SCAP
SOCIEDADE DE CIÊNCIAS AGRÁRIAS DE PORTUGAL

Structural characteristics and nutritional value of Tifton 85 grass under nitrogen doses at different ages of regrowth in the semiarid

Características estruturais e valor nutricional do capim-Tifton 85 sob doses de nitrogênio em diferentes idades de rebrota no semiárido

Weudes Rodrigues Andrade[1], Eleuza Clarete Junqueira de Sales[1], João Paulo Sampaio Rigueira[1], Virgílio Mesquita Gomes[1], Leidy Darmony Rufino[2], Daniel Ananias de Assis Pires[1], Marielly Maria de Almeida Moura[1], Gabriel Santos Souza David[1], Maria Catiane Araújo Silva[1], Mariana Oliveira de Jesus[1], Alisson Junior Moura Alves Barroso[1], Julieta Maria Alencar Chamone[1] and Flávio Pinto Monção[1,¥,*]

[1] Programa de Pós-graduação em Zootecnia, Universidade Estadual de Montes Claros, Unimontes, Av. Reinaldo Viana, 2630 – Morada do Sol, 39448-581, Janaúba – MG, Brasil
[2] EPAMIG, Norte, Montes Claros, Minas Gerais, Brasil
¥Bolsista de Pós-Doutorado da CAPES e professor colaborador do programa de pós-graduação em Zootecnia da Unimontes
*(*E-mail: moncaomoncao@yahoo.com.br)*
http://dx.doi.org/10.19084/RCA17293

Received/recebido: 2017.11.13
Accepted/aceite: 2018.06.16

ABSTRACT

The objective of this study was to evaluate the structural, productive and nutritional value of Tifton 85 grass fertilized with two nitrogen doses at four regrowth ages. The experimental design was a randomized block in a factorial 4 x 2, with four regrowth ages (28, 35, 42 and 49 days) and two levels of nitrogen (100 and 300 kg ha^{-1}) in six replicates, totaling 48 experimental units, of 25 m^2 (5x5m) each. The blocking criterion was the variation in the experimental area. Dry matter production increased linearly, on average 56.4%, as the regrowth age increased from 28 to 49 days (P<0.01). Among the N rates, there was a 17.2% increase in dry matter yield when fertilized with 300 kg / ha of nitrogen. The height of the plants (P <0.01), as well as the number of live leaves (P <0.01), number of expanded leaves (P <0.01) and the final leaf length (P <0.01) increased linearly with the advancement of cut age. Fertilization of Tifton 85 grass with 100 kg ha^{-1} of N, managed every 35 days improves the dry matter production, structural characteristics and nutritional value of forage for cutting and / or grazing.

Keywords: Fertilization, Cut management, mass production, height, nutritional value

RESUMO

Objetivou-se por meio deste estudo avaliar as características estruturais, produtivas e o valor nutritivo do capim-Tifton 85 adubado com duas doses de nitrogênio em quatro idades de rebrota. Foi utilizado delineamento em blocos casualizados seguindo esquema fatorial 4 x 2, com 4 idades de rebrota (28, 35, 42 e 49 dias) e duas doses de nitrogênio (100 e 300 kg ha^{-1}) com seis repetições, totalizando 48 unidades experimentais de 25 m^2 (5x5m) cada. O critério de blocagem foi à variação na área experimental. A produção de matéria seca incrementou linearmente, em média 56.4%, à medida que avançou a idade de rebrota de 28 para 49 dias (P<0,01). Entre as doses de N, houve aumento de 17.2% na produção de matéria seca quando adubado com 300 kg ha^{-1} de nitrogênio. A altura das plantas (P<0,01), assim como o número de folhas vivas (P<0,01), número de folhas expandidas (P<0,01) e o comprimento final da folha (P<0,01) aumentaram linearmente com o avanço da idade corte. A adubação do capim Tifton 85 com 100 kg ha^{-1} de N, manejado a cada 35 dias melhora a produção de matéria seca, características estruturais e valor nutricional da forragem para corte e/ou pastejo.

