Anais da Academia Brasileira de Ciências (2016) 88(1): 385-395
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
http://dx.doi.org/10.1590/0001-3765201620150180
www.scielo.br/aabc

Sward structure and nutritive value of Alexandergrass fertilized with nitrogen

PAULO R. SALVADOR, LUCIANA PÖTTER, MARTA G. ROCHA, ANELISE P. HUNDERTMARCK, MARIA JOSÉ O. SICHONANY, LUIZ G. AMARAL NETO, MATEUS NEGRINI and PAULO H. MOTERLE

Departamento de Zootecnia, Universidade Federal de Santa Maria, Av. Roraima,1000,
Bairro Camobi, 97105-800 Santa Maria, RS, Brasil

Manuscript received on March 12, 2015; accepted for publication on May 25, 2015

ABSTRACT

This experiment evaluated forage production, sward structure, stocking rate, weight gain per area and nutritive value of forage as grazed by beef heifers on Alexandergrass (*Urochloa plantaginea* (Link) Hitch) pasture fertilized with nitrogen (N): 0; 100; 200 or 300 kg of N/ha. The experiment was a completely randomized design following a repeated measurement arrangement. The experimental animals were Angus heifers with initial age and weight of 15 months and 241.5±5 kg, respectively. The grazing method was continuous, with put-and-take stocking. N utilization, regardless of the level, increase by 25% the daily forage accumulation rate and the weight gain per area by 23%. The level of 97.2 kg N/ha leads to a higher leaf blade mass and increases by 20% the leaf:stem ratio. Alterations in sward structure changes the nutritive value of forage as grazed. The utilization of 112.7 kg of N/ha allows the highest stocking rate (2049.8 kg of BW/ha), equivalent to 7.5 heifers per hectare.

Key words: leaf blade mass, leaf:steam ratio, hand plucking, *Urochloa plantaginea* (Link) Hitch.

INTRODUCTION

Nutrient availability in the soil is a limiting factor for forage production. Among these nutrients, nitrogen (N) defines the production capacity of grasses because it takes part in the processes of growth and development of plant tissues. Besides interfering with total forage production, N modifies the distribution of such production throughout the phenological cycle of the plant, providing increased carrying capacity of the pasture and animal production per hectare.

Using inadequate levels of N may increase the risk of environmental contamination since forage production of plants is not proportional to increased quantities of N (Scholefield and Titchen 1995). The knowledge of the production potential of forage species, in response to N fertilization, may reduce the risk of environmental contamination since, to minimize losses, this nutrient must be supplied in an amount equal to or less than the maximum capacity of absorption by plants (Farruggia et al. 2004). This response can be measured by the amount of forage produced and the capacity of soil in making N available and it determines the amount of N to be used by each species and soil type (Lemaire et al. 2008). Studies aimed at determining N rates that do not exceed the responsiveness of grass reinforce the concern of Boval and Lemaire

---

Correspondence to: Luciana Pötter
E-mail: potter.luciana@gmail.com

(2002), which highlights that the major challenges of production systems are related to reducing environmental impact, producing quality food, reducing production costs and increasing efficiency of N utilization.

Alexandergrass (*Urochloa plantaginea* (Link) Hitch), a species considered invasive in summer crops, has demonstrated suitable characteristics for use as forage for rearing of beef heifers (Costa et al. 2011, Souza et al. 2012, Oliveira Neto et al. 2013, Eloy et al. 2014). These studies used an average of 64 kg N/ha with a stocking rate of 2370.3 kg body weight/ha. However, in this species, additional studies on the use of N fertilization are still needed (Martins et al. 2000, Adami et al. 2010, Sartor et al. 2014). Changes in production and nutritive value of forage can happen by the N use and, as well, an increase in the stocking rate, allowing a greater number of beef heifers to reach the required development for mating at a young age, affecting the economic feasibility of the rearing activity.

This study aimed to investigate the production of forage, sward structure, stocking rate, weight gain per unit area and chemical composition of forage as grazed by beef heifers on Alexandergrass fertilized with N.

MATERIALS AND METHODS

This experiment was approved by the Ethics Committee for Animal Experimentation of Universidade Federal de Santa Maria (protocol 070/2013). The study was conducted at Universidade Federal de Santa Maria, located in the Depressão Central of Rio Grande do Sul, Brazil, from February to May of 2013, in four periods of 21 days each.

The climate in the region is humid subtropical according to the Köppen classification. Meteorological data were obtained from the Meteorological Station of the Universidade Federal de Santa Maria (Table I). The soil in the experimental area is classified as Paleudalf (EMBRAPA 2006) and the mean values for the chemical characteristics of the soil were: pH-H_2O: 5.82; % clay: 18 m/V; P: 15.8 mg/L; K: 85.6 mg/L; % organic matter: 2.7 m/V; Al^{3+}: 0.7 cmol/L; Ca^{2+}: 5.3 cmol/L; Mg^{2+}: 2.6 cmol/L; CEC pH 7: 11.4.

