PRODUCTION AND TILLERING OF MOMBAÇA GRASS WITH DIFFERENT SOURCES AND LEVELS OF APPLIED NITROGEN

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ABSTRACT

Nitrogen influences numerous physiological and morphological traits of forage grasses, which ultimately interfere directly with production and forage quality. Aimed to study was to evaluate the production of dry matter and the number of tillers of *Panicum maximum* cv. Mombaça grown with different sources and levels of applied nitrogen. The experiment was conducted at the Federal Institute of the Espírito Santo, Campus of Santa Teresa. The experimental design consisted of a randomised block design with three replicates in a 3 x 6 factorial design and three nitrogenous fertilizers (urea, ammonium sulphate and calcium nitrate), which were applied at six different levels (0, 120, 240, 360, 480 and 600 kg ha^{-1}) during the experimental period, for a total of 54 experimental units. Nitrogen levels were divided into seven applications, and the treatments were applied every 28 days, always after the forage was cut. The results show that Mombaça grass is responsive to nitrogen fertilization, and the response in terms of dry matter production and number of tillers for the same level of nitrogen varies depending on the nitrogen source used. Of the nitrogen sources, calcium nitrate had the best performance for the variables evaluated here. For this nitrogen source, the production of dry matter achieved at the maximum level of nitrogen was 18% and 36% higher than the dry matter achieved with the use of ammonium sulphate and urea, respectively.

Keywords: dry matter, fertilizers, *Panicum maximum*

RESUMO

PRODUÇÃO E PERFILHAMENTO DO CAPIM-MOMBAÇA SUBMETIDO A FONTES E DOSES DE NITROGÊNIO

O nitrogênio influencia inúmeras características morfofisiológicas das gramíneas forrageiras, que em última análise, interferem diretamente na produção e na qualidade da forragem. Objetivou-se no presente trabalho avaliar a produção de matéria seca e número de perfilhos do *Panicum maximum* cv. Mombaça, submetido a diferentes fontes e doses de nitrogênio. O experimento foi desenvolvido no Instituto Federal do Espírito Santo, Campus Santa Teresa. O delineamento experimental utilizado foi em blocos casualizados, com três repetições, em esquema fatorial 3 x 6, sendo três fertilizantes nitrogenados (ureia, sulfato de amônio e nitrato de cálcio) e seis doses de nitrogênio (0, 120, 240, 360, 480 e 600 kg ha^{-1}), aplicados durante o período experimental, totalizando 54 unidades experimentais. As doses de nitrogênio foram divididas em sete aplicações, sendo os tratamentos aplicados a cada 28 dias, sempre após o corte da forrageira. Os resultados apresentados mostram que o capim-mombaça é responsivo à adubação nitrogenada e sua resposta em produção de matéria seca e número de perfilhos para uma mesma dose de nitrogênio varia em função da fonte utilizada. Dentre as fontes de nitrogênio, o nitrato de cálcio apresentou desempenho superior para as variáveis avaliadas. Para essa fonte, a produção de matéria seca obtida na dose máxima de nitrogênio foi 18% e 36% superior a aquela observada com o uso do sulfato de amônio e ureia respectivamente.

Palavras-chave: matéria seca, adubação, *Panicum maximum*

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INTRODUCTION

Pastures are considered the most practical and economical way to feed cattle and play a key role in meat- and milk-production systems (VITOR *et al*., 2009). Approximately 90% of Brazilian cattle herds are grazed on pasture in extensive production systems (ANUALPEC, 2015).

To achieve high forage productivity, we should consider that forage grasses are just as demanding as many traditional cultivars. Therefore, for intensive exploitation, remediation and soil fertilization are among the factors that determine the level of production of pastures.

Pastures fall short of their potential productivity due to low levels of adopted remediation technologies (TEIXEIRA & HESPANHOL, 2014). Numerous factors contribute to these outcomes, but those factors related to soil fertility management should be noted.

