Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v36i2.21815

Biomass flows and defoliation patterns of alexandergrass pasture grazed by beef heifers, receiving or not protein salt

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ABSTRACT. The experiment aimed at evaluating leaf biomass flow, intensity and frequency of defoliation of Alexandergrass (*Urochloa plantaginea* (Link) Hitch) by beef heifers exclusively on pasture or that grazed and received protein salt. A completely randomized experimental design was used with repeated measures over time, two treatments and two area replications, with three Angus test heifers by paddock. Leaf blade intake flow is 18% superior for heifers exclusively on pasture. Grazing intensity (59.8%) is similar when heifers receive protein salt or not. Heifers receiving protein salt reduce by one day the defoliation frequency of tillers. The supply of protein salt for beef heifers grazing Alexandergrass affects the herbivore-plant relationship, decreasing intake flow and leaf blade defoliation frequency.

Keywords: defoliation frequency, defoliation intensity, morphogenesis, *Urochloa plantaginea*.

Fluxos de biomassa e padrões de desfolhação em papuã pastejado por bezerras recebendo ou não sal proteinado

RESUMO. O experimento foi conduzido para avaliar os fluxos de biomassa foliar, intensidade e frequência de desfolhação em papuã (*Urochloa plantaginea* (Link) Hitch), pastejado por bezerras de corte exclusivamente em pastejo ou em pastejo e recebendo sal proteinado. O delineamento foi inteiramente casualizado, com medidas repetidas no tempo, dois tratamentos e duas repetições de área, com três bezerras testes da raça Angus por piquete. O fluxo de consumo de lâminas foliares é 18% superior quando as bezerras permanecem exclusivamente em pastejo. A intensidade de pastejo (59,8%) é semelhante quando as bezerras recebem sal proteinado ou não. Bezerras que recebem suplemento reduzem em um dia a frequência de desfolhação dos perfilhos. O fornecimento de sal proteinado para bezerras de corte em pastejo em papuã resulta em alterações na relação herbívoro-planta reduzindo o fluxo de consumo e a frequência de desfolhação de lâminas foliares.

Palavras-chave: frequência de desfolhação, intensidade de desfolhação, morfogênese, *Urochloa plantagine*.

Introduction

Structural and morphogenic pasture measures, obtained through the technique of marked tillers allow the estimation of grass leaf tissue flow, at the tiller level as well as at the area level. Determination of these measures is useful for the understanding of forage growth processes and may indicate pasture management conditions, assuring efficient and sustainable animal production (SILVA; NASCIMENTO JUNIOR, 2007). Scientific information referring to leaf blade flow for tropical forages are scarce (CUTRIM JR. et al., 2013; LOPES et al., 2013). The importance of this information relies on the fact that, in Brazil, tropical forages are predominant. Also, leaf blades constitute the forage preferentially selected by grazing animals. Thus, this information may contribute to the comprehension of plant-animal interactions in tropical grazing systems.

Among warm season cycle forages, Alexandergrass (*Urochloa plantaginea* (Link) Hitch), considered an undesirable species in cropping areas, is adequate for grazing management (COSTA et al., 2011). Protein supplements are supplied to grazing cattle when higher performances are sought compared to those obtained exclusively on tropical forages (GOES et al., 2003). The effects of these supplements, because of supplying higher rumen degradable protein, appears to increase total dry matter and energy intake, in relation to intake obtained exclusively on pasture (VAN SOEST, 1994).

The production potential of a forage crop is genetically determined and for the achievement of that potential, the appropriate conditions of the environment and management should be observed

(FAGUNDES et al., 2006). Considering that the supply of protein to grazing animals, in tropical pastures, can interfere with forage intake and change leaf blade tissues flow, the present experiment evaluated the intensity and defoliation frequency and quantified the different leaf blade flows in Alexandergrass, grazed by beef heifers, supplemented or not with a protein salt.

Material and methods

The experiment was conducted from January through March, 2010 at the Animal Science Department experiment facilities of the Federal University of Santa Maria (UFSM), Rio Grande do Sul State, Brazil. The region has a humid subtropical climate according to Köppen classification. Soil of the experimental area is classified as Paleudalf, with the following characteristics: pH-H_20: 5.0; pH-SMP: 5.8; % clay: 19.2 m V^{-1}; P: 13.4 mg L^{-1}; K: 92 mg L^{-1}; %MO: 2.7 m V^{-1}; Al: 0.2 mol_c L^{-1}; Ca^{2+}: 4.6 $cmol_c$ L^{-1}; Mg^{2+}: 2.2 $cmol_c$ L^{-1}; base saturation: 56.6% and Al saturation: 3%. Values of mean temperature (°C) and rainfall (mm), during the experimental period were obtained from the Meteorological Station from the Department of Agronomy (UFSM).

