st and 3rd cuts. The LL leaves were larger ($p < 0.05$) at 35 d in the 2nd and 3rd cuts and at 28 d in the 4th cut. Leaf size was smaller and not significantly different ($p > 0.05$) in the first cut, probably owing to rapid tiller growth after N application. Neres et al. (2012) found that Tifton 85 leaves were, on average, 20.15, 22.76, and 20.49 cm without N at the 1st, 2nd, and 3rd cuts, and 15.08, 21.25, and 16.55 cm with 150 kg ha^{-1} of N applied three times, respectively. N was positively correlated with LL ($p < 0.05$) in the 1st, 2nd, and 4th cuts (Figure 8). Premazzi et al. (2011) found an increased LL and LER in treatments with no added N and with 80 mg N kg^{-1} of soil compared to applications of 160 and 240 mg N kg^{-1} of soil.

Figure 5. Effect of nitrogen doses on the average tiller mass in the four cuts of Tifton 85.

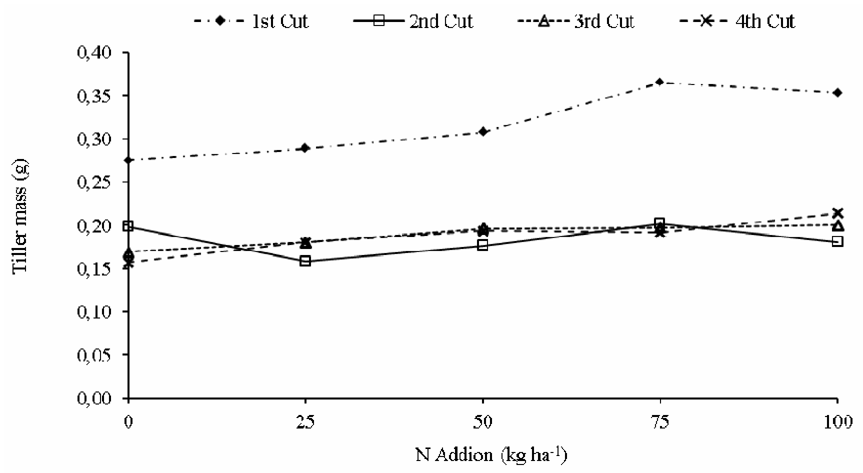


Figure 6. Effect of nitrogen on the leaf stem ratio (LSR) in the four cuts of Tifton 85.

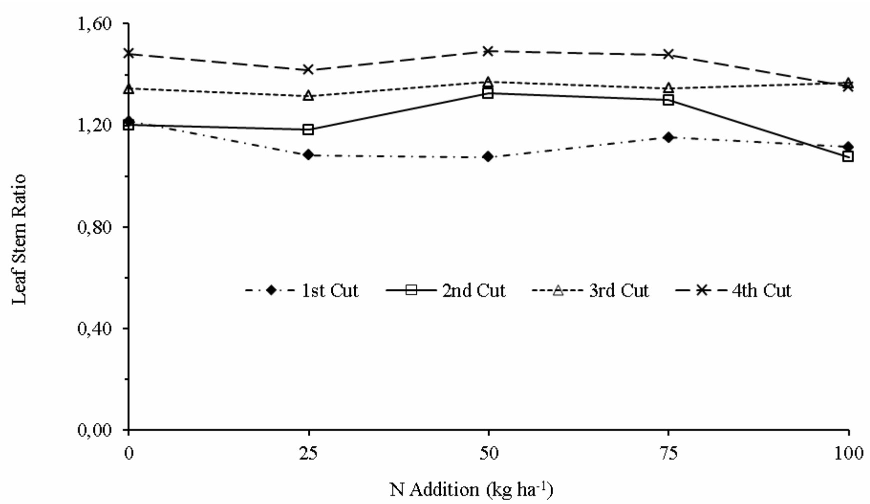


Figure 7. Effect of nitrogen on the average stem length (SL) in the four cuts of Tifton 85.