Treatments consisted of Alexandergrass (*Urochloa plantaginea* (Link) Hitch) pasture fertilized with 0; 100; 200 or 300 kg N/ha. The experimental area (5.6 ha) was divided into six experimental units of 0.4 ha and four experimental units of 0.8 ha each, plus a contiguous area of 2.8 ha for the put-and-take animals.

The Alexandergrass pasture was established by an existing seed bank in the area on December 15th, 2012, through two diskings. Paddocks received fertilization with phosphorus and potassium based on the recommendation of fertilization and liming for the states of Rio Grande do Sul and Santa

TABLE I
Average monthly temperature and rainfall during the evaluation period and normal history data. Santa Maria/RS.

	Month of evaluation					
Items	December	January	February	March	April	May
	- - - - - - - - - - - - - - Observed values[1] - - - - - - - - - - - - - -					
Rainfall (mm)	293.0	145.3	97.7	188.6	147.7	71.6
Average temperature (ºC)	24.9	24.2	24.4	21.5	20.3	19.8
	- - - - - - - - - - - - - Historical averages[2] - - - - - - - - - - - - - - -					
Rainfall (mm)	133.5	145.1	130.2	151.7	134.7	129.1
Average temperature (ºC)	22.7	24.6	24.0	22.2	18.8	16.0

[1]12/01/2012 - 05/31/2013; [2]1961 – 1990.

Catarina (ROLAS 1994). The total amount of N was split into three doses of similar amounts, the first applied at the time of soil tillage and the others on February 4th and March 3rd. The experimental animals were 30 Angus heifers with an initial age of 15 months and body weight of 241.5±5 kg.

The grazing method was "put and take" stocking to maintain 2500 to 3000 kg DM/ha of forage mass, with three test animals per paddock. The adjustment of stocking rate was performed every 10 days, according to Heringer and Carvalho (2002).

Forage mass (FM) was estimated every 10 days by direct visual estimation technique with double sampling. The forage was cut at ground level and the collected samples were split into two sub-samples for determination of dry matter (DM) content. Botanical and structural components were separated manually to calculate the leaf:stem ratio. The content of DM was determined by oven drying the samples at 55 °C for 72 h.

The forage accumulation rate (kg of DM/ha/day) was determined using three exclusion cages in each experimental unit, every 21 days (Gardner 1986). The vertical structure of the sward was evaluated in three representative areas of the forage mass in each experimental unit, every 21 days, according to the methodology described by Stobbs (1973), using 0.25 m^2 squares. In each square, forage samples were taken, every 10 cm, from the top to the bottom of the sward and separated manually into stem, leaf blade and dead material components. Then the components were oven-dried (at 55 °C for 72 h) and weighed to calculate the bulk density (g/cm^3) of each component.

The stocking rate (SR; kg body weight/ha), by period, was calculated according to the equation: [mean body weight of testers + (body weight of animals used for adjustments in the stocking rate * number of days at experimental unit) / days of trial period].

Forage allowance (FA) was calculated by the equation: FA = FM / number of days in the period + forage accumulation rate (FAR) / SR. Leaf blade allowance (LBA) was calculated by the equation: = FM / number of days in the period + FAR * % of leaf blade / SR. In both cases, values were multiplied by 100 and expressed in kg DM/100 kg live weight.

Hand plucking technique was performed according to the methodology proposed by Euclides et al. (1992). Forage samples were dried at 55 °C for 72 h, and ground in a Wiley type mill for subsequent laboratory analyses (crude protein, neutral detergent fiber, dry matter and organic matter digestibility).

Tiller density (tillers/m^2) was assessed by counting the tillers of Alexandergrass at three and two fixed locations (0.0625 m^2 each) in the paddocks of 0.8 ha and 0.4 ha, respectively. The number of green leaves and the length of leaf blades of Alexandergrass, in each paddock, were determined by marking 40 tillers with colored plastic wire (Carrère et al. 1997). The number of green leaves was determined by visual counting and the length of leaf blades was determined with the aid of a ruler graduated in centimeters.

Heifers were weighed every 21 days, following a 12 h fast from solids and liquids. The average daily weight gain (kg) was calculated as the weight difference between two consecutive weight dates divided by the number of days in the period. Dividing the average stocking rate by body weight of the test heifers in each treatment, the average number of animals per ha was obtained. Multiplying this value by the average daily weight gain of test heifers, the weight gain per unit of area, in kg of body weight/ha, was estimated.

A completely randomized design following a repeated measurement arrangement was used, with four treatments and three (200 and 300 kg N/ha) and two (0 and 100 kg N/ha) area replications for treatments.

Statistical analyses were performed using the 'Mixed' procedure of SAS software program for variables that showed normality of residuals. We used a mixed model with fixed effects (amounts of N, periods of assessment and their interactions) and random effects (the residual and the nested paddocks for each amount of N).