Alexandergrass (*Urochloa plantaginea* (Link) Hitch) leaf tissues flows were evaluated in a pasture grazed exclusively by beef heifers or in a pasture grazed by beef heifers supplemented with 0.2% body weight (BW) of a protein salt. This salt [with 34% crude protein (CP)] was supplied daily at 8am, and had the following composition: soybean bran, whole soybean bran (toasted grains), vegetable oil, urea, limestone, inorganic phosphate, ether extract: minimum 15%; calcium iodate: 50 g kg^{-1}; phosphorus (minimum): 20 g kg^{-1}; sodium: 50 g kg^{-1}; magnesium: 5 g kg^{-1}; sulfur: 6 g kg^{-1}; cobalt sulfate: 5 g kg^{-1} copper sulfate: 200 mg kg^{-1}; iron sulfate: 2000 mg kg^{-1}; manganese sulfate: 400 mg kg^{-1}; iodine: 20 mg kg^{-1}; selenium: 10 mg kg^{-1}; zinc oxide: 1500 mg kg^{-1}; metabolizable energy: 2000 kcal kg^{-1}.

A 3.2 hectare experimental area with four paddocks, constituting the experimental units, was used. In each area replication 40 tillers were marked, with colored plastic rings. A total of 15 evaluations were made in the following periods: Jan./22 – Feb./09; Feb./10 – Feb./27; Feb./28 – March/12 of 2010.

Alexandergrass was established from the existing soil seed bank in the area, with two subsoilings and two light harrowings. Area was fertilized with 250 kg ha^{-1} of a 05-20-20 (N-P-K) formula. Nitrogen (45 kg ha^{-1}) was topdressed, as urea, in Jan. 11st and Feb. 10th, 2010 (split applications of 22.25 kg ha^{-1} N). Continuous stocking was used with variable number of animals to maintain forage mass (FM) at 3,000 kg ha^{-1} dry matter (DM).

Twelve Angus heifers, with initial age and body weight (BW) of 15 months and 253.75 ± 17.9 kg, respectively, were utilized. Animal weighing was made at 21-day intervals, with previous solid and liquid fasting for twelve hours. Forage mass (FM) was estimated at 10-day intervals, through a double sampling technique. At the same occasion, forage sward height was measured, in the same stations utilized to estimate FM. Height was considered as the distance (cm) from ground surface to the average height of folding leaves.

Samples of harvested forage were homogenized for manual separation of botanical and structural components. After separation, these components were oven-dried, in circulating air oven at 55°C for 72 hours, and percent composition of leaves and stems was calculated to determine the leaf:stem ratio.

Grazing simulation was performed at 21-day intervals and, after observing intake behavior of animals for 15 min., it was proceeded the forage collection, similar to that consumed, until completing a 500 g sample. These samples were dried and ground to determine crude protein (CP) and neutral detergent fiber (NDF). The stocking rate (SR), by period, expressed in kg ha^{-1} body weight (BW), was calculated by the sum of heifer-test average weight, with the average weight of each put-and-take heifer, multiplied by the number of days in which they remained in each replication, divided by the number of days of the experimental period. Forage daily accumulation (FDA), kg ha^{-1} day^{-1} dry matter (DM), was estimated using three grazing exclusion cages per experimental unit. Forage allowance, expressed in kg DM 100 kg^{-1} BW, was calculated through the quotient between daily dry matter (DM) allowance (DM+FDA) and stocking rate. Leaf blade allowance was then established through the leaf blade proportion in forage mass and forage allowance. Thermal sum (TS) of each period was calculated by the equation:

$$TS = S(Tmd) - 10,$$

where:

Tmd is the daily average temperature (INMET, 2010) of the period; the value of 10 grades is the minimum temperature required for growth of warm season forage species.

At each evaluation, the following measures were taken: average stem height (from ground level to the base of the last expanded leaf, cm), length and number of expanded leaf blades (with visible ligule) and under expansion, besides their condition (in senescence or not and intact or defoliated). In senescent leaves, the length of the greenish portion was recorded. Expanded leaves were measured from their ligule and expanding leaves from the ligule of the last fully expanded leaf. The depth of leaf blade was calculated by the difference of the sward average height by the stem average height. Tiller population density (tillers m^2) was evaluated by counting Alexandergrass tillers found in four fixed stations, with an individual area of 0.0625 m^2, in each experimental unit.

To evaluate weight, by length unit (g cm^{-1} of DM) of leaf blades, samples were collected from exclusion cages, in which length (cm) of 300 fully expanded leaves and 300 in expansion were measured, and weighed after drying in a circulating air oven at 55°C for 72 hours.