Nitrogen (N) deficiency is one of the most limiting factors for achieving high productivity in forage-production systems. This nutrient is essential and can increase pasture productivity, which is reflected in more nutritious fertilizers, increased stocking rates of pastures and increased live weight gains (BARBERO *et al*., 2009).

According to Fagundes *et al*. (2005), the supply of N normally does not meet the demand of grasses, and their productivity is limited by the levels of this nutrient in the soil. Thus, providing an adequate supply of N in balanced proportions is critical in the pasture-production process (COSTA *et al*., 2009).

The supply of N is known to increase pasture productivity. However, this response varies among forage species. Pastures of *Panicum maximum* normally have a good response to N, a nutrient that has an important influence on the physiology and potential productivity of forage grasses (BRAGA *et al*., 2009). According to Jank *et al*. (1994), when supplied with high levels of N in balance with other nutrients in the soil, *Panicum maximum* yields can reach up to 41 tons ha^{-1} year^{-1} of dry matter.

Thus, the aim of the present study was to evaluate the effects of different sources and levels of N applications on the production of Mombaça grass *(Panicum maximum* Jacq.) during the rainy season in the municipality of Santa Teresa, State of Espírito Santo (ES), Brazil.

MATERIAL AND METHODS

The experiment was performed at the Midsize Animal Division of the Federal Institute of Espírito Santo (IFES), *campus* of Santa Teresa, which is located between 19º48'36'' south latitude and 40º40'48'' west longitude relative to the Greenwich meridian in the municipality of Santa Teresa, ES, and has an average altitude of 150 m. The regional climate is temperate humid with dry winters and hot summers; the climate is Cwa according to the Koppen classification.

The pasture area used was 1,200 m^2, divided into 6 m^2 plots, totalling 324 m^2 of area utilised. The Mombaça grass *(Panicum maximum* Jacq.) pasture had been established for over four years with high production and soil fertility management techniques performed as recommended by Prezotti *et al*. (2007) for irrigated pastures with high nutritional requirements.

The soil was classified as a eutrophic yellow Latosol (LA) and was clayey (EMBRAPA, 1999), with 343, 170 and 487 g kg^{-1} of sand, silt and clay, respectively. Four months prior to the start of the experiment, a chemical analysis of the soil was performed. Based on these results, liming was performed 110 days before the start of the experiment with the application of 1,000 kg ha^{-1} of dolomitic limestone. Fertilization (except the N supply) was performed 90 days after liming as recommended by the Liming and Fertilization Recommendation Manual for the state of Espírito Santo (PREZOTTI *et al*., 2007), considering the Mombaça grass cultivar *(Panicum maximum* Jacq.). Fertilizer was applied in the experimental area using the broadcasting method, using 463 kg ha^{-1} of triple superphosphate (41% of P_2O_5), 434 kg ha^{-1} of potassium chloride (60% of K_2O) and 60 kg ha^{-1} of FTE BR 10® (7.0% of Zn, 4.0% of Fe, 4.0% of Mn, 2.5% of B, 1.0% of Cu, 0.1% of Mo and 0.1% of Co). Immediately prior to the start of the experiment, a new soil sampling was performed in the experimental area at depths of 0.0 - 0.2 and 0.2 - 0.4 m (Table 1).

The experimental design consisted of randomised blocks. A 3 x 6 factorial design was used, consisting of three nitrogenous fertilizers

Table 1. Chemical characterisation of the soil in the experimental area at depths of 0 - 20 and 20 - 40 cm before and after soil liming and fertilization.