We performed a structure selection test, following the Bayesian information criterion (BIC), to determine the model that best represented the data. The variables leaf blade allowance, leaf:stem ratio and 10-20 cm strata (dead material) were transformed to square root. The General Linear Models (GLM) procedure was used to analyze the variables relating to the volume density in the different strata. The interaction between treatments and evaluation periods was significant at 5% probability and variable responses were modeled according to N levels. We used the Non Linear (NLIN) procedure for non-linear regression. The STEPWISE (Forward) procedure was utilized for the multiple regression, to identify independent variables influencing the response variables. When not fitted to regression models, the averages were compared using the 'lsmeans' procedure and by examining orthogonal contrasts between the level 0 *vs* 100; 200 and 300 kg N/ha.

RESULTS

Meteorological data for the trial period showed that the average daily temperature and monthly rainfall were 22.5 °C and 157 mm, respectively.

There was no interaction between levels of nitrogen (N) × evaluation periods for forage mass, forage allowance, leaf blades allowance and sward height (P>0.05). The forage mass (2965 kg of DM/ha) and sward height (17.1 cm) were similar in paddocks receiving different levels of N. In all paddocks, similar values were observed for forage allowance and leaf blades allowance, averaging 13.0 and 2.9 kg DM/100 kg body weight (BW), respectively.

There was no interaction between N levels × evaluation periods (P>0.05) for the forage accumulation rate, stem mass, leaf:stem ratio, tiller density (Table II), leaf blade mass, dead material mass, and leaf blade length.

Forage accumulation rate, averaging 92.8 kg DM/ha/day, did not fit the polynomial regression models tested (P>0.05). When the mean values of the forage accumulation rate were analyzed by contrast, the use of N led to an increase of 25.5 kg DM/ha/day on this rate (Table II).

The mean values of leaf blade mass (626.1 kg DM/ha) did not fit the polynomial regression models tested according to N levels (P>0.05). An increase in leaf mass up to 97.25 kg N/ha, with a maximum value of 680 kg DM/ha was observed when the mean values were subjected to nonlinear regression analysis.

The mass of stems of Alexandergrass was independent of N levels, averaging 1522.7 kg DM/ha. By contrast, there was an increase of 145 kg of stems/ha in the forage mass when using N (Table II). The mass of dead material was not modified by the use of different levels of N, averaging 377.9 kg DM/ha, with no significant change identified by the contrast analysis (P=0.8315). The use of different levels of N did not change the leaf:stem ratio, which was in average 0.45. By contrast, it has been found that the use of N increased by 0.08 the leaf:stem ratio (Table II).

TABLE II
Orthogonal contrasts for forage accumulation rate, mass of stems, leaf:stem ratio and tiller density of Alexandergrass grazed by heifers according to N use.

	-------N fertilization-------			
Items	Without[1]	With[2]	P[3]	CV[4]
Forage accumulation rate[5]	73.7	99.2	0.0500	13.1
Mass of stems[6]	1413.7	1559.1	0.0151	6.4
Leaf:stem ratio	0.39	0.47	0.0015	5.5
Tiller density[7]	953.0	1165.3	0.0416	27.0
Weight gain per area[8]	372.6	461.5	0.0443	12.3

[1]zero kg N/ha; [2]100; 200 and 300 kg N/ha; [3]probability of contrast test; [4]coefficients of variation (%); [5]kg DM/ha/day; [6]kg DM/ha; [7]tiller/m²; [8]kg BW/ha.

The values of tiller density did not fit the regression models tested ($P>0.05$). By contrast, the use of N enabled the maintenance of 1165 tillers/m^2, which is 212 tillers/m^2 higher than the tiller density in paddocks where N was not applied (Table II). Leaf blade length, 9.0 cm, did not change ($P>0.05$) with the use of different quantities of N.

An interaction was detected between levels of N and evaluation periods for the number of green leaves ($P=0.0038$). Regardless of N use, the number of green leaves was 5.3 in the first and 4.4 leaves/tiller in the second period. The number of green leaves per tiller on the third evaluation period fitted a negative linear regression according to N levels, with a reduction of 0.002 leaves/tiller to each kg N applied ($\hat{Y}=4.3-0.002x$; $P=0.0124$; $r^2=0.56$; CV=6.5%). In the fourth period, the number of green leaves per tiller fitted a quadratic regression model, where the largest number of green leaves was estimated when applied 125 kg N/ha ($\hat{Y}=3.06+0.005x-0.002x^2$; $P=0.0207$; $r^2=0.64$; CV=7.1%)

There was no interaction between N levels and evaluation periods ($P>0.05$) for the structural components of the sward (leaf, stem and dead material) in 0-10 and 10-20 cm strata (Table III).