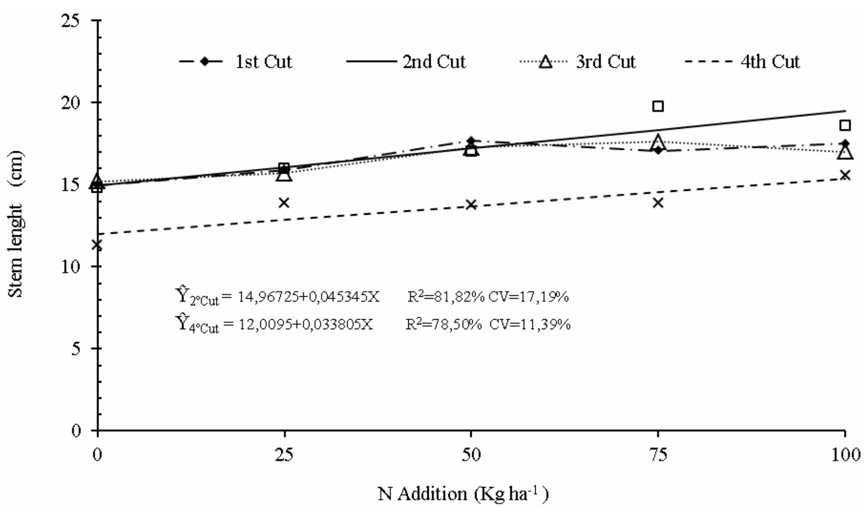
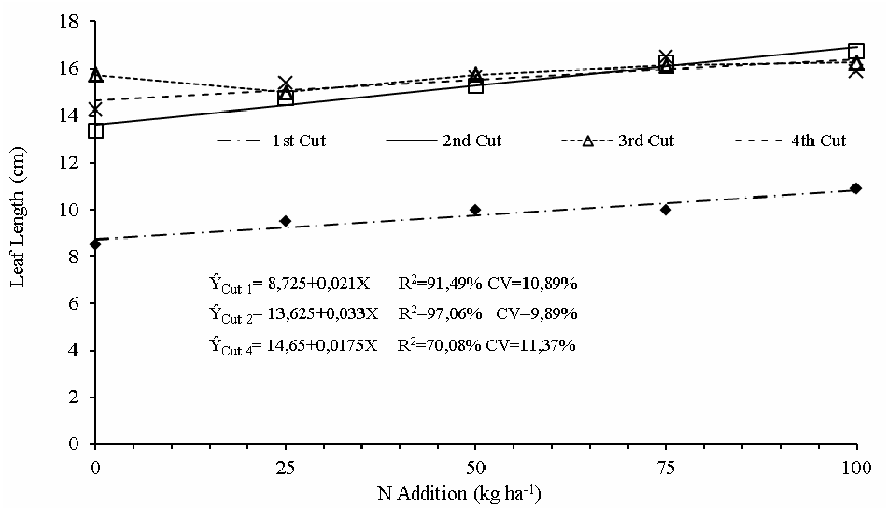
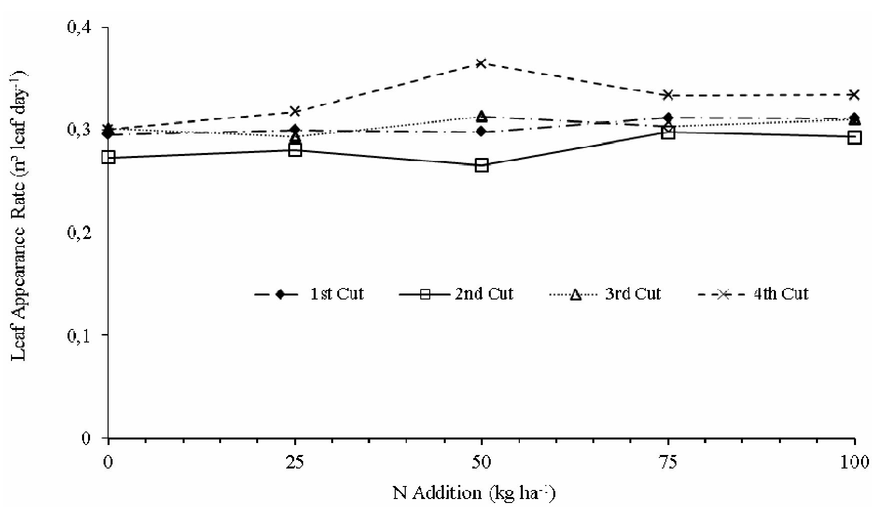