Depth	pH[1]	Ca	Mg	Al	H+Al	CEC	SB	P	K	$S\text{-}SO_4^{2-}$	OM	V
Before soil liming and fertilization												
(m)		------------------ $cmol_c\ dm^{-3}$------------------						-------- $mg\ dm^{-3}$ --------			-----%-----	
0.0 - 0.2	5.0	1.7	0.6	0.3	3.1	5.5	2.4	11	30	6.2	2.6	43
0.2 - 0.4	5.4	1.9	0.6	0.1	2.8	5.4	2.6	3.4	22	5.5	2.2	48
After soil liming and fertilization												
0.0 - 0.2	5.6	3.2	1.1	0.0	1.2	5.9	4.7	32	155	10	2.5	80
0.2 - 0.4	5.3	2.1	0.9	0.1	2.5	5.6	3.2	0.3	14	4.4	1.6	56

[1] pH in H_2O 1:2.5; P and K - Mehlich extraction; Ca, Mg and Al - KCl extraction; H + Al - calcium acetate extraction; CEC - cation exchange capacity, pH 7.0; SB - sum of bases; $S\text{-}SO_4^{2-}$ barium chloride extraction; OM - organic matter; V - percentage of base saturation.

(urea, ammonium sulphate and calcium nitrate) and six levels of N (0, 120, 240, 360, 480 and 600 kg ha^{-1}), which were divided and applied in the seven applications throughout the experimental period. In total, three replicates were used, totalling 54 experimental units.

The 3 x 2 m plots were demarcated. Uniform cuts were then performed across the entire area with the aid of a rotary mower, and the treatments were applied soon afterward. The treatments (sources and levels) were dissolved in 10 litres of water and applied to the plots with the aid of a watering can to better distribute the nitrogenous fertilizers.

The experiment was conducted during the rainy season, from 1 October 2011 to 14 April 2012. The Mombaça grass was cut every 28 days, taking into consideration the optimal grazing interval for this forage grass (SANTOS *et al*., 2014). After each cutting, the different sources and levels of N were applied according to each treatment, for a total of seven applications. Immediately after the application of different levels of the N sources, a water depth of 8 mm was applied throughout the experimental area using a sprinkler irrigation system with 74% application efficiency.

The forage grass was collected with the aid of a 50 x 50 cm iron square and cut with steel shears 30 cm from the soil surface, simulating the ideal cutting height for this fodder grass (SANTOS *et al*., 2014). After each evaluation cutting, a uniform cutting of the whole experimental area was performed, at the same cutting height as the evaluated plants. The plant material from these uniformity cuttings was then removed from the area.

The material collected in each cutting, in a 0.25 m^2 area, was placed in a plastic bucket, identified and immediately weighed to calculate the weight of the fresh mass (FM) of grass. Subsequently, an approximately 400 g representative sample of material was removed from the collected material, wrapped in paper bags, labelled and then placed in an air-circulating oven, which was maintained between 60 °C and 65 °C until a constant mass was achieved. This process was performed to determine the dry matter. After drying, the samples were ground in a Willey mill with a 1 mm sieve and packed into polyethylene bags. The ground material was placed in the oven again to remove any residual moisture. Dry matter production (DMP) per hectare was determined using the fresh mass of collected material in a 0.25 m^2 area and the dry matter content obtained after processing the sample using the following formula: DMP = [%DM x (FM x 40000)]/100, where DMP: dry-matter production in kg ha^{-1}; %DM: percentage of dry matter of the sample after processing, FM: fresh matter in kg, collected in 0.25 m^2; 40,000: factor used to convert the production into hectares.

Throughout the 196-day experimental period, the rainfall was always insufficient, and the pasture was irrigated, with an irrigation depth calculated based on the evapotranspiration of the cultivar (ETc), using the Penman-Monteith method. The meteorological data used to calculate the ETc was provided by an automatic meteorological station located 550 m from the experimental area. Some of the climate variables observed during the experimental period are presented in Figure 1.

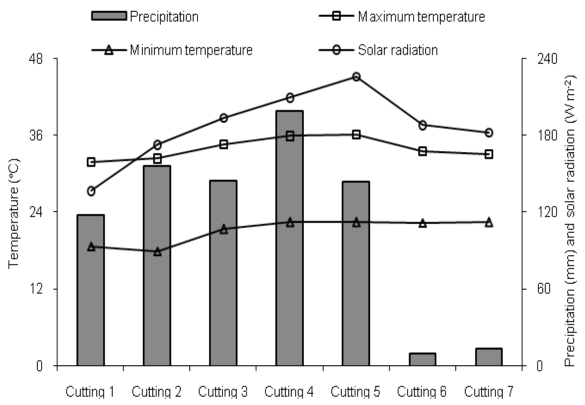

Figure 1. Valuesof the climate variables observed during the trial period in Santa Teresa - ES.