Palavras-chave: Adubação, manejo de corte, produção de massa, altura, valor nutricional

INTRODUCTION

Beef cattle production in Brazil is highly dependent on forage-based grazing systems. Therefore, strategically well-planned grazing systems are critical to optimize beef production (Barbero *et al.*, 2015). Therefore, the search for forages with high production potential is of fundamental importance in the optimization of the production system. Grasses of the *Cynodon* genus have been noted for their high mass production, especially in tropical regions (Monção *et al.*, 2016; Paris *et al.*, 2016).

However, in regions with semi-arid climate, studies with *Cynodon* are still incipient, especially when it comes to cutting management. In the semi-arid region of northern Minas Gerais, Brazil, forage production has fluctuated considerably in the last five years due to low rainfall and long dry periods. Consequently, the productive potential of forages such as *Cynodon* has not been reached, which has altered the pasture stocking rate. In this sense, the use of forage adduction strategies in these regions has been an alternative to maximize forage production (Sales *et al.*, 2014; Machado *et al.*, 2017). However, gaps still exist regarding the association of nitrogen fertilization (N) and cutting management on the structural characteristics, forage production and nutritional value.

According with Machado *et al* (2017), among these factors, soil fertility can be manipulated through pasture fertilization. N fertilization is the most striking in terms of gains in forage production (Sales *et al.*, 2014; Coblentz *et al.*, 2017). Its application is of fundamental importance for the maintenance of productivity and sustainability of the pasture, being its deficiency considered an important factor to trigger the process of degradation (Sales *et al.*, 2014; Machado *et al.*, 2017). The main function of this nutrient is to be the constituent of proteins, besides interfering directly in the photosynthetic process (Gastal and Lemaire, 2002). Furthermore, the soil must be corrected for pH and supplied with phosphorus (P), potassium and other macro and micronutrients for the N to maximize forage production in intensive production systems (Hajighasem *et al.*, 2016).

Based on the above, the objective of this study was to evaluate the structural, productive and nutritional value of Tifton 85 grass fertilized with two nitrogen doses at four regrowth ages.

MATERIAL AND METHODS

The experiment was conducted at the Experimental Farm of the State University of Montes Claros – UNIMONTES, in the municipality of Janaúba, Minas Gerais, Brazil, during the period from 10/29/2015 to 05/12/2016.

The municipality of Janaúba is located in the northern region of Minas Gerais, at 15º 47' south latitude, 43º 18' west longitude and 516 m altitude. The climate of the region, according to the classification of Köppen (1948), is Aw type with summer rains and dry periods well defined in winter (Antunes, 1994). The average annual rainfall is 876 mm, with an annual average temperature of 24°C. The climate is tropical mesothermal, almost megathermic, due to altitude, subhumid and semi-arid, with irregular rains, causing long periods of drought (Figure 1).

The experiment was carried out in a flat area with Tifton 85 grass (*Cynodon dactylon* cv. Tifton 85), already established since 2007, on dystrophic red-yellow soil with clay texture with the following chemical characteristics: pH in water, 6.0, P (Mehlich): 6.0 mg.dm^{-3}; K (Mehlich): 68 mg.dm^{-3}; Ca^{2+} (KCl 1 mol L $^{-1}$): 3.7 cmolc.dm^{-3}; Mg^{2+} (KCl 1 mol L^{-1}): 1.0 cmolc.dm^{-3}; Al^{3+} (KCl 1 mol L^{-1}) 0.1 cmolc.dm^{-3} H + Al (calcium acetate 0.5 mol L^{-1}):

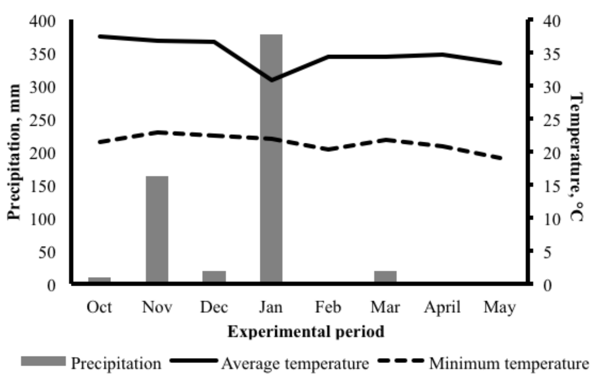

Figura 1 - Meteorological data of the experimental period. Source: INMET (2017) - CSC – BNMEP – Meteorological Database for Teaching and Research.

