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Short Communication

Yield, chemical composition, and efficiency of use of nitrogen by Marandu grass

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ABSTRACT - The objective of this study was to evaluate the effect of five nitrogen doses on the productive and quality characteristics and the use efficiency of *Brachiaria brizantha* cv. Marandu grass. The treatments consisted of four doses of nitrogen (0, 60, 120, 180 and 240 kg ha^{-1}), distributed through a completely randomized design with four replicates. Samples of the material were collected to analyze productivity variables, concentrations of neutral detergent fiber, crude protein and neutral detergent insoluble nitrogen, and *in vitro* dry matter digestibility. The nitrogen use efficiency, recovery of the applied nitrogen (RAN) and agronomic efficiency of the applied nitrogen (AE) were calculated. Dry mass production increased by 1,624.67 (kg/ha) as the nitrogen doses were increased. The doses of nitrogen affected the concentrations of neutral detergent fiber (from 294.6 to 381.4 $g.kg^{-1}$, in the leaf), crude protein (from 86.1 to 99.6 $g.kg^{-1}$, in the leaf) and neutral detergent insoluble protein (from 402.9 to 396.2 $g.kg^{-1}$ CP, in the leaf). Nitrogen use efficiency increased, whereas RAN and AE were not affected by the nitrogen doses. Nitrogen fertilization promotes improvement in productivity and chemical composition of Marandu grass, also improving the efficiency with which the grass utilizes the nitrogen.

Key Words: nitrogen use efficiency, nutritional characteristics, urea

Introduction

The pasture is the foundation of the cattle farming system in Brazil, having an important role in the profitability and sustainability of this system. It is estimated that in Brazil the total cultivated pastures amounts to over 200 million hectares, most of which are composed of grasses of African origin, and 80% of these belong to the genus *Brachiaria spp*. (Medeiros et al., 2007).

Yet, rational exploitation of the pasture requires caution, especially regarding the supply of nutrients at the adequate quantity and proportion to the plants. Among these nutrients, nitrogen (N) is largely responsible for the productivity and quality of the forage plant (Batista and Monteiro, 2006). Hence, N takes on fundamental importance in the production process of grasses, since the soil nitrogen, originating from the mineralization of the organic matter, is not sufficient to meet the requirements of grasses with a high productive potential (Fagundes et al., 2006). Nitrogen is properly used when the producer aims at increasing the recovery of the N applied in the soil-plant system minimizing the losses of the fertilizing nitrogen without causing damages to the environment.

The efficiency in the use of N for food production in the world is very low (Espindula et al., 2010). Thus, maximizing the efficiency of conversion of the N from the fertilizer into forage dry mass is extremely important for the final bioeconomic result of nitrogen fertilization in pastures (Martha Júnior et al., 2007).

In view of the foregoing, the objective of this study was to evaluate the effect of five doses of N (0, 60, 120, 180 and 240 kg/ha) on the productive and qualitative characteristics and the use efficiency of *Brachiaria brizantha* cv. Marandu grass.

Material and Methods

The experiment was conducted at Universidade Federal de Viçosa, in the Department of Animal Science. Viçosa city is located at an altitude of 651 m, 20º 45' south latitude and 42º 51' west longitude. The soil is classified as a Red-

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Yellow Acrisol. The soil was collected at a depth of 0 to 0.20 m, and the chemical analysis showed: pH in water = 5.6; CEC (T) = 8.17; H +Al = 4.21; sum of bases = 3.96; Ca = 2.8; Mg = 1.1 cmolc dm^{-3}; P = 66.6 mg dm^{-3}; K = 123 mg dm^{-3}; and 1.49 dag kg^{-1} organic matter.

The area was prepared by plowing and with two disking in which the soil was fertilized with 300 kg ha^{-1} of the N-P-K formulation (8-28-16). The *Brachiaria brizantha* cv. Marandu was sown at a ratio of 3 kg ha^{-1} of pure viable seeds in a row-spacing of 0.45 m.

Because of the uniformity of the area, we adopted a completely randomized design with four replicates. Treatments consisted of four doses of nitrogen (0, 60, 120, 180 and 240 kg ha^{-1}), broadcast over the whole area, in the form of urea. The doses of 120, 180 and 240 kg ha^{-1} were applied twice at 25 and 60 days after the grass leaves started to emerge.