The period which includes the first three cuttings, was used as pasture adaptation. Because the pasture was intensively managed and received high doses of N before the liming, we used this adaptation period to reduce the stores of N in the soil so that the response of Mombaça grass would be a function of the applied treatments and not the N stores already in soil. Thus, the results shown are for the last four cuttings.

The DMP and tiller density were evaluated for the different treatments. The data were analysed using analysis of variance, and a regression analysis was then performed using the program SAS (2002).

RESULTS AND DISCUSSION

The DMP of Mombaça grass is presented in Figure 2 as a function of the source and level of N. The DMP was influenced by the treatments evaluated. For the different sources of N, there was a linear increase up to 600 kg ha^{-1} of N, where the best results were obtained with the use of calcium nitrate. At levels greater than 273 kg N ha^{-1} of N, urea was the source with the lowest DMP response. At applications of 600 kg ha^{-1} of N, the production with the application of calcium nitrate was 26.6% greater than the production with the use of urea and 11.5% higher than the production with the use of ammonium sulphate.

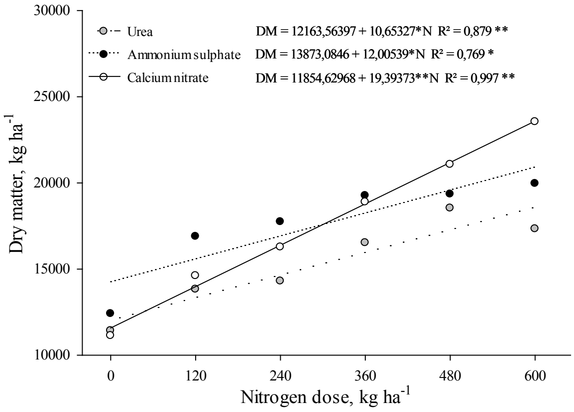

Figure 2. Cumulative production of dry matter (DM) of Mombaça grass in response to the application of different sources and levels of nitrogen (N). * and **: significance of regression coefficient and determination coefficient $p < 0.05$ and $p < 0.01$, respectively.

Thus, regardless of the source, there was an increase in DMP with increasing levels of N. According to Canto *et al*. (2013), N acts by increasing the volumetric density of the forage grass and, further, the production of the leaves in the canopy, due to the emergence and elongation of the leaves, thus increasing the DMP. Thus, balanced N fertilization is essential to the production process of pastures because the N from the mineralisation of organic matter in the soil is not sufficient to meet the demand of grasses with a high production potential (FAGUNDES *et al*., 2006).

In Figure 2, for the maximum level of N, the production generated with the application of ammonium sulphate was 13.6% greater than that generated with the use of urea. Similar results were reported by Costa *et al*. (2010). These authors reported that for the maximum dose of N (300 kg ha^{-1}) for Marandu grass, there was an 18% reduction in the DMP when urea was used as the N source compared to ammonium sulphate. This fact can be explained by the changes that urea undergoes in the soil, resulting in higher losses of N. Upon application to the soil, urea [$CO(NH_2)_2$] is hydrolysed by the enzyme urease, resulting in formation of ammonium carbonate [$CO(NH_2)_2 + 2H_2O \rightarrow (NH_4)_2CO_3$], which degrades rapidly into ammonium bicarbonate and a hydroxyl group

$[(NH_4)_2CO_3 + H_2O \rightarrow 2NH_4^+ + OH^- + HCO_3^-]$, raising the pH around the fertilizer granules (ROCHETTE *et al*., 2009). Thus, part of the ammonia is converted into NH_3, which can be lost into the atmosphere if the urea is not incorporated into the soil (SANGOI *et al*., 2003). Therefore, even with the adoption of recommended management practices of incorporating this fertilizer into the irrigation scheme after dissolving the N into the water, there may still be N losses, which can explain the lower production results for this N source. In addition, the sulphur in the ammonium sulphate might have contributed to the increase in DMP. Santos & Monteiro (1999) evaluated the response of signal grass to different levels of sulphur and concluded that forage grasses are responsive to the application of sulphur, such that as the levels increase, within certain limits, there is a proportional increase in the DMP and in the number of tillers.