2.6 cmolc.dm^{-3} base sum: 4.9 cmolc.dm^{-3}; cation exchange capacity: 7.4 cmolc.dm^{-3} V: 65%.

The experimental design was a randomized block in a factorial 4 x 2, with four regrowth ages (28, 35, 42 and 49 days) and two levels of nitrogen (100 to 300 kg ha^{-1}) in six replicates, totaling 48 experimental units, of 25 m^2 (5 x 5m) each. The blocking criterion was the variation in the experimental area. At regrowth ages (28, 35, 42 and 49 days), the mean heights were 21, 22, 28 and 30 cm, respectively. The regrowth ages were chosen because of the high growth of grass *Cynodon*, which reach physiological maturity early, as shown in previous researches of Monção *et al.* (2014) and Oliveira *et al.* (2016).

On October 29, 2015, a standardization cut was carried out on Tifton 85 grass close to the soil, using costal brush cutters. Then, the plots were fertilized with 100 kg of P_2O_5 and 100 kg of K_2O in the single superphosphate and potassium chloride forms, respectively. Nitrogen fertilization was done in split-plot three times after the cut of uniformity and in the two subsequent cuts. Urea (45% N) was used as the source of N and the doses tested were calculated equivalent to the area of each plot. During the experimental period the Tifton 85 grass was irrigated once a week as recommended by Mota *et al.* (2010). The irrigation remained during the whole experimental period, being activated in the absence of rain.

The mean height of the tifton 85 grass was obtained by measuring the base of the plant up to the curvature of the last newly expanded leaf, measuring 10 points per plot before each cut.

The forage plant was collected in two points per plot with the aid of a metal frame (0.25 m^2), and cut with a knife, at a height of 5 cm from the soil surface. The collected material was packed in a plastic bag, identified and sent to the laboratory, where it was weighed to determine the green mass per plot, after which a sample of approximately 400 grams was taken, then the material was placed in a forced air ventilation oven, with temperature of 55º for 72 hours to determine the partial dry matter. After drying the samples were milled in Willey type mills in 1 and 2 mm sieve, and stored in pots with lid properly identified.

The dry mass production per hectare (MDP) was determined by weighing all material harvested in a metal frame of (0.25m^2) and corrected for the dry matter content obtained after the samples were processed.

The total number of tillers was obtained by counting all the tills present in the metal frame of (0.25 m^2). From these tillers 10 units were separated per plot to determine the structural characteristics. To determine the final length of the blade, the completely expanded leaves were measured, from their insertion in the ligule to the leaf apex. The number of live leaves was determined as the fraction of total leaves that had no senescence signal, and the final stem length calculated based on the soil level up to the last expanded leaflet of each tiller.

Part of the collected tillers were separated on a blade, stem + hem and whole plant, later packed in a paper bag, weighed and fed to the forced circulation oven at 55ºC for 72 hours to evaluate the dry mass content for determination of the blade: stem ratio.

A sample of hay was removed from each cut at the different cutting ages, homogenized, milled in a Willey mill, using a 1 and 2 mm sieve and packed in polyethylene bottles, fitted with lids and previously identified. The hay was analyzed for dry matter (DM, method 934.01), crude protein (CP, method 978.04) and ashes (method 942.05) according to AOAC (1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose were determined according to the procedures described by Robertson and Van Soest (1981). The cellulose was solubilized in 72% sulfuric acid and the lignin content was obtained by difference (Goering and Van Soest 1970).