Figure 8. Leaf length (LL) as a function of nitrogen in the four cuts of Tifton 85.



LAR is the average number of leaves that appeared per tiller per day or degree days (PEREIRA et al., 2011; MACHADO et al., 2013). LAR was higher ($p < 0.05$) in the 1st and 4th cut at the 28-d interval and there was no difference in the 2nd and 3rd cuts (Table 1). N application did not influence LAR ($p > 0.05$; Figure 9). However, Pereira et al. (2011) reported that LAR in Tifton 85 grass increased from 0.0024 and 0.0023 leaves per tiller per day for each increase of 1 kg of N applied in the first and second year, respectively. N is required for cell division and elongation in the tiller meristematic zone and therefore, in most cases, LAR increases with increasing N. Phy is the time interval between the appearance of two successive leaves and is the inverse of LAR (PACIULLO et al., 2005; PEREIRA et al., 2011; MACHADO et al., 2013).

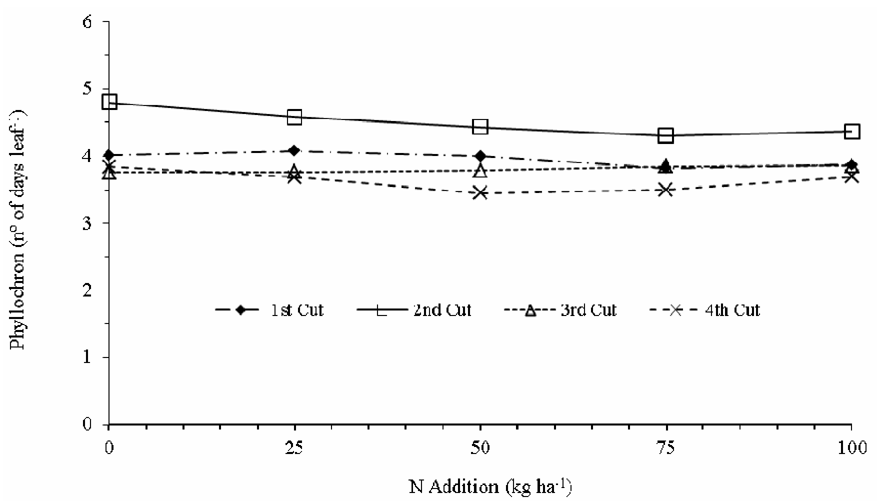
Figure 9. Leaf appearance rate (LAR) as a function of nitrogen in the four cuts of Tifton 85.



Phy was higher ($p < 0.05$) for the 35-d interval in the 1st, 2nd, and 4th cuts, and there was no difference in the 3rd cut compared to 28 d interval (Table 1). N application had no significant effect on Phy ($p > 0.05$; Figure 10). In contrast, Pereira et al. (2011) found that Phy decreased between 0.015 and 0.010 unit for each kg of N applied ff a study that lasted two years. The same authors found that Phy increased between 0.04 and 0.01 d in the first and second year for every increment of 1 cm in plant height at cutting time LER reflects daily growth. There was no difference in LER in the 1st and 3rd cuts, while it was higher ($p < 0.05$) in the 2nd and 4th cuts for the 28-d interval (Table 1). N application significantly influenced cuts 1 and 2 (Figure 11). Differences in weather affected LAR, Phy, and LER (Figure 1). Pereira et al. (2011) found a consistent increase in LAR, Phy, and LER in response to N fertilization in Tifton 85.