The Marandu grass was harvested 120 days after sowing; samples were obtained by randomly casting an iron frame (100 × 100 cm) over the floor area of the plots and cutting the material within the frame. The material collected from each plot was weighed and homogenized. Next, representative samples were taken for separation of leaves and stems, at a standard quantity (1,000 g of sample) for later analysis of the chemical and morphological composition. Total productions of dry mass (DMP), leaves and stems and leaf:stem ratio were evaluated.

The dry mass productivity (DMP/ha) was calculated by multiplying the total green mass (kg m^{-2}) by the original dry mass content. The material was pre-dried for 72 hours in an oven at 55 ºC, and then ground in a Wiley mill (1 mm mesh sieve). Two grams of dry mass were sampled and dried in an oven at 105 ºC for 12 hours to quantify the dry matter.

The concentrations of neutral detergent fiber (NDF) were determined as described by Van Soest et al. (1991). Crude protein (CP) was quantified as described by the AOAC (1990); neutral detergent insoluble protein (NDIP), as described by Mertens (2002), and the *in vitro* digestibility was determined by adopting the methodology described by Tilley and Terry (1963).

The N accumulation values were obtained as the product of the N concentration in the plant and the dry mass production (DM). Having the dry mass and N accumulation data, the following indices were calculated:

Nitrogen Use Efficiency (NUE) = (total dry mass, kg)/(accumulated N, kg), as kg of DM/kg of accumulated N (Siddiqi and Glass, 1981);

Recovery of the Applied Nitrogen (RNA) = accumulated N with fertilization (kg) – accumulation of N without fertilization (kg)/N dose applied (kg) × 100, as % (Fageria, 1998);

Agronomic Efficiency of the Applied Nitrogen (AE) = fertilized dry mass (kg) – unfertilized dry mass (kg)/N dose (kg); as kg of DM/kg N applied (Fageria, 1998).

The statistical analyses involved the application of basic descriptive measurements aimed to obtain the profile of the dataset by the measures of central tendency (mean) and of dispersion (standard error of the mean [SEM]) by using procedure PROC MEANS. The data were subjected to variance analysis; in the case of a significant F test, regression analysis was performed as a function of the N doses applied on the topsoil, and procedure PROC REG of software SAS (Statistical Analysis System, version 9) was used. To select the regression models (linear and quadratic), the criteria utilized was Akaike's information criterion (Akaike, 1974).

Results and Discussion

The production of dry mass increased ($P<0.05$) as the N doses were increased (Table 1), corroborating the information obtained by Martha Jr. et al. (2007), in which application of N promotes increase in the dry mass of *B. brizantha*. This result is a consequence of the functions performed by the N, like being a structural component of macromolecules and enzymes, involved in the process of vegetative development in plants (Malavolta, 2006). According to Mistura et al. (2006), greater chlorophyll content can be observed in plants with greater nitrogen availability, which increases the availability of photoassimilates that affect the morphogenetic and structural plant characteristics such as the number and size of tillers. Thus, the nitrogen is manifested, on the one hand, by directly improving the efficiency of photosynthesis, and on the other hand, by promoting the priority redistribution of the carbon to form the aerial part (Silva et al., 2013).

The leaf:stem ratio and dead material:full plant ratios were not affected ($P>0.05$) by increase in the N doses (Table 1). Despite the elevation in dry mass production, there was no reduction in the dry matter content ($P>0.05$) (Table 1).

The crude protein concentration in the leaf, stem and full plant showed to have been quadratically affected ($P<0.05$), with point of minimum estimated at 150 kg/ha (Table 1). As the cutting age increases, the cell content is reduced and the fibrous fraction of the grass increases, causing a reduction in the forage nutritional value, because soluble fractions are inversely proportional to the fibrous fractions when the plant age is increased.