The obtained data were submitted to the analysis of variance using PROC MIXED of SAS (SAS Institute Inc., Cary, NC). When the "F" test was significant for the treatments, the regrowth ages were analyzed by means of orthogonal contrasts. As ages are not equidistant, the SAS PROC IML was used to estimate the Linear, Quadratic and Cubic order matrix. Nitrogen doses were analyzed by the T test. For all the tests the probability of 5% was used.

RESULTS AND DISCUSSION

There was interaction between doses of N x age of regrowth only for the final length of the stem (P = 0.02), being the highest average verified at age 49 days and at the dose of 300 kg ha^{-1} of N. The dry matter production (DMP) linearly increased, on average 56.4%, as the regrowth age increased from 28 to 49 days (P <0.01). Among N rates, there was a 17.2% increase in DMP of Tifton 85 grass when fertilized with 300 kg / ha of N in relation to the dose of 100 kg ha^{-1} (average of 3.835 kg dry matter [DM] ha^{-1}; Table 1).

The height of the plants (P <0.01), as well as the number of live leaves (P <0.01), number of expanded leaves (P <0.01) and the final leaf length (P <0.01) increased linearly with the advancement of cut age. The increase of 36.3% in the height of the plant is justified mainly by the limitation of the photosynthetic rate, in smaller height, resulting from the competition between the plants. In this way, the plant lengthens the stem, as verified in this study, as a strategy to expose the leaf blade to sunlight to capture solar energy. The growth speed of the stem and, consequently, of the height of the plant was increased by 23.5% with the presence of N in the dose of 300 kg ha^{-1} in relation to the lower dose. With this, the number of live leaves was increased by 34.3% and expanded by 20.4% with the advancement of plant age. As the plant grows and reaches physiological maturity, changes in the cellular content and cell wall ratio occur as a strategy for plant survival and propagation (Monção *et al.,* 2016). The increase in height is a reflection of the increase of cell wall components in detriment of the dilution of the constituents of the cellular content. In addition, the speed with which these changes occur is dependent on several factors, being this, mainly, and the N content in the soil. This is because the N stimulates the cell division causing the plant to reach the growth potential, consequently, increases in dry mass production as verified in this research.

Contrary behavior was verified on the number of tillers (P = 0.03) and leaf: stem ratio (P <0.01) that reduced linearly with the advancement of regrowth age. With the expansion of tiller growth, shading occurs in the basal area of the plant, which implies a reduction in the appearance of new tillers. Therefore, there was a decrease of 11.5% in the number of tillers. The variations in N rates did not change the number of tillers (P = 0.16), with a mean of 723 tillers / m². With the increase in plant height due to the age of regrowth, the proportion of stalk increases in relation to leaf blade, which, consequently, reduces the blade: stem ratio. In this study, this reduction was 36.5% when the regrowth age increased from 28 days to 49 days. Some studies (Monção *et al.,* 2016; Oliveira *et al.,* 2016) reported that the management of grasses of the genus *Cynodon* present a reasonable nutritional value when management blade: stem ratio of 1. This value in this research was verified when the plants were managed at 35 days of regrowth or 23.7 cm of average height. The application of N did not modify the blade: stem ratio of Tifton 85 grass (P = 0.41). Nutritionally, the management of Tifton 85 grass at ages greater than 42 days of regrowth

Table 1 - Structural and productive characteristics of Tifton 85 grass fertilized with nitrogen and managed at four regrowth ages

