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Forage accumulation, tillering and bromatological characteristics of Brachiaria grass under nitrogen fertilization

Acúmulo de forragem, perfilhamento e características bromatológicas do capim-braquiária sob adubação nitrogenada

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Abstract

The objective of this study was to evaluate the influence of different nitrogen doses on the forage accumulation, tillering and chemical characteristics of Braquiaria grass (*Urochloa decumbens* (Stapf) Webster cv. Basilisk). A randomized block design with four replications was used, and each plot (50 m²) was an experimental unit. The treatments consisted of four doses of N (100, 200, 300 and 400 kg ha^{-1} year^{-1}) and the control treatment. There was an increase in whole-plant crude protein (CP) and in leaf crude protein (LCP) and a decrease in whole-plant neutral detergent fiber (NDF) and leaf neutral detergent fiber (LNDF). Total dry matter accumulation (TDMA) and dry matter accumulation rate (DMAR) increased linearly in response to the N doses applied. Nitrogen fertilization promotes benefits such as increased biomass accumulation and improved forage chemical composition and tillering in Brachiaria grass.

Additional keywords: biomass production; fertilization; nutritional value; *Urochloa*.

Resumo

Objetivou-se avaliar a influência de diferentes doses de nitrogênio sobre o acúmulo, perfilhamento e características químicas do capim-braquiária (*Urochloa decumbens* (Stapf) Webster cv. Basilisk). Foi utilizado o delineamento experimental em blocos ao acaso, com quatro repetições, sendo cada parcela (50 m²) a unidade experimental. Os tratamentos consistiram em quatro doses de N: 100, 200, 300 e 400 kg ha^{-1} ano^{-1} e o tratamento-controle. Houve aumento da proteína bruta da planta inteira (PBT) e da proteína bruta das folhas (PBF), e redução da fibra em detergente neutro da planta inteira (FDNT) e das folhas (FDNF). O acúmulo total de matéria seca (ATMS) e a taxa de acúmulo de matéria seca (TACUMS) aumentaram linearmente em resposta às doses de N aplicadas. A adubação nitrogenada promove benefícios, como o aumento de acúmulo de massa e a melhoria da composição química de forragem, e o perfilhamento no capim-braquiária.

Palavras-chave adicionais: fertilização; produção de massa; *Urochloa*; valor nutricional.

Introduction

Among the forage plants that compose the pasture areas in Brazil, those of the genus *Brachiaria* are the most cultivated due to their adaptability in several ecosystems, acceptance by the animals and high accumulation of forage mass (Sales et al., 2013). As pastures of Brachiaria grass are the basis of livestock feeding in Brazil, there is a concern to improve their use. With this, the need to characterize the factors influencing their development, such as edaphoclimatic conditions of the region, soil fertility and animal management, is increased.

Among these factors, soil fertility can be manipulated through pasture fertilization. Nitrogen (N) fertilization is the most striking in terms of gains in forage production (Da Silva et al., 2012; Gastal & Lemaire, 2002; Sales et al., 2013). 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; Faria et al., 2015). The main function of this nutrient is to be the constituent of proteins, besides interfering directly in the photosynthetic process (Gastal & Lemaire, 2002). Furthermore, in order to be used as a strategic tool to maximize forage production in intensive production systems, the soil must be properly corrected and supplied with phosphorus (P) and other macronutrients, such as potassium, and micronutrients (Simili et al., 2010).

Phosphorus (P) is very important in the forage establishment, acting on metabolism, playing an important role in photosynthesis, respiration, sugar metabolism, cell division and cell enlargement. Its adequate supply promotes a more efficient use of water and, consequently, of other nutrients such as nitrogen and potassium (Faria et al., 2015).

For Simili et al. (2014), potassium (K) may also limit the response of production of forage plants with higher nutritional requirements, especially in intensive systems, where improper nutrient ratios may adversely affect the mineral nutrition of plants. This nutrient directly or indirectly participates in numerous biochemical processes involved in the metabolism of carbohydrates, such as photosynthesis and respiration, and its deficiency is reflected in a low growth rate (Simili et al., 2010).