The bulk density of leaves and stems fitted a non-linear regression model in the 0-10 cm strata. According to the model, there was an increase in bulk density of leaves up to 161 kg N/ha, with a maximum value of 2.35 g DM/cm^3 ($r^2=0.57$). The bulk density of stems increased up to 208 kg N/ha, reaching a maximum of 9.20 g DM/cm^3 ($r^2=0.86$). The bulk density of dead material in the 0-10 cm strata, with a mean of 3.22 g DM/cm^3 did not change with the use of different quantities of N.

In the 10-20 cm strata, structural components did not fit the regression models tested. In this strata, the bulk density of leaf and stem averaged 1.52 and 2.14 g DM/cm^3, respectively. The bulk density of dead material, when examined by contrast, showed a reduction of 0.5 g DM/cm^3 when N was used (0.77 vs. 0.27 g DM/cm^3).

No interaction between N levels and evaluation periods ($P>0.05$) for crude protein (CP) content and *in situ* digestibility of organic matter of forage as grazed was observed.

The content of CP of the forage as grazed fitted a nonlinear regression model, in which there was an increase in the CP content up to 152.6 kg N/ha, reaching a maximum of 16.1% ($P=0.0210$; $r^2=0.66$). Heifers grazed forage with similar *in situ* digestibility of organic matter, regardless of N application. By contrast, there was an increase of 2.8% in the organic matter digestibility of forage as grazed when Alexandergrass received N fertilizer (76.2 *vs* 79.0%).

There was interaction between N levels × evaluation periods ($P<0.05$) for neutral detergent fiber content of forage as grazed. In the first

TABLE III
Bulk density of the structural components of the sward (leaves, stems and dead material) of Alexandergrass in the 0-10 and 10-20 cm strata according to N levels.

	-------Levels of N[1]-------						
Component[2] / strata	0	100	200	300	P[3]	P[4]	CV[5]
Leaf / 0–10 cm	1.28	1.96	2.43	2.26	0.0497	-	30.3
Stem / 0–10 cm	7.06	8.14	9.12	9.19	0.0009	-	21.5
Dead material / 0–10 cm	3.29	3.43	3.32	2.92	ns	ns	27.7
Leaf / 10–20 cm	1.36	1.84	1.35	1.56	ns	ns	32.8
Stem / 10–20 cm	2.43	2.36	2.07	1.73	ns	ns	28.0
Dead material / 10–20 cm	0.77	0.35	0.25	0.21	ns	0.0382	40.8

[1]kg N/ha; [2]g/cm^3; [3]probalitity of regression models; [4]probability of contrast test; [5]coefficients of variation (%).

evaluation period, heifers harvested forage with an average value of neutral detergent fiber of 55.0%. In the second period, the forage as grazed showed a higher content of neutral detergent fiber in paddocks without N fertilization (55.9%), without difference from paddocks fertilized with 100 or 200 kg N/ha, on average 52.64%. The lower value of neutral detergent fiber was determined in forage as grazed from paddocks fertilized with 300 kg N/ha and did not differ from the value of forage collected in paddocks fertilized with 100 or 200 kg N/ha.

In the third evaluation period, the data of neutral detergent fiber fitted a negative linear regression model, with a reduction of 0.022% for each kg of N used ($\hat{Y}=62-0.022x$; $r^2=0.59$; CV=3.9%). In the fourth period, there was a quadratic effect of N levels on the content of neutral detergent fiber of forage with a lower value when 200 kg N/ha was used ($\hat{Y}=64.9-0.064x + 0.00016x^2$; P=0.032; $r^2=0.67$; CV=3.1%).

We found no interaction between N levels × evaluation periods (P>0.05) for average daily gain and stocking rate. Average daily gain was similar (P>0.05; 0.744 kg/day), when animals remained on Alexandergrass paddocks, regardless of the level of N utilized. With that average daily gain, the average weight of heifers at the end of the grazing period was 304.3 kg BW.

Values of stocking rate fitted a nonlinear regression model, increasing to the level of 112.7 kg N/ha, with a maximum of 2049.8 kg BW/ha (P=0.0396; $r^2=0.60$). The weight gain per area, averaging 448.5 kg BW/ha did not fit any regression model tested (P>0.05). In the contrast analysis, we observed that the weight gain per area in nitrogen-free paddocks was 88.9 kg BW/ha lower than the gain obtained in the paddocks fertilized with N, which averaged 461 kg BW/ha (Table II).

DISCUSSION

The average temperature during the experiment was similar to the historical average (21.3 °C). The rainfall exceeded by 120 mm the rainfall expected for the period, providing suitable climatic conditions for plant development.

The forage mass, 2965 kg DM/ha, is within the range intended by the experimental protocol. Maintaining this value of forage mass in Alexandergrass, which is a tropical and annual species, did not allow an early elongation of stems. This elongation reduces the proportion of leaves in relation to stems and increases the mass of senescent and dead material. Similar values of forage mass and sward height allowed similar grazing conditions in all paddocks used to evaluate the different levels of N. The forage and leaf blades allowance were 5.6 and 1.2 times higher, respectively, than the requirement of dry matter intake (NRC 1996). This value of forage allowance in tropical forage species ensures no restriction on intake (Moojen and Maraschin 2002).