A greater ($p < 0.05$) TN per square meter (Table 1) was found in the 1st cut in at the 28-d interval (3846 m^{-2}), with fewer in the second cut at the 35-d interval (1253 m^{-2}). TN was greater ($p < 0.05$) only in the 4th cut at the 35-d interval. N levels at the start of the regrowth interval tend to increase tiller number, which is then reduced owing to shading from a tall canopy. Plant height was greatest in the 1st cut at 35 d of regrowth, an interval with abundant precipitation (388 mm). However, self-shading from a tall canopy increases tiller senescence (ALDERMAN et al., 2011), so fewer tillers were present in the 2nd cut at the 35-d interval, which also had less precipitation (92 mm). Moreira et al. (2015) reported the following average TN per square meter in the specified months and with different N applications (kg ha^{-1}): 2340 (December 2008, 0), 2440 (January 2009, 100), 2329 (February 2009, 200), and 2265 (March 2009, 400) and the highest number of total tillers occurred with an application of 227 kg ha^{-1} of N. Vilela et al. (2005) stated that at a height of 20 cm, grass may reduce the incidence of solar radiation at the tiller base, thereby reducing tiller number. This effect might explain the reduction in tiller number in the 2nd cut of the present study, after a period associated with higher rates of daily leaf elongation.

Figure 10. Effect of nitrogen on the phyllochron (Phy) in four cuts of Tifton 85.



There was a significant effect ($p < 0.05$) of interval for DM, NDF, CP, LIG, and CEL (Table 2) and of N in ADF and CP (Figures 3 and 4). There was no interaction ($p > 0.05$) between N levels and interval for these factors. The DM content in all cuts at the 35-d interval was higher ($p < 0.05$) than in the 28-d interval (Table 2). A lower content (196.7 g kg^{-1}) was recorded from the first cut at 28 d. MM content was not significant different among cuts or regrowth intervals (Table 2). The amount varied between 72.8 and 77.8 g kg^{-1} DM and was lower than those reported by Aguiar et al. (2006) from tropical grasses (pearl millet Bulk-1 and Sudanense S-4202, elephant Cameroon, sorghum SF-25 and API-467-4-2, 84.5-111.4 g kg^{-1} DM), but was similar to those found by Ribeiro et al. (2001) from Tifton 85 with regrowth intervals of 28, 35, 42, and 56 d, and higher than that (61.2 g kg^{-1} DM) reported by Silva et al. (2007) at Tifton 85 hay. N did not influence MM content.

Figure 11. Effect of nitrogen on the daily leaf elongation rate (LER) in four cuts Tifton 85.