According to Van Soest (1994), at forage CP contents lower than 7%, the digestion is reduced due to inappropriate

Table 1 - Productivity and chemical composition of the Marandu grass according to the different nitrogen doses

Variables	Doses						Regression coefficients							P-value	
	0	60	120	180	240	SEM	β0 (SD)	β1 (SD)	β2 (SD)	AICc	Δr	Wr	ERr	L	Q
DMP (kg/ha)	1,740.48	2,011.36	2,184.61	2,461.19	3,365.15	1,47.52	1,927.55 (391.05)	–217 (198.01)	+97.82 (48.73)	161	0.0	0.99	1.0	0.001	0.06
L:S	1.64	1.64	1.65	1.73	1.9	0.05								0.08	0.12
DMt:FP	0.11	0.1	0.31	0.09	0.1	0.04								0.93	0.56
Leaf															
DM ($g.kg^{-1}$)	321.4	312.2	302.1	296	295.7	4.98								0.39	0.56
NDF ($g.kg^{-1}$)	294.6	291.5	240.9	271.4	381.4	23.41	403.47 (98.70)	–116.30 (75.22)	+21.94 (12.30)	133	0.0	0.85	1.0	0.35	0.16
CP ($g.kg^{-1}$)	86.1	86.5	88.6	95.8	99.6	2.71	86.26 (7.05)	–1.37 (0.38)	+0.83 (0.08)	53.9	0.0	0.63	1.0	0.004	0.36
NDIP $g.kg^{-1}$ CP)	402.9	382	372.1	358.9	396.2	7.97	449.82 (12.65)	–52.05 (9.64)	+8.06 (1.58)	71.4	0.0	1.0	1.0	0.27	0.001
IVD ($g.kg^{-1}$)	717.5	711.4	709	715.1	651.6	12.42								0.24	0.37
Stem															
DM ($g.kg^{-1}$)	324.8	324.9	326	317.1	320.9	1.65								0.22	0.55
NDF ($g.kg^{-1}$)	655.9	642.8	659.4	647	618.2	7.25	635.81 (15.90)	+18.77 (12.11)	–4.32 (1.98)	78.2	0.0	0.92	1.0	0.02	0.01
CP ($g.kg^{-1}$)	36.2	36.4	36.8	43.1	48.3	2.41	38.78 (1.79)	–3.67 (1.36)	+1.12 (0.22)	12.7	0.0	1.0	1.0	0.001	0.001
NDIP $g.kg^{-1}$ CP)	393.7	415.7	376.6	449.6	412.3	12.22								0.25	0.53
IVD ($g.kg^{-1}$)	506.5	519.1	504.6	520.4	535.8	5.63								0.06	0.10
Full plant															
DM ($g.kg^{-1}$)	323.1	318.5	314.6	306.5	308.3	3.1								0.67	0.9
NDF ($g.kg^{-1}$)	565.2	610	594.1	575.9	572.6	8.14	540.07 (17.92)	+40.31 (13.66)	–7.04 (2.23)	81.8	0.0	0.99	1.0	0.58	0.02
CP ($g.kg^{-1}$)	71.3	52.8	62.3	50.2	72.5	4.59	91.87 (8.07)	–25.76 (16.15)	+4.29 (1.01)	57.9	0.0	0.99	1.0	0.99	0.004
NDIP $g.kg^{-1}$ CP)	286.4	381.9	334	367.4	351.2	16.51	238.49 (11.05)	+72.50 (30.72)	–10.16 (5.02)	106.1	0.0	0.9	1.0	0.11	0.05
IVD ($g.kg^{-1}$)	662.7	620.2	640.2	608.4	645.9	9.59								0.42	0.15

SEM - standard error of the mean; SD - standard deviation; AICc - Akaike's information criterion; Δr - differences among AICc values; Wr - Akaike weights or likelihood probabilities; ERr - evidence ratio or relative likelihood; L - linear; Q - quadratic; DMP - dry mass production; L:S - leaf:stem ratio; DMt:FP - dead material:full plant ratio; DM - dry matter; NDF - neutral detergent fiber; CP - crude protein; NDIP - neutral detergent indigestible protein; IVD - *in vitro* digestibility.

levels of nitrogen for the rumen microorganisms, which reduces their population, and consequently the digestibility and intake of dry mass. Thus, a higher CP content is necessary in order to meet the protein requirements of the animal organism. In the present study, we observed that the CP levels varied from 5.02 to 7.25%.