The production of DM in Alexandergrass depends on climatic conditions and the contribution of N which, in turn, is dependent on the amount of organic matter in soil. The OM content in the soil where the pasture was cultivated is considered medium (ROLAS 1994). Under this condition, the increase in daily DM accumulation, started from the use of 100 kg N/ha. In soils with high organic matter content (5.7%), the greatest forage accumulation was observed with the application of 200 kg N/ha, resulting in forage production 68% higher than that obtained herein (Adami et al. 2010). These results make evident that the input of N only from the soil does not allow annual summer grasses to express their maximum potential due to high accumulation rates and high demand for N (Sympson and Stobbs 1981).

The amplitude of response to N fertilization in soils with different contents of OM confirms that, to produce the same amount of forage, the larger the N supply by soil, the lower is the requirement for N fertilization (Peyraud and Astigarraga 1998). Besides the hypothesis mentioned by these authors, Alexandergrass is considered an invasive plant and, probably, has a higher efficiency in uptake and utilization of nutrients (Firbank and Watkinson 1985), with production of 73.7 kg DM/ha/day even without the use of N.

The tiller density changed, with 212 more tillers per m^2 in the paddocks under N fertilization. In pastures where there is limitation of N, due to the high demand for this nutrient, not all buds develop and generate a new tiller (Lemaire 1985). Thus, the increased input of N allowed the development of a greater number of tillers in the potential growth points generated from the growth and differentiation of phythomers of Alexandergrass. According to Davies (1974), with increasing availability of N, there is an increase in potential tillering rate and hence in tiller density, without changing the leaf appearance rate.

The higher tiller density in response to N fertilization may have contributed to increase the forage accumulation rate and hence DM production, because they are variables that depend on the growth of individual tillers. Without N fertilization, considering the corresponding forage accumulation rate, every tiller produced 0.0077 g DM/day, and when N was applied, there was an increase of 8% in DM production in each tiller.

The values of leaf blade length fitted a multiple regression model ($\hat{Y} = 2.20 + 0.30$ sward height; $r^2=0.62$; $P<0.0001$), where the sward height explained 62% of leaf blade length. The increase in leaf blade size is due to an increase in leaf expansion rate caused by the higher N input or the longer duration of leaf elongation as a function of increased sheath size (Lemaire and Chapman 1996). Greater sward heights may have resulted in longer length of leaf sheath and, thus, may have extended the duration of leaf elongation (Duru et al. 1999).

Moreover, higher leaf blade mass can be explained by the increase in tiller density provided by the use of N. The use of N, from 97.25 kg/ha resulted in 10% increase in the mass of stems and 54% in the mass of leaf blades. Considering only the increase in the production of stems and leaves caused by N, 1.67 kg leaf blade were produced for each kg of stem, increasing the leaf:stem ratio. This increased leaf:stem ratio is desirable because in tropical grasses, like Alexandergrass, the largest proportion of leaves may allow selection of forage with better quality, since stems are a physical barrier to the bite formation mainly due to the density and resistance they offer to grazing herbivorous (Benvenutti et al. 2006).

In Alexandergrass, which has caespitose/decumbent growth habit, changes in the mass of leaves, stems and leaf:stem ratio resemble the effect produced by N in caespitose grasses and also in stoloniferous species. According to Cruz and Boval (2000), in the vegetative phenological stage of caespitose grasses, in response to additional N, only leaf blades are produced. In stoloniferous species, however, both leaves and stolons are produced.

The relative participation of dead material in the forage mass averaged 12% in all paddocks. It is possible that the maintenance of the same forage allowance and sward height may have contributed to the similarity of the observed values.

The leaf blades mass of Alexandergrass explained 60% of the forage accumulation rate ($\hat{Y} = -1.75 + 0.15$ leaf mass; $P<0.0001$; $r^2=0.60$; CV=30%). According to the equation, it is estimated that with the increase of one kg/ha DM of leaf blades, an increase of 0.15 kg DM/ha/day in forage accumulation rate is expected. The increased mass of leaf blades can increase light interception and efficiency of utilization of photosynthetically active radiation which combined, with N fertilization, can increase the forage accumulation rate.

The N effect on the number of green leaves/tiller was only observed 12 days after the last application of N (15/03/2013). There was a reduction in the number of green leaves with increasing levels of N, with an estimated reduction of 0.002 leaves for each kg of N. Probably, the higher N supply change the use of this nutrient by plants. In this case, the plants used the N for stem elongation and inflorescence formation in detriment to maintain the major number of green leaves/tillers.