However, in soils with proper contents of phosphorus and potassium, production will be influenced by the availability of N to the plant. In this context, the objective of this research was to evaluate the contribution of nitrogen application on the forage accumulation, tillering and bromatological characteristics of *Urochloa decumbens* (Stapf) Webster cv. Basilisk, in the central region of Minas Gerais.

Material and methods

The experiment was conducted at the Experimental Farm of the Agricultural Research Company of Minas Gerais (EPAMIG), in the municipality of Felixlândia, midwest of Minas Gerais, located at 18º 45' 28" South latitude and 44º 53' 56" West longitude, at an altitude of 614 m. The climate of the region is rainy tropical (monsoon rains) with dry winter and rainy summer, average temperature of 22.1 °C and average annual rainfall of 1,230 mm, data obtained at the Main Climatological Station of Felixlândia.

Total monthly rainfall and temperture averages corresponding to the months of experiment are presented in Figure 1. The soil of the region is classified as dark red dystrophic Latosol with loamy texture (EMBRAPA, 2006) (Table 1).

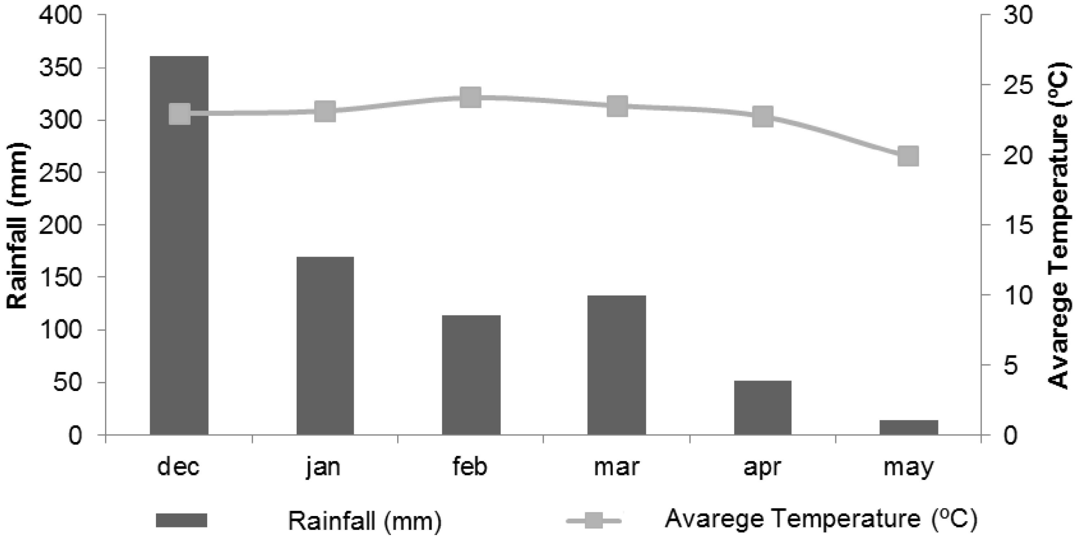

Figure 1 – Total monthly rainfall and average monthly air temperature during the experimental period. Source: data provided by EPAMIG Felixlândia-MG

Table 1 - Soil chemical characteristics in samples of the experimental area in the 0-20 cm layer depth.

Layer (cm)	pH	Ca^{2+}	Mg^{2+}	H+Al	Al^{3+}	SB	CEC	P	K^+
	(H_2O)			(cmol$_c$ dm^{-3})				(mg dm^{-3})	
0-20	5.4	1.3	0.6	5.6	1.2	2.6	8.2	1.8	260

pH(H_2O) = pH in water; H+Al = Potential acidity; Al^{+3} = Exchangeable acidity; SB = Sum of bases; CEC = Cation exchange capacity at pH 7; V = Saturation by bases

Experimental plots were demarcated in Brachiaria grass (*Urochloa decumbens* (Stapf) Webster cv. Basilisk) pasture in December 2011. The area was demarcated according to the dimensions of each experimental unit of 50 m² each (5 x 10 m). Weed control was done throughout the experimental period by manual weeding within the plots and by using hoes between the lines, whenever necessary.