Item (% DM)	Dose N 100 (kg.ha^{-1})				Dose N 300 (kg.ha^{-1})				SEM	P-value				
	Age of regrowth (days)				Age of regrowth (days)									
	28	35	42	49	28	35	42	49		Age L	Age Q	Age C	Dose N	I x D
DMP, t.ha^{-1}	3147	3526	3886	4781	3491	3964	4929	5600	310	<0.01	0.36	0.89	<0.01	0.54
Height (cm)	20.5	22.7	24.7	27.4	22.8	24.7	32.4	31.6	1.6	<0.01	0.48	<0.01	<0.01	0.23
Number of Tillers (nº/m²)	747	725	657	666	777	792	721	701	46.8	0.03	0.97	0.43	0.16	0.97
Number of live leaves (nº/perf)	4.20	4.81	5.55	5.78	4.87	5.23	6.46	6.40	0.28	<0.01	0.32	0.13	0.00	0.86
Expanded sheets	1.49	1.86	1.89	1.82	1.59	1.94	1.79	1.89	0.08	<0.01	0.00	0.05	0.47	0.56
Final length of the stem (cm)	11.1d	10.4d	15.0c	16.8c	12.9d	18.7c	28.1b	31.1a	2.51	<0.01	0.97	0.18	<0.01	0.02
Final leaf length (cm)	10.69	10.14	10.90	16.33	11.21	13.57	17.14	20.96	1.52	<0.01	0.09	0.80	0.00	0.30
Leaf:stem ratio	1.25	1.08	0.84	0.94	1.22	1.06	0.77	0.87	0.08	<0.01	0.02	0.07	0.41	0.98

DMP – Dry matter production; SEM – Standard error mean; N- Nitrogen; DM – Dry matter; L – Linear; Q – Quadratic; C – Cubic; I x D- Interaction; P - probability is not interesting, because the stem ratio is higher than leaf blade as observed in the blade: stem ratio and for ruminants, the highest amount of nutrients comes from leaves in relation to the stem.

On the nutritional parameters, Table 2, with the exception of CP content (P <0.01), neutral detergent insoluble nitrogen (P = 0.01), there was no interaction between ages x N regrowth doses (P = 0.81). The DM content, neutral detergent fiber corrected for ash and protein, acid detergent fiber (ADF), hemicellulose, cellulose and lignin did not differ (P> 0.05) due to the regrowth age and not a function of N levels, with an average of 33.2, 75.3, 35.2, 42.3, 29.8 and 5.4%, respectively.

For the ash content (P = 0.19) and organic matter (P = 0.16) there was no effect of the N doses, with the averages of 8.6% and 91.4%, respectively. However, the means of these two variables adjusted to the quadratic regression model as a function of the increase of the regrowth ages. Several studies (Bassegio *et al.,* 2013, Monção *et al.,* 2016; Benjamin and Bradford, 2017) with forage plants have verified effects of cutting age on structural and nutritional characteristics. These changes reported by the same authors have been justified by the change in the proportion of cellular components that occur as a function of the physiological maturity of the plant. In this study, the interval between cuts associated to the soil and climatic characteristics of the northern semiarid region may have influenced the non-alteration of most components related to nutritional value. Monção *et al.* (2016) verified the effect of regrowth age on grasses of the genus *Cynodon* at ages up to 79 days. Wilson (1993, 1997) also reported that thickening of the secondary cell wall with maturation of plant tissues (increased cut age) increases the concentration of neutral detergent fiber, ADF and lignin at the expense of cellular content, a fact not verified in this search.

The N is well known for accelerating the growth of the forage so that it reaches in less time the maturity, which consequently changes the proportion of the cel constituents (Velásquez *et al.,* 2010; Coblentz *et al.,* 2017). However, in this study, the shortest interval was not enough to allow modification in some nutritional parameters as a function of nitrogen fertilization. However, the content of CP 13.1% when handled at 28 days and fertilized with 300 kg ha^{-1} of N in relation to the dose of 100 kg ha^{-1} (P <0.01). At the ages of 35 and 42 days there was no difference between the N doses on the CP content, the average being 15.2%. At age 49 days, CP content was 24.7% higher when fertilized with 100 kg ha^{-1} of N than the 300 kg ha^{-1} dose (9.8%). This difference is a strong indicative of losses of N applied, mainly having urea as source. The highest concentration of nitrogen neutral detergent insoluble nitrogen was verified at a dose of 300 kg ha^{-1}, when the grass was managed at the age of 35 and 42 days. This means that 6.5% CP is associated with the cell wall of the plant with slow ruminal degradation. Velasquez *et al.* (2010) observed in several tropical forages such as Tifton 85 grass that the fraction A of CP, variable not quantified in this study, reduces with