The quadratic effect of N levels, in the fourth period of evaluation, evidences the plant capacity to shift the use of N over time according to its requirement of nutrients for tissue formation, since in this period, most plants had already reached the reproductive stage.

The use of N increased by 38% and 40% the ratio of the volume density of leaves and stems in the 0-10 and 10-20 cm strata, respectively. This effect of N in providing greater amount of leaf blades relative to stems in the 10-20 cm strata is of utmost importance because the forage in this stratum is more easily consumed by animals.

The higher amount of N available, probably reduced the remobilization of N from leaf tissues for the formation of new organs in the plant (Bredemeier and Mundstock 2000), enabling maintenance of a smaller amount of dead material in the 10-20 cm strata. This effect of N in maintaining a smaller amount of dead material in the strata more accessible to the animals, and the higher leaf:stem ratio, may have allowed animals to select forage with higher crude protein and *in situ* digestibility of OM.

Changes caused by different N levels on tiller density, mass of leaves and stems, leaf:stem ratio, density of dead material in the 10-20 cm strata and the ratio between leaf and stem density in the 10-20 cm strata may have increased the content of crude protein and OM digestibility of the forage as grazed. This evidence of the role of sward structure on herbivore and plant relationship had already been observed by Trindade et al. (2012). Furthemore, as observed by Benvenutti et al. (2006), in tropical grasses, stems are primarily responsible for changes in sward structure and define forage intake.

Values of CP of forage as grazed fitted a multiple regression model ($\hat{Y}$ = 13.09 + 5.5 leaf:stem ratio + 0.01 forage accumulation rate; r^2=0.83; P=0.0041), and can be explained by the leaf:stem ratio (74%) and the forage accumulation rate (9%). The largest proportion of leaf blades in relation to stems in the forage mass and the highest forage accumulation rate, may have provided a sward structure favorable to the greater selection of leaves, which are richer in N.

In paddocks receiving N fertilization, heifers harvested forage with *in situ* digestibility of OM increased by 2.8%. This was due to the higher leaf:stem ratio of Alexandergrass in the pasture under N fertilization, since leaves have higher digestibility in comparison to stems (Queiroz et al. 2000).

In the first evaluation period, the leaf:stem ratio (0.75) of Alexandergrass, allowed the selection of forage with similar values of neutral detergent fiber (NDF). In the second evaluation period, the content of NDF in forage as grazed was explained by the tiller density (53.7%) and by the leaf blade length (37.3%) ($\hat{Y}$ = 45.1 – 0.009 tiller density + 1.77 leaf blade length; P=0.003; r^2=0.91). With higher tiller density, a reduction in the participation of stems in the grazeable strata may have occurred by the reduction in the size of tillers. With smaller tiller size, a reduction in the leaf blade size (Cruz and Boval 2000), providing a sward structure more favorable to forage harvest and hence with lower content of NDF, may have occurred.

In the third evaluation period, heifers harvested forage with NDF content 0.022% lower for each kg of N applied. The higher supply of N may have provided favorable sward structure for harvesting of leaf blades, which have lower content of NDF in relation to stem. It is expected that 84% of the diet of grazing cattle is composed of leaf blades (Euclides et al. 2000). Corroborating these authors, in that period, according to the multiple regression model, the content of NDF of forage as grazed was explained by leaf:stem ratio (44.5%) and by the leaf blade length (28.5%) ($\hat{Y}$ = 39.1 – 32.6 leaf:stem ratio + 3.7 leaf blade length; P=0.0102; r^2=0.73).

In the fourth evaluation period, there was a quadratic effect of N levels on the content of NDF in the forage as grazed. The lowest NDF content was obtained with the use of 200 kg N/ha. In paddocks fertilized with this quantity, it is likely that the tillers of Alexandergrass prolonged their vegetative stage, since in this final period of pasture utilization, most tillers had already reached the reproductive stage. With the onset of the reproductive stage, tillers directed nutrients to the stem elongation and inflorescence emission, which can result in greater sward height. This hypothesis is confirmed by the fact that during this period, the sward height explained 64% of the NDF content of forage as grazed ($\hat{Y}$ = 47.06 + 1.0 sward height; P=0.0050; r^2=0.64).

The average daily gain attained by heifers can be considered high, being similar to gains achieved by animals of the same category in cold forage pastures (Pötter et al. 2010). According to the nonlinear regression model, there was an increase in the stocking rate up to the level of 112.7 kg N/ha. The increased stocking rate in paddocks subjected to N fertilization can be attributed to the higher forage accumulation rate, representing an increase of 2.3 heifers/ha (5.2 vs 7.5 heifers/ha). In addition to the stocking rate increase promoted by the use of N, the gain per area was 88.9 kg/ha BW higher in paddocks subjected to N fertilization.