The significant increase seen in DMP of Mombaça grass in response to higher N levels is also due to climate changes during experimental period. High temperatures, increased solar radiation, long days and mainly water availability make forage grasses with high productive potential such as Mombaça grass reach high fodder production. According to Valente *et al*. (2011), Mombaça grass is sensitive to water restriction. Thus it has higher productivity in the summer. Therefore, this forage grass is usually used in intensive production systems, where irrigation is an important tool to achieve high growth in handled areas. The importance of water availability for producing Mombaça grass can be seen in the results obtained by Souza *et al*. (2005). In this study, the authors concluded that Mombaça grass was the crop that best responded to DMP. Thus, rain precipitation played a relevant role in the early stage of the experimental period, associated to irrigation, which supported high production of Mombaça grass in the last two cuts, due to low rain precipitation.

The different sources and levels of N also influenced the density of the profiles. In Figure 3, beginning at 430 kg N ha^{-1}, the tiller density was highest for the treatment with calcium nitrate, followed by urea and ammonium sulphate. According to the equations shown in Figure 3, the maximum density of the tillers was achieved at 385 kg ha^{-1} of N when using urea and ammonium sulphate as the N source. For calcium nitrate, there was a linear increase in the tiller density as a function of the application of N within the limits evaluated. The tiller is the basic vegetative unit of grasses (HODGSON, 1990). It presents great importance on the pastures study, due to the fact that its productivity is conditioned to population density and to the individual tillers mass. According to Barth Neto *et al*. (2010), N fertilization accelerates the tillering of Mombaça grass, which is reflected in a higher DMP. Costa *et al*. (2011) evaluated the effect of N and potassium fertilization on Xaraés grass and reported a linear increase in the number of tillers with increasing levels of N, indicating that the increase in the levels of N positively influenced the tiller density.

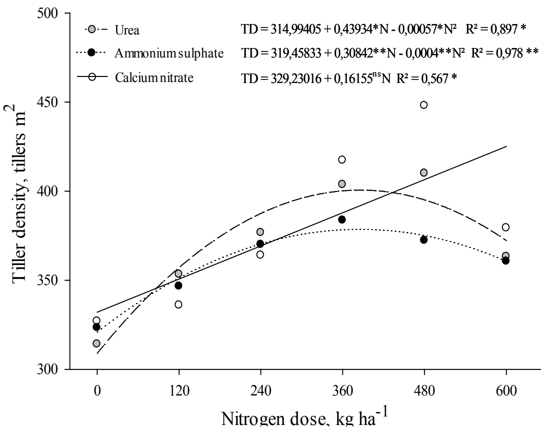

Figure 3. Tiller density (TD) refers to the mean of the last four cuttings of Mombaça grass in response to the application of different sources and levels of nitrogen (N). * and **: significance of regression coefficient and determination coefficient $p < 0.05$ and $p < 0.01$ respectively. ^{ns}: $p > 0,05$.

The increase in tiller density observed with the use of calcium nitrate and the results obtained in the present study for DMP using this source of N can both be explained by the contribution of calcium, which was supplied to the pasture as part of the application of N source. According to Souza *et al*. (2007), calcium is an essential element in the growth of meristems, especially in the growth and proper functioning of the root apex. Calcium is a component of the middle lamella, where it performs a cementing function as Ca pectate. In addition, Ca plays a structural role in maintaining the integrity of the plasma membrane and acts as a modulator of the action of plant hormones, which control, for example, the senescence and abscission of leaves. According to Freitas *et al*. (2011), this element is essential in the development of Mombaça grass, which can have concentrations ranging from 0.55 to 0.83 g kg^{-1} in the plant tissues.