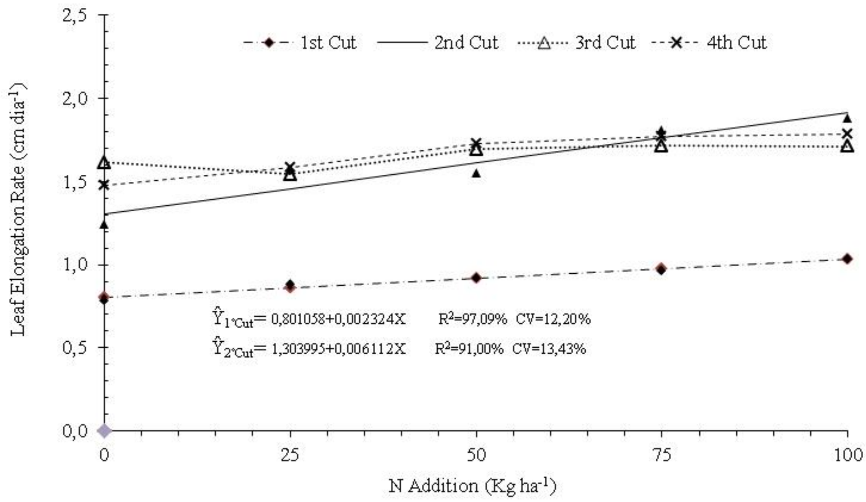


Table 2. Contents (g kg^{-1}) of dry matter (DM), mineral matter (MM), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), lignin (LIG) cellulose (CEL), hemicellulose (HEM), and in vitro digestibility of dry matter (IVDDM) in Tifton 85 at fresh forage harvested at 28 and 35 days of regrowth.

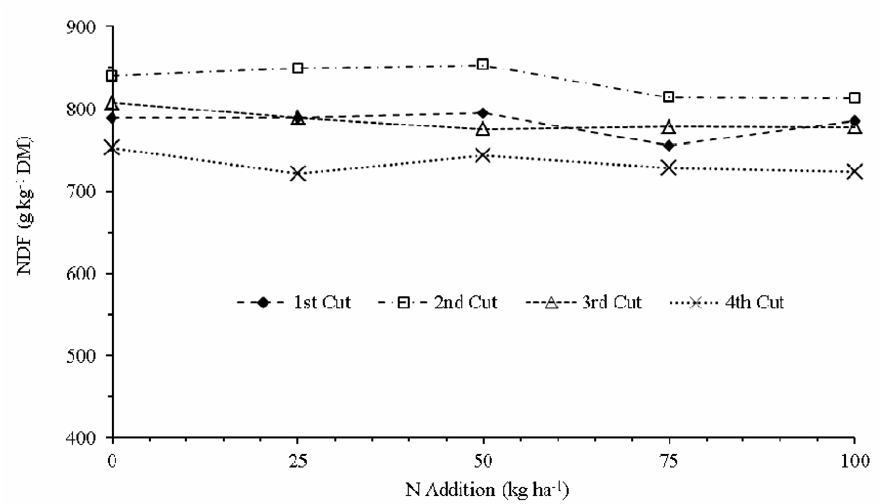
Regrowth age	DM	MM	NDF	ADF	CP	LIG	CEL	HEM	IVDDM
					1st Cut				
28 days	196.7 b	77.8 a	777.2 a	427.6 a	185.4 a	137.2 a	278.3 b	349.5 a	522.6 b
35 days	225.3 a	75.6 a	787.3 a	463.1 a	158.9 b	150.7 a	318.5 a	324.3 a	558.1 a
CV (%)	7.56	10.63	5.50	19.19	15.02	50.83	14.35	27.97	9.36
					2nd Cut				
28 days	216.2 b	74.8 a	827.5 a	493.2 a	140.1 a	147.1 a	352.5 a	334.3 a	480.2 b
35 days	262.9 a	72.8 a	839.9 a	521.0 a	146.4 a	159.3 a	342.9 a	318.8 a	529.2 a
CV (%)	6.36	10.08	5.51	10.47	9.22	31.30	14.45	22.41	19.40
					3rd Cut				
28 days	268.6 a	74.6 a	786.2 a	411.9 a	169.7 a	71.8 a	339.9 a	374.4 a	584.3 a
35 days	248.6 b	78.7 a	785.0 a	406.5 a	159.3 b	75.8 a	337.5 a	378.5 a	594.2 a
CV (%)	4.25	10.42	5.03	13.730	7.60	38.99	12.24	12.61	9.01
					4th Cut				
28 days	234.4 b	74.7 a	757.3 a	457.4 a	208.2 a	61.2 b	382.7 a	300.0 a	582.5 a
35 days	321.8 a	74.7 a	709.8 b	443.1 a	193.2 b	88.8 a	336.8 b	266.8 a	588.5 a
CV (%)	3.63	15.90	5.44	12.73	9.40	34.12	10.11	23.68	8.41

Values followed by the same letter in each column and in each cut do not differ at 5% probability with Tukey's test.