CONCLUSION

The level of 97.2 kg nitrogen/ha increases the mass of leaf blades and the leaf:stem ratio of Alexandergrass. Heifers grazing on Alexandergrass fertilized with levels from 100 kg nitrogen/ha harvest forage with higher crude protein content and *in situ* digestibility of organic matter. The use of nitrogen fertilization on Alexandergrass increases the forage production allowing a higher stocking rate and gain per area and enables the rearing of 2.3 more heifers per hectare. In Alexandergrass used for grazing, we recommend the level of 100 kg nitrogen/ha.

RESUMO

Nesse experimento objetivou-se estudar a produção de forragem, estrutura do dossel, taxa de lotação, ganho de peso por área e o valor nutritivo da forragem aparentemente consumida por bezerras de corte em pastagem de papuã (*Urochloa plantaginea* (Link) Hitch) adubada com nitrogênio (N): 0; 100; 200 ou 300 kg/ha. O delineamento experimental foi inteiramente casualizado, com medidas repetidas no tempo. Os animais experimentais foram bezerras da raça Angus com idade e peso iniciais de 15 meses e 241±5 kg, respectivamente. O método de pastejo foi contínuo, com número variável de animais. A utilização de N, independente da quantidade, aumentou em 25% a taxa de acúmulo de forragem. A adubação com N proporciona aumento de 25% na taxa de acúmulo diária de forragem e 23% no ganho de peso por área. A dose de 97,2 kg/ha de N proporciona maior massa de lâminas foliares e aumento de 20% na razão folha:colmo. As alterações na estrutura do dossel modificam o valor nutritivo da forragem da simulação de pastejo. A dose de 112,7 kg/ha de N permite a manutenção da maior taxa de lotação (2049,8 kg/ha de PC), equivalendo a 7,5 bezerras por hectare.

Palavras-chave: massa de lâminas foliares, razão folha: colmo, simulação de pastejo, *Urochloa plantaginea* (Link) Hitch.

REFERENCES

ADAMI PF, SOARES AB, ASSMANN TS, ASMANN AL, SARTOR LR, PITTA CSR, FRANCHIN MF AND MIGLIORINI F. 2010. Dynamic of a papuã pasture under two grazing intensities and two nitrogen levels. Rev Bras Zootecn 39: 2569-2577.

BENVENUTTI MA, GORDON IJ AND POPPI IJ MA. 2006. The effect of density and physical properties of grass stem on the foraging behavior and instantaneous intake rate by cattle grazing an artificial reproductive tropical swards. Grass Forage Sci 61: 272-281.

BOVAL M AND LEMAIRE G. 2002. N uptake and distribution in crops: an agronomical and ecophysiological perspective. J Ex Bot 53: 789-799.

BREDEMEIER C AND MUNDSTOCK CM. 2000. Regulação da absorção e assimilação do nitrogênio nas plantas. Cienc Rural 30: 365-372.

CARRÈRE P, LOUAULT F AND SOUSSANA JF. 1997. Tissue turnover within grass-clover mixed swards grazed by sheep. Methodology for calculating growth senescence and intake fluxes. J Appl Ecol 34: 333-348.

COSTA VG, ROCHA MG, PÖTTER L, ROSO D, ROSA ATN AND REIS J. 2011. Comportamento de pastejo e ingestão de forragem por novilhas de corte em pastagens de milheto e papuã. Rev Bras Zootecn 40: 251-259.

CRUZ P AND BOVAL M. 2000. Effect of nitrogen on some morphogenetic traits of temperate and tropical perennial forage grasses. In: Grassland Ecophysiology and Grazing Ecology, CAB International, Lemaire G, Moraes A, Nabinger C and Carvalho PCF (Eds), Wallingfor, CAB, p. 151-167.

DAVIES A. 1974. Leaf tissue remaining after cutting and regrow in perenial ryegrass. J Agr Sci 82: 165-172.

DURU M, DUCROCQ H AND FEUILLERAC E. 1999. Effet du régime de défoliation et de l'azotesur le phyllochrone du dactyle. Cr Acad Sci III-Vie 322: 717-722.

ELOY LR, ROCHA MG, PÖTTER L, SALVADOR PR, STIVANIM SCB AND HAMPEL VS. 2014. Biomass flows and defoliation patterns of alexandergrass pasture grazed by beef heifers, receiving or not protein salt. Acta Sci-An Sci 36: 123-128.

EMBRAPA. 2006. Centro Nacional de Pesquisa de Solos. Sistema brasileiro de classificação de solos. Rio de Janeiro: EMBRAPA. Rio de Janeiro, 306 p.

EUCLIDES VPB, CARDOSO EG, MACEDO MCM AND OLIVEIRA MP. 2000. Consumo voluntário de *Braquiaria decumbens* cv. Basilisk e *Braquiaria brizanta* cv. Marandú sob pastejo. Rev Bras Zootecn 29: 2200-2208.

EUCLIDES VPB, MACEDO MCM AND OLIVEIRA MP. 1992. Avaliação de diferentes métodos de amostragem para estimar o valor nutritivo de forragens sob pastejo. Rev Bras Zootecn 21: 691-701.