Also, among the N sources used, calcium nitrate is the only one that does not alter soil pH, whereas urea and especially ammonium sulphate promote soil acidity by generating ions H^+ during the process of ammonium nitrification. According to Malavolta (1981), calcium nitrate is a fertilizer that contains N in the nitric form, which does not undergo transformation in the soil. Therefore, its use does not promote pH reduction in the soil. Hence, this source of N, and the possible maintenance of pH close to neutral during the experimental period, contributed to development of better Mombaça grass root system, extraction of nutrients and, consequently, higher DMP. Finally, with pH close to neutral, there is an increased availability of N in the soil, as well as of other macronutrients.

There was a quadratic fit for the tiller density when using urea and ammonium sulphate as N sources. Because of its influence on morphological and physiological characteristics of forage grasses, N acts by promoting an increase in the tiller density. However, at high levels of N, there is a stabilisation or even reduction in the tiller density, as observed by Hoeschl *et al*. (2007) for Tanzânia grass and Eichler *et al*. (2008) for Mombaça grass. But this reduction in the numbers of tillers did not result in minor DMP of Mombaça grass (Figure 2). According to Santana *et al*. (2008), pastures submitted to elevated levels of N may present reduction on the number of tillers, due to an increase on leaf area and competition for luminosity among them. However, the productivity increase is sustained due to the higher tillers development. This way, the increase in the tillers individual weight it proportionally higher to the tiller reduction, allowing the pasture to sustain elevated productivities even with the reduction in tillers population. Similar results to the obtained in this work were presented by Carard *et al*. (2008), where it was observed for *Brachiaria brizantha* cultivars a reduction on the number of tillers and an increase on DMP with the increment on levels of N.

CONCLUSIONS

- Mombaça grass is responsive to nitrogen fertilization, and its response in terms of dry matter production and tiller density for the same levels of nitrogen varies depending on the source used;
- Of the studied sources of nitrogen, calcium nitrate showed superior performance for the variables evaluated;
- Regardless of the source of nitrogen, it was not possible to identify a maximum dry matter production point for Mombaça grass within the limits evaluated here.

REFERENCES

ANUALPEC. **Anuário da Pecuária Brasileira**. São Paulo: Angra/FNP, 2015. 407p.

BARBERO, L.M.; CECATO, U.; LUGÃO, S.M.B.; GOMES, J.A.N.; LIMÃO, V.A.; BASSO, K.C. Produção de forragem e componentes morfológicos em pastagem de *coastcross* consorciada com amendoim forrageiro. **Revista Brasileira de Zootecnia**, Viçosa, v.38, n.5, p.788-795, mai. 2009.

BARTH NETO, A.; BOLETA, V.S.; PANCERA JÚNIOR, E.J.; ALMEIDA, G.M.; CANTO, M.W.; GASPARINO, E.; BALTAZAR, L.F. Nitrogênio e época de colheita nos componentes da produtividade de forragem e sementes de capim-mombaça. **Pesquisa Agropecuária Brasileira,** Brasília, v.45, n.11, p.1312-1320, nov. 2010.

BRAGA, G.J.; MELLO, A.C.L.; PEDREIRA, C.G.S.; MEDEIROS, H.R. Fotossíntese e taxa diária de produção de forragem em pastagens de capim-tanzânia sob lotação intermitente. **Pesquisa Agropecuária Brasileira,** Brasília, v.44, n.1, p.84-

91, jan. 2009.

CANTO, M.W.; HOESCHL, A.R.; BONA FILHO, A.; MORAES, A.; GASPARINO, E. Características do pasto e eficiência agronômica de nitrogênio em capim-tanzânia sob pastejo contínuo, adubado com doses de nitrogênio. **Ciência Rural**, Santa Maria, v.43, n.4, p.682-688, abr. 2013.

CARARD, M.; NERES, M.A.; TONELLO, C.L. Efeito de doses crescentes de nitrogênio no desenvolvimento de cultivares de *Brachiaria brizantha*. **Revista da FZVA,** Uruguaiana, v.15, n.2, p.135-144, set. 2008.