The NDF content (Table 2) varied between 709.9 and 839.9 g kg^{-1} DM in the four cuts and intervals, with no difference between intervals in the 1st, 2nd and 3rd cuts; in the 4th cut, the NDF content was higher ($p < 0.05$) at the 28-d interval (757.3 g kg^{-1} DM) than at the 35-d interval (709.9 g kg^{-1} DM), that is justified by the smaller LSR and greatest content of cellulose and hemicellulose (Table 2). The contents, which were relatively high, exceeded those found by Fontaneli et al. (2004) and are considered high, but were similar to those found by Ribeiro and Pereira (2010) and Quaresma et al. (2011) and lower than that reported by Silva et al. (2007) in Tifton 85 hay. There was no effect of N on the NDF in the four cuts

(Figure 12).The NDF content of forage is what most influences consumption, and values above 600 g kg^{-1} may be negatively associated with forage intake (MERTENS, 1994; REZENDE et al., 2015; VAN SOEST, 1994). Ataíde Júnior (2000) concluded that sheep consumed the maximum amount of Tifton 85 hay at a 38 d regrowth interval, and that thereafter there would be a limitation of consumption caused by the physical limitation of intake.

Figure 12. Effect of nitrogen on the average contents of neutral detergent fiber (NDF) in the dry matter of Tifton 85 in the four cuts.



ADF ranged from 406.5 to 463.1 g kg^{-1} DM, with no difference among intervals or cuts (Table 2). The values were similar to those reported by Quaresma et al. (2011), who did not find differences between four cuts at 30 d intervals and N levels. Fontaneli et al. (2004) found a mean value of 354.0 g kg^{-1} DM from three years of Tifton 85 samples from Rio Grande do Sul, measured with near infrared reflectance spectroscopy. The ADF values of this study were similar to those found by Oliveira et al. (2000) in the stems of Tifton 85 at different regrowth intervals. In the 3rd cut only, there was a quadratic effect of N application on ADF content (Figure 13).

CP content differed between regrowth intervals in the 1st, 3rd, and 4th cuts (Table 2), with a higher content ($p < 0.05$) at the 28-d interval; at the 2nd cut, there was no difference between intervals. The highest CP values (208.2 and 193.2 g kg^{-1} DM for 28 and 35 d, respectively) were recorded from the 4th cut, which also had the lowest NDF values and higher LSR from the 28 d (1.27) and 35 d (1.62) intervals (Table 1). The CP values found in this study were higher than those found in other studies (RIBEIRO; PEREIRA, 2010; NERES et al., 2012; MARCHESAN et al., 2013). Many studies have reported that CP content increased with progressive increases of N application, and this study demonstrated a linear relationship between them in the 2nd, 3rd, and 4th cuts (Figure 14). However, at the 4th cut, CP content was higher, approximately 177.08 g CP kg^{-1} of DM without N to 224,34 g CP kg^{-1} of DM with 100 kg N ha^{-1} (PB = 177,08 + 0,47255*N).

Figure 13. Effect of nitrogen on the average contents of acid detergent fiber (ADF) in the dry matter of Tifton 85 in the four cuts.