Table 2 - Nutritional value of Tifton 85 grass fertilized with nitrogen and managed at 4 regrowth ages

Item (% DM)	Dose N 100 (kg.ha^{-1})				Dose N 300 (kg.ha^{-1})				SEM	P-value				
	Age of regrowth (days)				Age of regrowth (days)									
	28	35	42	49	28	35	42	49		Age L	Age Q	Age C	Dose N	I x D
Dry matter	32.40	34.34	32.80	36.81	32.91	31.03	32.04	33.14	1.75	0.23	0.32	0.58	0.15	0.58
Ashes	8.80	8.09	8.66	7.94	8.58	9.09	9.81	7.56	0.41	0.10	0.02	0.03	0.19	0.15
Organic matter	91.20	91.91	91.34	92.06	91.32	90.91	90.19	92.44	0.41	0.08	0.03	0.03	0.16	0.17
Crude protein	14.45b	15.35b	15.04b	12.20b	16.35a	15.54b	15.06b	9.78c	0.54	<0.01	<0.01	0.07	0.84	<0.01
IPND	0.84b	0.90b	0.88b	0.62c	0.66c	1.05a	1.05a	0.63c	0.06	0.03	<0.01	0.60	0.34	0.01
Neutral detergent fiber	76.63	77.94	77.07	79.35	76.28	76.18	78.46	78.40	1.02	0.02	0.73	0.92	0.57	0.48
Neutral detergent fiber cp	74.60	76.12	74.69	77.28	74.62	73.64	74.95	76.64	1.13	0.06	0.25	0.48	0.38	0.62
Acid detergent fiber	33.72	36.24	34.66	35.20	34.11	35.85	35.36	36.54	0.90	0.10	0.33	0.09	0.43	0.81
Hemicelullose	42.90	41.70	42.41	44.16	42.16	40.34	43.10	41.86	1.39	0.48	0.38	0.29	0.35	0.75
Celullose	29.04	30.31	28.73	29.37	28.96	30.57	30.84	30.63	1.15	0.52	0.46	0.42	0.28	0.77
Lignin	4.68	5.93	5.93	5.83	5.16	5.28	4.52	5.91	0.44	0.09	0.95	0.14	0.23	0.17

SEM – Standard error mean; N- Nitrogen; DM – Dry matter; IPND - Insoluble protein in neutral detergent; L – Linear; Q – Quadratic; C – Cubic; I x D- Interaction; P - probability the increase of regrowth age, which means lower isoacid supply required by rumen microorganisms (Russell *et al.,* 1992).

However, with nitrogen fertilization, the fraction A content increases as verified in the study of Neumann *et al.* (2017) with tropical forages. In ruminant nutrition, Detmann *et al.* (2014) verified that the minimum CP of the diet should be 8% of the dry matter, implying that Tifton 85 grass fertilized with N, independent of dose 100 or 300 kg ha^{-1}, and handled up to 49 days meets those requirements. However, it is interesting to adjust the energy levels to maximize the ruminal synthesis of microbial protein.

In the semiarid conditions of northern Minas Gerais state, a peculiarity of ruminant production systems has as main impasse the quantitative limitation of forage, especially in the dry season, which makes explicit the importance of cutting management. Tifton 85 grass management every 35 days seems to positively associate DMP and the best forage nutritional value.

CONCLUSIONS

Fertilization of Tifton 85 grass with 100 kg / ha of N, managed every 35 days improves the dry matter production, structural characteristics and nutritional value of forage for cutting and / or grazing.

ACKNOWLEDGEMENTS

To Foundation for Research Support of the State of Minas Gerais (FAPEMIG), the National council for scientific and technological development (CNPq) and the Coordination for the Improvement of higher education personnel (CAPES) for granting scholarships and financial support in research projects.