The treatments consisted of four nitrogen doses: control: 0 kg ha^{-1} year^{-1}, 100, 200, 300 and 400 kg ha^{-1} year^{-1}, distributed in a randomized complete block design with four replications and spacing of 1.5 m between blocks. The nitrogen fertilizer used was urea, where the equivalent dose was calculated to each plot, being manually applied in each experimental unit, after each cut. Nitrogen fertilization was divided in four applications, with 25% being applied after each cut.

Before the beginning of the experiment, the forage was cut at 10 cm at ground level to standardize the experimental area. Phosphate fertilization with 100 kg ha^{-1} of P_2O_5 was performed, using simple superphosphate as source of P, calculated according to soil analysis and plant requirement (Cantarutti et al., 2007).

Four cuts were made to collect forage samples for bromatological analyses. The cuts occurred on January 5, February 23, April 12, and May 17, 2012. Therefore, the interval between cuts corresponded to the period of time necessary for the canopy to reach the average height of 40 cm.

After each sample collection, paddocks were grazed by three crossbred cows (450 kg live weight), in a physiological state of maintenance. The cows were removed when the pasture height reached 10 cm of residue, the canopy height of entry of animals being of 40 cm. During grazing, there was daily evaluation of canopy height (50 sampling points/hectare) using ruler graduated in centimeters.

To determine forage mass, a 1 m^2 square was randomly chosen three times within the useful area of each plot and the material was collected three times. The plants were cut at a height of 10 cm at ground level and weighed to determine the dry matter accumulation (DMA) per hectare. For determination of the dry matter (DM) contents, a subsample of approximately 300 g was withdrawn, placed in a paper bag and taken to an oven with forced air ventilation at 55 ºC for 72 hours for drying (Silva & Queiroz, 2006). The values of total dry matter accumulation (TDMA) were converted to kg ha^{-1}. Another subsample was taken for evaluation of plant morphological components (leaf blade, stem + sheath and dead material).

In order to evaluate the dry matter accumulation rate (DMAR; kg ha^{-1} day^{-1}), the initial dry matter was measured at 10 cm at ground level, and then the final matter was measured at 40 cm at ground level. The difference between the initial and final matter of each plot, verified in the period divided by the number of days of regrowth - Interval 1: 01/05 to 02/23 (49 days); Interval 2: 02/23 to 04/12 (49 days) and Interval 3: 04/12 to 05/17 (35 days) and the plot area in hectares (ha), corresponded to the DMAR expressed in kg ha^{-1} day^{-1}.

The cell wall components: whole-plant neutral detergent fiber (NDF), leaf neutral detergent fiber (LNDF), stem neutral detergent fiber (SNDF), whole-plant acid detergent fiber (ADF), leaf acid detergent fiber (LADF) and stem acid detergent fiber (SADF) were obtained according to the sequential analysis proposed by Van Soest & Robertson (1985). Crude protein (CP) was obtained according to the procedure described by AOAC (1990).

At the beginning of the first regrowth period, three tillers per plot (total of 60 tillers) were randomly marked in different clumps to evaluate the morphogenic characteristics of the canopy during the rest period of the pastures. The tillers were identified with plastic rings and for better visualization in the field, next to each tiller was set a stem with numbered labels. At each cycle, the new basal tiller was marked in the same clump. Evaluations were conducted weekly.

Live tillers that had visible inflorescence were classified as reproductive. Yet those that did not present inflorescence were called vegetative, and those whose stem was fully senesced were classified as dead. The sum of the vegetative and reproductive tillers corresponded to the number of live tillers, while the number of total tillers was obtained by the sum of live and dead tiller.