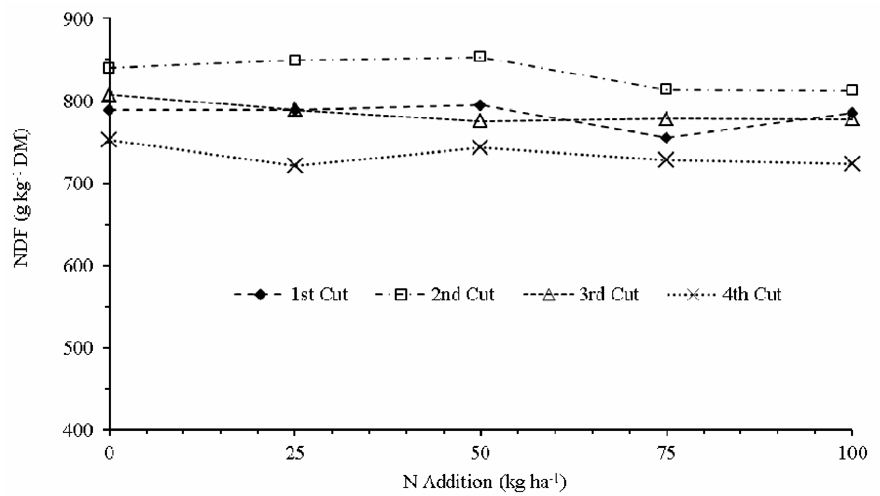
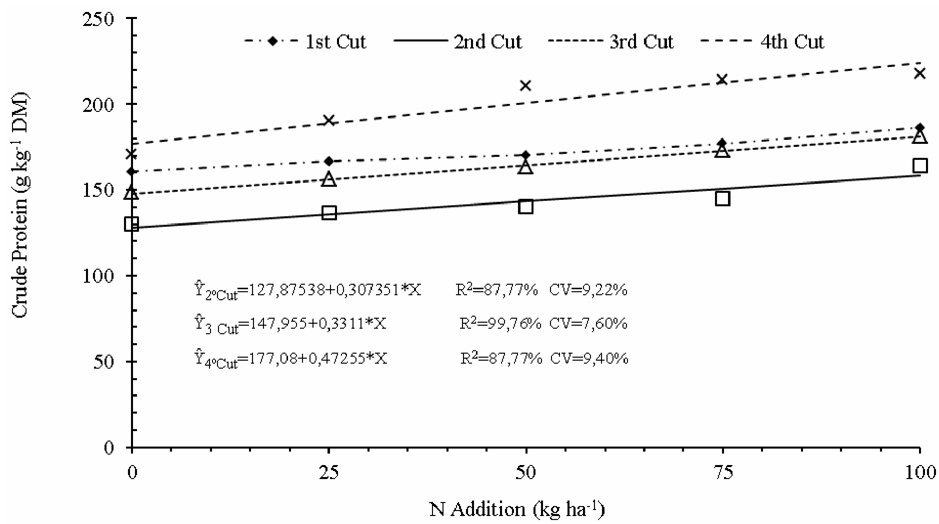


Figure 14. Effect of nitrogen on the contents of CP with regrowth ages of 28 and 35 days in four cuts of Tifton 85.



The diference of the amount of protein produced was of 151.65 kg CP ha^{-1} in the 4th cut (616.05 kg CP ha-1; 100 kg N ha-1) to the 1st cut (464.4 kg CP ha-1; 0 kg N ha-1), equivalent to 344.65 kg of soybean meal with 44% CP. At the 1st, 2nd and 3rd cut the difference was higher because de highest DMY (Table 1, Figure 3). Such an amount reflects a high capacity for one fertilized pasture to support meat or milk production (DIAS et al., 1998). Mazza et al. (2009) found linear increases in yield and CP content with N fertilization in Mombasa pasture grass (*Panicum maximum*) and Alderman et al. (2011) and Quaresma et al. (2011) reported a similar effect in Tifton 85.