REFERENCES

Antunes, F. Z. (1994) – Caracterização climática. *Informe Agropecuário*, vol. 17, n. 68, p. 15-19.

AOAC (1995) – *Official methods of analysis*. 16th.ed. Association of Official Analytical Chemists,Washington, DC.

Barbero, R.P.; Malheiros, E.B.; Araújo, T.L.R.; Nave, R.L.G.; Mulliniks, J.T.; Berchielli, T.T.; Ruggieri, A.C. & Reis, R.A. (2015) – Combining Marandu grass grazing height andsupplementation level to optimize growth and productivityof yearling bulls. *Animal Feed Science and Technology*, vol. 209, p. 110-118. https://doi.org/10.1016/j.anifeedsci.2015.09.010

Bassegio, D.; Santos, R.F.; Oliveira, E.; Wernecke, I.; Secco, D. & Souza, S.N.M. (2013) – Effect of nitrogen fertilization and cutting age on yield of tropical forage plants. *African Journal of Agricultural Research*, vol. 8, n. 16, p. 1427-1432. https://doi.org/10.5897/AJAR2013.7060

Benjamin, S.A. & Bradford, B.J. (2017) – Effect of Seed Variety and Cutting Age on Dry Matter Yield, Nutritive Values and In Vitro Digestibility of Teff Grass. *Advances in Crop Science and Technology*, vol.5, n. 3, p. 1-6. https://doi.org/10.4172/2329-8863.1000281

Coblentz, W.K.; Akins, M.S.; Cavadini, J.S. & Jokela, W.E. (2017) – Net effects of nitrogen fertilization on the nutritive value and digestibility of oat forages. *Journal of Dairy Science*, vol. 100, n. 3, p. 1739-1750. https://doi.org/10.3168/jds.2016-12027

Detmann, E.; Valente, E.E.L.; Batista, E.D. & Huhtanen, P. (2014) – An evaluation of the performance and efficiency of nitrogen utilization in cattle fed tropical grass pastures with supplementation. *Livestock Science*, vol. 162, p. 141-153. https://doi.org/10.1016/j.livsci.2014.01.029

Gastal, F. & Lemaire, G. (2002) – N uptake and distribution in crops: an agronomical and ecophysiological perspective. *Journal of Experimental Botany*, vol. 53, n. 370, p. 789-799. https://doi.org/10.1093/jexbot/53.370.789

Goering, H.K. & Van Soest., P.J. (1970) – *Forage fiber analysis (Apparatus, reagents, procedures and some applications)*. Washington, DC: USDA.

Hajighasemi, S.; Keshavarz-Afshar, R. & Chaichi, M.R. (2016) – Nitrogen fertilizer and seeding rate influence on grain and forage yield of dual-purpose barley. *Agronomy Journal*, vol. 108, n. 4, p. 1486-1494. https://doi.org/10.2134/agronj2015.0447

INMET (2017) – *Instituto Nacional de Meteorologia*. [cit. 2017.05] http://www.inmet.gov.br/portal/

Köppen, W. (1948) – *Climatologia*: *con un estudio de los climas de la tierra*. Fondo de Cultura Econômica. México. 479p.

Machado, S.L.M.; Sales, E.C.J.; Reis, S.T.; Mesquita, V.G.; Carvalho, Z.G.; Monção, F.M.; Gomes, E.A.S.; Queiroz, D.S. & Lima, A.C.R. (2017) – Forage accumulation, tillering and bromatological characteristics of Brachiaria grass under nitrogen fertilization. *Científica*, vol. 45, n. 2, p. 197-203. http://dx.doi.org/10.15361/1984-5529.2017v45n2p197-203

Monção, F.P.; Oliveira, E.R.; Gabriel, A.M.A.; Nascimento, F.A.; Pedroso, F.W. & Freitas, L.L. (2016) – Nutritional parameters of leaf blade from different tropical forages. *Scientia Agraria*, vol. 15, n. 2, p. 185-193. http://dx.doi.org/10.18188/1983-1471/sap.v15n2p185-193