These tillers were also classified according to the origin of development. Basal tillers come from basal buds located near and/or at ground level. Aerial tillers are those originating from lateral buds in the main basal tiller.

The means of the experimental units, obtained from the variables evaluated in this study, were submitted to analysis of variance and when significant, the means were submitted to regression analysis, using the SISVAR program (Ferreira, 2014).

Results and discussions

Nitrogen utilization in Brachiaria grass reduced ($P<0.05$) by 2.4%, 0.16% and 1.2%, for each percentage unit of N applied, the total dry matter (TDM), neutral detergent fiber (NDF) and leaf neutral detergent fiber (LNDF) contents, respectively. However, leaf crude protein (LCP) and stem crude protein (SCP) contents presented increases of 1.03% and 0.5% for each kilogram of N applied, respectively. No effect of N application was observed for the contents of stem neutral detergent fiber (SNDF), whole-plant acid detergent fiber (ADF), leaf acid detergent fiber (LADF) and stem acid detergent fiber (SADF), with means of 74.7%, 35%, 27.8% and 39.4%, respectively (Table 2).

N application in pasture at doses above 50 kg ha^{-1} promotes alteration in cellular components, which modifies the cellular content:cell wall ratio by means of dilution (Castagnara et al., 2011; Sales et al., 2014). This dilution reduces the contents of DM and cell wall components represented by NDF, a fact observed in this study, where a reduction of 31.6% and 0.9% was observed for DM and NDF, respectively.

Nonetheless, climatic factors such as rainfall can change plant responses to N fertilization (Lopes et al., 2011). In this study, the lack of moisture in the Brachiaria grass(Table 1) may have modified the plant life cycle accelerating the physiological maturity, which corroborates the results of LNDF, which increased on average by 8.5%, with marginal variation (variation of the means of the control treatment in relation to the treatment with higher dose of N). Even with moisture reduction, the applied N increased by 34.65% and 33.9% the levels of LCP and SCP, respectively. Nevertheless, the mean CP levels presented a quadratic behavior of regression, with the highest average being verified at the dose of 312.5 kg ha^{-1} of N.

Table 2 – Percentage of dry matter, crude protein and fiber in Brachiaria grass under nitrogen doses, in Felixlândia, Minas Gerais.

Characteristics	Treatments					CV (%)	P>F
	0	100	200	300	400		
TDM (%)[1]	36.4	29.5	30.4	27.9	24.9	15.5	0.04
TCP (%)[2]	7.7	8.6	11.1	10.8	10.0	11.84	0.01
LCP (%)[3]	10.1	11.5	14.0	15.0	13.6	8.89	0.01
SCP (%)[4]	6.2	7.3	8.0	8.6	8.3	8.68	0.01
NDF (%)[5]	69.5	69.4	69.2	69.0	68.9	1.71	0.01
LNDF (%)[6]	59.1	63.2	61.4	60.2	64.1	2.38	0.01
SNDF (%)	75.6	74.4	74.9	73.8	74.6	1.32	0.18
ADF	33.7	35.7	34.9	35.6	35.1	3.50	0.21
LADF	28.4	27.5	26.9	27.9	28.4	4.53	0.47
SADF	39.5	39.5	38.7	39.5	39.9	2.83	0.67

TDM = Total dry matter, TCP = total crude protein, LCP = leaf crude protein, SCP = stem crude protein, NDF = whole-plant neutral detergent fiber, LNDF = leaf neutral detergent fiber, SNDF = stem neutral detergent fiber, ADF = whole-plant acid detergent fiber, LADF = leaf acid detergent fiber, SADF = stem acid detergent fiber. CV = coefficient of variation.