FARRUGGIA A, GASTAL F AND SCHOLEFIELD D. 2004. Assessment of the nitrogen status of grassland. Grass Forage Sci 59: 113-120.

FIRBANK LG AND WATKINSON AR. 1985. On the analysis of competition within two-species mixtures of plants. J Appl Ecol 22: 503-517.

GARDNER AL. 1986. Técnicas de pesquisa em pastagens e aplicabilidade de resultados em sistemas de produção. IICA. Brasil, 197 p.

HERINGER I AND CARVALHO PCF. 2002. Ajuste da carga animal em experimentos de pastejo: uma nova proposta. Cienc Rural 32: 675-679.

LEMAIRE G. 1985. Cinétique de croissance d'um peuplement de fétuque élévéé (*Festuca arundinacea* Schreb.) pendant l'hiver et le printemps. Effects des festeurs climatiques. Thèse Doctorat és Sciences Naturelles, Université de Caen, France.

LEMAIRE G AND CHAPMAN DF. 1996. Tissue flows in grazed plants communities: In: The Ecology and Management of Grazing Systems, CAB International, Hodgson J and Illius AW (Eds), Wallingfor, CAB, p. 3-36.

LEMAIRE G, JEUFFROY MH AND GASTAL F. 2008. Diagnosis tool for plant and crop N status in vegetative stage: theory and practices for N management. Eur J Agron 28: 614-624.

MARTINS JD, RESTLE J AND BARRETO IL. 2000. Produção animal em capim papuã (*Braquiaria plantaginea* (Link) Hitch) submetido a níveis de nitrogênio. Cienc Rural 30: 887-892.

MOOJEN EL AND MARASCHIN GZ. 2002. Potencial produtivo de uma pastagem nativa do Rio Grande do Sul submetida a níveis de oferta de forragem. Cienc Rural 32: 127-132.

NRC - NATIONAL RESEARCH COUNCIL. 1996. Nutrient requirements of beef cattle.7th ed., Washington: National Academy, 90 p.

OLIVEIRA NETO RA, SILVA JHS, ROCHA MG, PÖTTER L, SICHONANY MJO, BISCAÍNO LL, SANTOS FA AND DIFANTE MVB. 2013. Ingestive behaviour, performance and forage intake by beef heifers on tropical pasture systems. Rev Bras Zootecn 42: 549-549.

PEYRAUD JL AND ASTIGARRAGA L. 1998. Review of the effect of nitrogen fertilization on the chemical composition, intake, digestion and nutritive value of fresh herbage: consequences on animal nutrition and N balance. Anim Feed Sci Tech 72: 235-259.

PÖTTER L, ROCHA MG, ROSO D, COSTA VG, GLIENKE CL AND ROSA ATN. 2010. Suplementação com concentrado para novilhas de corte mantidas em pastagens cultivadas de estação fria. Rev Bras Zootecn 39: 992-1001.

QUEIROZ DS, GOMIDE JA AND MARIA J. 2000. Avaliação da folha, e do colmo de topo e base de perfilhos de gramíneas forrageiras. 1. Digestibilidade *in* vitro e composição química. Rev Bras Zootecn 29: 53-60.

ROLAS. 1994. Recomendações de adubação e calagem para os Estados do Rio Grande do Sul e Santa Catarina. Passo Fundo: SBCS Núcleo Regional Sul, 224 p.

SARTOR LR, ASSMANN TS, SOARES AB, ADAMI PF, ASSMANN AL AND ORTIZ S. 2014. Assessment of the nutritional status of grassland: nitrogen nutrition index. Semin-Ciênc Agrar 35: 449-456.

SHOLEFIELD D AND TITCHEN NM. 1995. Development of a rapid field test for soil mineral nitrogen and its application to grazed grassland. Soil Use Manage 11: 33-43.

SOUZA ANM, ROCHA MG, ROSO D, PÖTTER L, ROSA ATN, ILHA GF AND CONFORTIN ACC. 2012. Productivity and reproductive performance of grazing beef heifers bred at 18 months of age. Rev Bras Zootecn 41: 306-313.

STOBBS TH. 1973. The effect of plant structure on intake of tropical pasture. I. variation in bite size of grazing cattle. Aust J Agr Res 24: 809-819.

SYMPSON JR AND STOBBS TH. 1981. Nitrogen supply and animal production from pastures. In: Morley FHW (Ed), Grazing Animals. Amsterdam: The Hague, p. 261-288.

TRINDADE JK, PINTO CE, NEVES FP, MEZZALIRA JC, BREMM C, GENRO TCM, TISCHLER MR, NABINGER C, GONDA HL AND CARVALHO PCF. 2012. Forage allowance as a target of grazing management: implications on grazing time and forage searching. Rangeland Ecol Manag 65: 382-393.