Mota, V.J.G.; Reis, S.T.; Sales, E.C.J.; Rocha Júnior, V.R.; Oliveira, F.G.; Walker, S.F., & Cóser, A.C. (2010) – Lâminas de irrigação e doses de nitrogênio em pastagem de capim-elefante no período seco do ano no norte de Minas Gerais. *Revista Brasileira de Zootecnia*, vol. 39, n. 6, p. 1191-1199. http://dx.doi.org/10.1590/S1516-35982010000600005

Neumann, M.; Nörnberg, J.L.; Leão, G.F.M.; Horst, E.H. & Figueira, D.N. (2017) – Chemical fractionation of carbohydrate and protein composition of corn silages fertilized with increasing doses of nitrogen. *Ciência Rural*, vol. 47, n. 5, art. e20160270. http://dx.doi.org/10.1590/0103-8478cr20160270

Oliveira, E.R.; Monção, F.P.; Gabriel, A.M.A.; Silva, L.H.X.; Carbonari, V.M.S.; Pedroso, F.W.; Pereira, T.L. & Nascimento, F.A. (2016) – Nutritional value of stem of tropical grass. *Scientia Agraria*, vol. 15, n. 3, p. 256-264. http://dx.doi.org/10.18188/1983-1471/sap.v15n3p256-264

Paris, W.; Tonion, R.; Martinello, C.; Sartor, L.R.; Paula, F.M.L. & Oliveira, J.G. (2016) – Productivity and nutritional value of African Star managed with different leaf blade mass. *Acta Scientiarium. Animal Science*, vol. 38, n. 1, p. 31-36. http://dx.doi.org/10.4025/actascianimsci.v38i1.28549

Robertson, J.B. & Van Soest, P.J. (1981) – The detergent system of analysis and its application to human foods. In: James, W.P.T. & Theander, O. (Eds.) – *The analysis of dietary fiber in food*. New York: Marcel Dekker, p. 123-158.

Russell, J.B.; O'Connor, J.D.; Fox, D.G.; Van Soest, P.J. & Sniffen, C.J. (1992) – A net carbohydrate and protein system for evaluating cattle diets: I. Ruminal fermentation. *Journal of Animal Science*, vol. 70, n. 11, p. 3551-3561.

Sales, E.C.J.; Reis, S.T.; Rocha Júnior, V.R.; Monção, F.P.; Matos, V.M.; Pereira, D.A.; Aguiar, A.C.R. & Antunes, A.P.S. (2014) – Morphogenic and structural traits of *Brachiaria brizantha* cv. Marandu under different nitrogen levels and residues heights. *Semina: Ciências Agrárias*, vol. 35, n. 5, p. 2673-2684. http://dx.doi.org/10.5433/1679-0359.2014v35n5p2673

Velásquez, P.A.T.; Berchielli, T.T.; Reis, R.A.; Rivera, A.R.; Dian, P.H.M. & Teixeira, I.A.M.A. (2010) – Chemical composition, fractionation of carbohydrates and crude protein and in vitro digestibility on tropical forages in the different cutting ages. *Revista Brasileira de Zootecnia*, vol. 39, n. 6, p. 1206-1213. http://dx.doi.org/10.1590/S1516-35982010000600007

Wilson, J.R. (1993) – Organization of forage plant tissues. *In*: Jung, H.G.; Buxton, D.R.; Hatfield, R.D. *et al*. (Eds.) – *Forage cell wall structure and digestibility*. Madison: American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, p. 1-32.

Wilson, J.R. (1997) – Structural and anatomical traits of forage influencing their nutritive value for ruminants. *In: SIMPÓSIO INTERNACIONAL SOBRE PRODUÇÃO ANIMAL EM PASTEJO*, 1997, Viçosa, MG. Anais... Viçosa, MG: Universidade Federal de Viçosa, p. 173-208.