[1] $\hat{Y}$= -0.024x + 34.73 (R^2=0.83); [2] $\hat{Y}$= -0.00004x^2 + 0.025x + 7.3883 (R^2=0.88); [3] $\hat{Y}$= 0.0103x + 10.78 (R^2=0.68); [4] $\hat{Y}$= 0.0055x + + 6.57 (R^2=0.83); [5] $\hat{Y}$= -0.0016x + 69.51 (R^2=0.96); [6] $\hat{Y}$= -0.012x + 63.98 (R^2=0.97).

The application of N in the form of urea consisting basically of non-protein nitrogen (NPN), when absorbed by the plant, is stored mainly in the cellular content, which promotes significant increases in crude protein (CP) levels, as verified in this research ($P<0.05$). Several reports in the literature have shown positive results in the protein content of the plant in response to nitrogen fertilization (Magalhães et al., 2011; Viana et al., 2011; Vitor et al., 2011). This increase, promoted by the higher availability of N in the soil, favors greater absorption of this nutrient (N) by the plant, providing a higher concentration in the plant tissue, especially in the green foliar tissue (Santos et al., 2010). Since N is considered the main constituent of proteins, their content is consequently increased (Costa et al., 2006). In ruminant nutrition, when the N-fertilized pasture protein is degraded in the rumen, much of the CP fractionation is constituted of NPN (Silva et al., 2009), which favors ammonia synthesis. Ammonia is mainly used by fibrolytic bacteria to degrade the fibrous fraction of the diet, increasing the synthesis of microbial protein and short-chain fatty acids. Considering the mean values of LCP that varied from 10.1% to 13.6%, management with categories of young animals in the growth phase, such as post-weaning animals, would be recommended. Also, as an animal management strategy and based on nutritional requirements, true protein supplementation becomes necessary as a source of undegraded protein in the rumen.

For cell wall components, as N doses increased, there was a reduction in NDF content. The minimum NDF was 66.9% in the whole plant and 60.49% in the leaves, with N doses of 257.5 and 245.07 kg ha^{-1} $year^{-1}$, respectively. The reduction of forage cell wall components may have occurred due to the higher protein concentration in the forage, especially in the leaves, which contributes to the dilution of cell wall components (Magalhães et al., 2011), reducing cellulose, hemicellulose and lignin content and increasing the fraction of soluble compounds readily available and usable by the animals (Costa et al., 2006).

According to Van Soest & Robertson (1985), there is a negative association between DM consumption and fiber content of the food, since fibrous components are digested more slowly, thus taking up space in the animal's rumen, reducing feed intake. Values above 55% of cell wall content in the plant may limit DM consumption by the animal (Van Soest, 1982). Therefore, nitrogen confers an increase in the crude protein levels and leads to a decrease in the NDF and ADF contents of the leaves, as verified by Magalhães et al. (2015), improving the quality of the forage consumable by the animals.

The effect of N doses was significant for dry matter production (DMP) ($P<0.05$). The DMP increased linearly in response to the applied N doses, from 5.816 kg ha^{-1} to 8.813 kg ha^{-1} with the application of 400 kg ha^{-1} $year^{-1}$ of N in relation to the control treatment, representing an increase of 51.53% (Table 3).

This increased forage production can be due to the greater stimulus of division and expansion of cells by the N (Gastal & Lemaire, 2002), allowing plant growth and consequently increased DMP. Increases in forage production through nitrogen fertilization of pasture are mentioned by several authors (Lopes et al., 2013; Lobo et al., 2014).

Despite the plant's production potential being determined genetically, suitable conditions such as temperature, humidity, luminosity and mainly N availability must be present for this potential to be achieved (Fagundes et al., 2005). Thus, the adequate supply of nitrogen to the plants can increase pasture production.

Table 3 - Dry matter production kg ha^{-1}, dry matter accumulation rate kg ha^{-1} day^{-1}, total number of tillers, number of basal tillers, number of aerial tillers in Brachiaria grass under nitrogen doses in Felixlândia, Minas Gerais.