COSTA, K.A.P.; OLIVEIRA, I.P.; FAQUIN, V.; SILVA, G.P.; SEVERIANO, E.C. Produção de massa seca e nutrição nitrogenada de cultivares de *Brachiaria brizantha* sob doses de nitrogênio. **Ciência e Agrotecnologia,** Lavras, v.33, n.6, p.1578-1585, nov./dez. 2009.

COSTA, K.A.P.; FAQUIN, V.; OLIVEIRA, I.P. Doses e fontes de nitrogênio na recuperação de pastagens do capim-marandu. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia,** Belo Horizonte, v.62, n.1, p.192-199, jan. 2010.

COSTA, K.A.P.; OLIVEIRA, I.P.; FAQUIN, V.; SEVERIANO, E.C.; GUIMARÃES, K.C.; MOREIRA, J.F.M.; BENTO, J.C. Adubação nitrogenada e potássica na produção de massa seca e composição bromatológica do capim-xaraés. **Global Science and Technology**, Rio Verde, v.4, n.1, p.51-60, jan./abr. 2011.

EICHLER, V.; SERAPHIN, E.S.; PORTES, T.A.; ROSA, B.; ARAÚJO, L.A.; SANTOS, G. Produção de massa seca, número de perfilhos e área foliar do capim-mombaça cultivado em diferentes níveis de nitrogênio e fósforo. **Ciência Animal Brasileira,** Goiânia, v.9, n.3, p.617-626, jul./set. 2008.

EMBRAPA. **Sistema brasileiro de classificação de solos**. Rio de Janeiro: EMBRAPA Solos, 1999. 412p.

FAGUNDES, J.L.; FONSECA, D.M.; GOMIDE, J.A.; NASCIMENTO JUNIOR, D.; VITOR, C.M.T.; MORAIS, R.V.; MISTURA, C.; REIS, G.C.; MARTUSCELLO, J.A. Acúmulo de forragem em pastos de *Brachiaria decumbens* adubados com nitrogênio. **Pesquisa Agropecuária Brasileira,** Brasília, v.40, n.4, p.397-403, abr. 2005.

FAGUNDES, J.L.; FONSECA, D.M.; MORAIS, R.V.; MISTURA, C.; VITOR, C.M.T.; GOMIDE, J.A.; NASCIMENTO JUNIOR, D.; SANTOS, M.E.R.; LAMBERTUCCI, D.M. Avaliação das características estruturais do capim-braquiária em pastagens adubadas com nitrogênio nas quatro estações do ano. **Revista Brasileira de Zootecnia,** Viçosa, v.35, n.1, p.30-37, jan./fev. 2006.

FREITAS, K.R.; ROSA, B.; NASCIMENTO, J.L.; BORGES, R.T.; BARBOSA, M.M.; SANTOS, D.C. Composição química do capim-mombaça (*Panicum maximum* jacq.) submetido à adubação orgânica e mineral. **Ciência Animal Brasileira,** Goiânia, v.12, n.3, p.407-414, jul./set. 2011.

HODGSON, J. **Grazing management: science into practice**. New York: John Willey & Sons, 1990. 203p.

HOESCHL, A.R.; CANTO, M.W.; FILHO, A.B.; MORAES, A. Produção de forragem e perfilhamento em pastos de capim tanzânia adubados com doses de nitrogênio. **Scientia Agraria,** Curitiba, v.8, n.1, p.81-86, jan./fev. 2007.

JANK, L.; SAVIDAN, Y.H.; SOUZA, M.T.; COSTA, J.C.G. Avaliação de germoplasma de *Panicum maximum* introduzido da África. I. Produção forrageira. **Revista Brasileira de Zootecnia,** Viçosa, v.23, n.3, p.433-440, mai./jun. 1994.

MALAVOLTA, E. **Manual de química agrícola adubos e adubação**. 3. ed. São Paulo: Ceres, 1981. 596p.