The neutral detergent fiber (NDF) from the stem of the forage reduced ($P<0.05$) (Table 1) as well as in the full plant. The response for this variable was quadratic ($P<0.05$), with maximum peak estimated at 100 kg/ha (Table 1). According to Mistura et al. (2007), nitrogen fertilization can reduce the percentage of NDF in plants by stimulating the growth of new tissues, which have lower levels of structural carbohydrates in the dry matter. By contrast, supplying nitrogen at high doses, under favorable climatic conditions, may accelerate the maturity and senescence of the plant, limiting the beneficial effect of nitrogen fertilization on the NDF values. This might have occurred in this study when no influence of nitrogen fertilization was observed on the NDF content.

The neutral detergent insoluble nitrogen (NDIP) content in the leaf and in the plant increased quadratically ($P<0.05$) as the N doses were elevated (Table 1), with maximum peak estimated at 150 kg/ha. This NDIP content may compromise the use of N by the rumen microorganisms, due to the association of N with the lignocellulosic components.

The different N doses had no impact ($P>0.05$) on the *in vitro digestibility* (IVD). The nitrogen use efficiency ($P<0.05$) increased along with the increase in the N doses applied (Figure 1), and its values varied from 24.42 to 47.21%, showing a difference of 51.73% when compared (Table 2); thus, as the quantity of nitrogen in the soil is augmented, its deposition in the plant tissues will also increase.

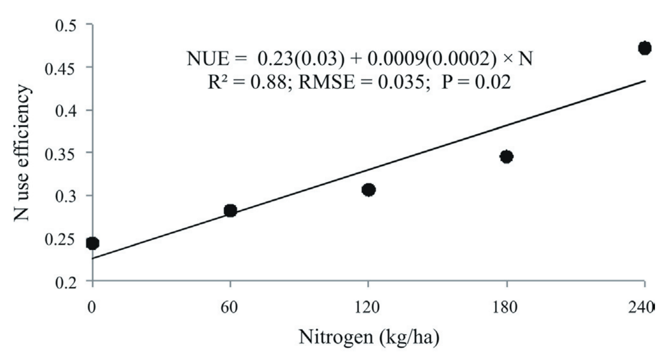
Siddiqi and Glass (1981) reported that plant growth is also related to the concentration of this nutrient in the tissues, and not only in the absolute quantity accumulated, because growth only occurs from a minimum concentration in the plant tissue, which is different among species or varieties.

The recovery of the applied N (RAN) in the form of fertilizer corresponds to the percentage of the total N applied by means of sources (fertilizers) that were absorbed and accumulated additionally by the plants of the fertilized plots in relation to the non-fertilized plants (Fageria, 1998). However, the increase in the N doses in this study did not affect ($P>0.05$) this index (Table 2).

According to Primavesi et al. (2006), this index is easy to estimate and low-cost, because it utilizes only the total N content of the plant and the forage dry mass of the fertilized and unfertilized plots. In intensively managed pastures, where high N doses are used, knowing the recovery of N from the fertilizer by the plants is important so as to maximize its use efficiency and minimize the environmental impact.

The agronomic efficiency of the applied nitrogen was not affected ($P>0.05$) by the doses and sources of N (Table 2). Agronomic efficiency (AE) refers to the additional production of dry mass by the forage in the fertilized plots in relation to the unfertilized plot per unit of nitrogen applied by the utilized sources (Fageria, 1998).

In a study on the agronomic efficiency of Marandu grass, Primavesi et al. (2006) verified that the best indices occurred when the lowest N doses were applied, with reduction in these values as the N doses were increased.



RMSE - Root mean square error.

Figure 1 - Nitrogen use efficiency according to the N doses in Marandu grass.

Table 2 - Nitrogen use efficiency (NUE), recovery of applied nitrogen (RAN) and agronomic efficiency of the nitrogen (AE) according to the nitrogen doses in the Marandu grass

Variables	Doses (kg ha^{-1})					SEM	P-value	
	0	60	120	180	240		L	Q
NUE	0.244	0.282	0.307	0.345	0.472	0.04	0.02	0.04
RAN		0.322	0.264	0.285	0.483	0.05	0.34	0.12
AE		0.452	0.37	0.4	0.677	0.07	0.34	0.12

SEM - standard error of the mean; L - linear effect; Q - quadratic effect.

Conclusions

Nitrogen fertilization allows for improvement in the productivity and chemical composition of Marandu grass, also improving the efficiency with which the grass utilizes the nitrogen.

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