Characteristics	Treatments					CV (%)	P>F
	0	100	200	300	400		
DMP (kg ha^{-1}) [1]	5506.0	5816.0	6959.0	6694.0	8813.0	16.35	0.01
DMAR(kg ha^{-1} day^{-1}) [2]	116.9	136.6	166.9	170.7	216	11.07	0.01
TNT(Nº m^{-2}) [3]	43.9	60.5	91.3	109.2	88.7	4.86	<0.01
NBT[4]	27.0	35.1	40.0	50.4	54.8	7.09	<0.01
NAT[5]	5.0	9.0	13.8	12.5	11.4	10.49	<0.01

DMP = dry matter production, DMAR = dry matter accumulation rate, TNT = total number of tillers m$^{2-1}$, NBT = number of basal tillers m$^{2-1}$, NAT = number of aerial tillers, CV = coefficient of variation. R^2 = coefficient of determination.
[1] $\hat{Y} = 7.49x + 5259.2$ ($R^2 = 0.83$); [2] $\hat{Y} = 0.23x + 114.96$ ($R^2 = 0.94$); [3] $\hat{Y} = -0.0006x^2 + 0.39x + 38.62$ ($R^2 = 0.89$); [4] $\hat{Y} = 0.071x + 27.28$ ($R^2 = 0.98$); [5] $\hat{Y} = -0.0001x^2 + 0.06x + 4.75\ 9$ ($R^2 = 0.94$).

The effect of nitrogen fertilization was significant for DMAR (P<0.05), which increased linearly in response to nitrogen fertilization. Every 50 kg of N applied increases DMAR by 11.1 kg ha^{-1} day^{-1}. Forage DMAR is an important variable, since it reflects the balance in the dynamics of the plant growth and senescence rates (Fagundes et al., 2005; Lobo et al., 2014).

Maranhão et al., (2010) obtained a 109% increase in the daily forage production of Brachiaria grass in response to the application of 200 kg ha^{-1} year^{-1} of N in relation to the treatment without fertilization. The DMAR of 152.1 kg ha^{-1} day^{-1} of DM, obtained by these authors, was lower than that found by the present study, which was 166.92 kg ha^{-1} day^{-1} of DM, both receiving 200 kg ha^{-1} year^{-1} of N fertilization and with intervals between cuts of 42 and 40 days, respectively.

The total number of tillers (TNT) was influenced (P<0.05) by nitrogen fertilization, with the data being adjusted to positive quadratic models. The N dose that provided the maximum tillering was 325 kg ha^{-1} year^{-1} of N, with 101.08 tillers m^{-2}. This increase obtained in tillering in response to nitrogen fertilization can be explained by the proven action of N in stimulating cell division and expansion, causing the plant to grow and tiller more (Gastal & Lemaire, 2002). A higher tillering provides greater soil coverage by the clump, reducing the exposure to the impact of rain and sun, contributing to the reduction of soil degradation (Sales et al., 2013; Sales et al., 2014ab).

The number of basal tillers (NBT) increased from 27 to 55 tillers per m^2 with 0 and 400 kg ha^{-1} year^{-1} of N, respectively. This increase can be justified since N strongly interferes in the activation of the meristematic tissues present in the axillary buds (Nabinger, 1996). When deficient, there is an increase in the number of dormant buds, whereas adequate supply allows maximum tillering of the grass (Costa et al., 2006).

Conclusion

Nitrogen fertilization, at strategic times, with doses of up to 400 kg ha^{-1} is essential to ensure forage for animals throughout the year, especially in regions with water deficit or irregular rainfall cycle. N application, based on the soil analysis and the results verified in this research, implies greater forage durability and establishment, mainly due to the increase in the number of tillers.

Notwithstanding, grazing management is essential not to compromise regrowth or promote grass degradation. The results suggest that the fertilization of Brachiaria grass promotes interesting increases in the biomass accumulation, which may favor increases in the stocking rate. However, it is essential that before applying N in the pastures an analysis of the benefit is carried out, taking into account the cost of using the technological package, in this case nitrogen fertilization, since the values of inputs vary throughout the year and in the different regions of the country.

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