LIG content was significantly different (p < 0.05) between the 28 d (61.2 g kg^{-1} DM) and 35 d (88.8 g kg^{-1} DM) intervals at the 4th cut (Table 2). The average contents were high compared to those reported in other studies, especially the 1st and 2nd cuts, although they were within the range of 5 to 25% of the cell wall in grasses reported by Sniffen et al. (1992). Silva and Queiroz (2009) suggested levels between 4 and 12%, with an extreme of 20%. N had no significant difference (p > 0.05) on LIG content among the cuts. LIG content is not measured equally by all methods. Bacha (2006) did not consider the acid detergent LIG, Klason LIG, or the LIG permanganate methods to be accurate. Sample preparation at temperatures higher than 55 °C also changes the apparent lignin content by forming complexes of HEM and LIG (OLIVEIRA, 2006; SILVA; QUEIROZ, 2009). Forage type also influences effective LIG content, as there are different types of LIG with different digestibility. Grasses and legumes with the same LIG content (SILVA; QUEIROZ, 2009) differ so much in digestibility with respect to LIG that accurate predictions are scarcely possible for tropical grasses (DETMANN et al., 2004), and LIG cannot represent the indigestible fraction of the diet (OLIVEIRA JUNIOR et al., 2004). According to Mertens (1994), it is easier to measure DM digestibility than intake; however, intake is more important than digestibility in assessing forage quality, because 60-90% of the differences in nutrient intake are related to ingestion, while 10-40% relate to differences in digestibility.

CEL content (Table 2) was greater ($p < 0.05$) at the 35 and 28-d intervals at the 1st and 4th cuts respectively, with no differences at the 2nd and 3rd cuts. CEL content ranged between 278.3 and 466.7 g kg^{-1} DM, similar to those found by Aguiar et al. (2006). There was no effect ($p > 0.05$) of N application on CEL levels.

There was no significant difference ($p > 0.05$) in HEM content between intervals and cuts (Table 2), nor was there an effect of N. The values ranged from 266.8 to 378.5 g kg^{-1} DM, which are higher than those reported by Aguiar et al. (2006) from other tropical grasses. The degree of bioavailability of CEL and HEM to rumen microorganisms is variable and is linked to the degree of lignification and Maillard reactions (VAN SOEST, 1994), which produce physical and chemical interactions between carbohydrates and phenolic compounds; therefore, it is difficult to establish a standard for comparing digestibility (DETMANN et al., 2008).

IVDDM differed between the 28 and 35 d regrowth intervals in the 1st and 2nd cuts, both of which had higher digestibility at the 35-d interval. In the 1st cut, the high rainfall in the last week before harvest at 35 d enabled the rapid development of young plant tissues (Figure 1). In the 2nd cut, many caterpillars (*Spodoptera frugiperda* JE Smith) partially defoliated plots with the 28-d interval, which is reflected in a significantly higher LSR (1.02 vs. 1.41) at the 35-d interval (Table 2). In the 1st and 2nd cuts, IVDDM was lower than that reported by Corriher et al. (2007) over two years of an experiment, but the 3rd and 4th cuts were similar. The NDF of Tifton 85 has less LIG and polysaccharides linked by ether and ferulic acid, which enhances rumen microbial digestion of this forage (CORRIHER et al., 2007). These authors found seasonal variation of IVDDM in Tifton 85, which might explain the higher digestibility in the 3rd and 4th cuts (Table 2).

According to formula $TDN = 87.84 - 0.70 \times ADF$, proposed by Rodrigues (2009), estimated levels for the 1st, 2nd, 3rd, and 4th cut at the 28-d interval were 57.9%, 53.3%, 59.0%, and 55.8%, respectively, with an average of 56.5%. For cuts at the 35-d interval, estimates were 55.4%, 51.4%, 59.4%, and 57.5%, respectively, with an average of 55.9%. Factors that lower the ADF content, such as N and all conditions that affect the availability and absorption by the forage, as well as the cutting or grazing interval, also change the TDN level in Tifton 85.

Conclusions

The application of 100 kg N ha^{-1} after each cut promoted greater DMY and better forage quality of Tifton 85, with higher LER, canopy height, SL, and LL and dry matter production.

Cutting at 28 d of regrowth (vs. 35 d) provided better bromatological values and qualitative feature in Tifton 85 forage.

DM kg^{-1} N ha^{-1} was highest with 200 kg ha^{-1} N at the 28 d regrowth interval and 100 kg ha^{-1} N at the 35-d interval, when N was applied after each of four cuts.

Regrowth intervals of 28 and 35 d produced forage with similar digestibility.

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