PREZOTTI, L.C.; GOMES, J.A.; DADALTO, G.G.; OLIVEIRA, J.A. **Manual de recomendação de calagem e adubação para o Estado do Espírito**

Santo. 5ª aproximação. Vitória: SEEA/INCAPER/CEDAGRO, 2007. 305p.

ROCHETTE, P.; MACDONALD, J.D.; ANGERS, D.; CHANTINI, M.H.; GASSER, M.; BERTRAND, N. Banding urea increased ammonia volatilization in a dry acidic soil. **Journal of Environmental Quality,** New York**,** v.38, n.4, p.1383-1390, mai. 2009.

SANGOI, L.; ERNANI, P.R.; LECH, V.A.; RAMPAZZO, C. Volatilização de N-NH_3 em decorrência da forma de aplicação de ureia, manejo de resíduos e tipo de solo, em laboratório. **Ciência Rural,** Santa Maria, v.33, n.4, p.687-692, jul./ago. 2003.

SANTANA, C.V.S.; SANTOS, A.S.; MISTURA, C.; TURCO, S.H.N.; LOPES, R.S. Efeito do nitrogênio na dinâmica, peso e número de perfilho do capim-aruana. **Agropecuária Científica no Semi-Árido,** Patos, v.04, n.1, p.37-41, jun. 2008.

SANTOS, A.R.; MONTEIRO, F.A. Produção e perfilhamento de *Brachiaria decumbens* Stapf. em função de doses de enxofre. **Scientia Agricola,** Piracicaba, v.56, n.3, p.689-692, jul. 1999.

SANTOS, P.M.; SANTOS, A.C.; SILVA, J.E.C.; SILVA NETO, S.P.; ALEXANDRINO, E. Atributos morfogênicos de pastos de capim-mombaça adubados com resíduo de laticínio. **Revista Caatinga,** Mossoró, v.27, n.3, p.221-231, set. 2014.

SAS. **Statistical Analysis System user's guide.** Version 9.0. Cary: Statistical Analysis System Institute, 2002. 513p.

SOUZA, D.M.G.; MIRANDA, L.N.; OLIVEIRA, S.A. Acidez do solo e sua correção. In: NOVAIS, R.F.; ALVAREZ, V.V.H.; BARROS, N.F.; FONTES, R.L.F.; CANTARUTTI, R.B.; NEVES, J.C.L. (eds.). **Fertilidade do solo**. Viçosa: Sociedade Brasileira de Ciência do Solo, 2007, p.205-274.

SOUZA, E.M.; ISEPON, O.J.; ALVES, J.B.; BASTOS, J.F.P.; LIMA, R.C. Efeitos da irrigação e adubação nitrogenada sobre a massa de forragem de cultivares de *Panicum maximum* Jacq. **Revista Brasileira de Zootecnia,** Viçosa, v.34, n.4, p.1146-1155, jul./ago. 2005.

TEIXEIRA, J.C.; HESPANHOL, A.N.A trajetória da pecuária bovina brasileira. **Caderno Prudentino de Geografia**, Presidente Prudente, v.1, n.36, p.26-38, jan./jul. 2014.

VALENTE, T.N.P.; LIMA, E.S.; HENRIQUES, L.T.; MACHADO NETO, O.R.; GOMES, D.I.; SAMPAIO, C.B.; COSTA, V.A.C. Anatomia de plantas forrageiras e a disponibilidade de nutrientes para ruminantes: revisão. **Revista de Medicina Veterinária e Zootecnia**, Botucatu, v.18, n.3, p.347-358, set. 2011.

VITOR, C.M.T.; FONSECA, D.M.; CÓSER, A.C.; MARTINS, C.E.; JÚNIOR, D.N.; JÚNIOR, J.I.R. Produção de matéria seca e valor nutritivo de pastagem de capim-elefante sob irrigação e adubação nitrogenada. **Revista Brasileira de Zootecnia,** Viçosa, v.38, n.3, p.435-442, mar. 2009.