Leaf elongation and senescence rates, measured in cm degree-day^{-1}, were calculated by the ratio between elongation or tiller average senescence, between two consecutive evaluations, and the thermal sum accumulated in the same period (PONTES et al., 2004). Leaf appearance rate, by period, was determined by linear regression between the number of leaves produced and thermal sum of the period. Leaf appearance rate is the slope value of the regression and the phyllochron is its inverse value, both expressed in degree-day. Leaf duration was calculated by the product of the average number of live leaves per tiller and its phyllochron in the period. Leaf tissue flow, potential efficiency and actual utilization and net balance of leaf blade were calculated according to Pontes et al. (2004).

Defoliation intensity was obtained by the equation:

$$Intensity = \frac{initial\ lenght - final\ lenght}{initial\ lenght}.$$

$$Frequency = NC/(NPC * ED),$$

where:

NC=number of contacts; NPC=number of possible contacts; ED=evaluation duration.

A completely randomized experimental design was used, with repeated measures over time, with two treatments and two area replications. The normality of data was checked by Shapiro-Wilk test and all variables presented normal distribution. Data were subjected to analyses of variance and F-test at 10% level. Selection test structures was performed using the Bayesian information criterion (BIC) to determine the model that best represents the data and variance components were utilized as structure of covariance. When differences were observed, mean values were compared by *lsmeans*, using the MIXED procedure of SAS 9.0. A polynomial regression was run by PROC GLM, considering the period (X = days) variable. The general mathematical model referring to the analysis of variance was represented by:

$$Yijk = \mu + Ti + rk(Ti) + Pj + (TO)ij + \varepsilon ij,$$

where:

Yijk is the dependent variables; μ is the mean of all observations; Ti is the fixed effect of the *i*-th feeding system; rk (Ti) is the random effect of the *k*-th replication in the *i*-th feeding system (error a); Pj is the fixed effect of the *j*-th period; (TP) ij is the interaction between the *i*-th feeding system and the *j*-th period; and εijk is the residual experimental error (error b).

Results and discussion

Average temperatures were 2.8% (25.3°C), 10.4% (26.8°C) and 12.9% (25.5°C) higher than historical averages in January, February and March, respectively. Rainfall in January was 64.2% (405.9 mm) higher than the historical average. In February and March, rainfall values were 4.4% (124.7 mm) and 100% (0 mm) lower than historical averages, respectively.

Leaf expansion (0.05 ± 0.01 cm grades-day^{-1}), leaf senescence (0.059 ± 0.005 cm grades day^{-1}), leaf appearance (0.01 ± 0.001 leaves grades day^{-1}) and lifespan of Alexandergrass leaves (635.56 ± 62.95 degree) were similar in tillers measured in paddocks of the different feeding systems ($p < 0.10$), which was expected, since these variables are genetically determined and influenced by environment factors, such as temperature, light intensity, water availability, humidity and nutrients, mainly nitrogen (POMPEU et al., 2009).

Tiller population density was similar ($p > 0.10$) in paddocks of the two feeding systems. This structural characteristic is directly affected by leaf appearance rate, with an average value of 1169.5 ± 119.27 tillers m^{-2}. Considering that tiller density is affected by environment, light, water and nutrient availability, especially nitrogen, and that these factors were similar, this similarity was expected.

The supply of protein salt to grazing animals did not result in changes in defoliation intensity of Alexandergrass (Table 1). A daily reduction in the leaf: stem ratio

$(\hat{Y} = 1.95 - 0.03x; r2 = 86.2\%; p < 0.0001)$

and in the depth of leaf blades

$(\hat{Y} = 9.67 - 0.13x; r2 = 82.2\%; p < 0.0001)$

was observed. Height of pseudostem was greater in the first, intermediate in the second and smaller in the third evaluation period, with values of 23.2; 19.4 and 17.6 cm, respectively ($p < 0.10$). Changes observed in these structural variables were insufficient to modify defoliation intensity during the phenological cycle of Alexandergrass. The average value of 59.8% for defoliation intensity remained constant. The stability of the value confirms Lemaire et al. (2009) who stated that the proportion of leaf blade removed is relatively constant through the phenological cycle of the grass. According to these authors, the intensity of defoliation is equivalent to 50%.

Similar values of forage mass (FM; 2906.4 ± 55.26 kg ha^{-1} dry matter (DM) and height (22.5 ± 1.79 cm) ($p > 0.10$) were observed in all paddocks. The following parameters also were similar: forage offer (FO; 10.2 ± 0.7 kg DM 100 kg^{-1} of BW), and number of senescent leaves (1.2 ± 0.02).

The supply of protein salt to grazing animals resulted in changes for the Alexandergrass defoliation frequency. Heifers that received protein salt defoliated the same tiller with a longer interval (one day) in relation to animals exclusively on pasture (Table 1). For heifers that received protein salt, the satiety point may have been signalized by chemical factors, through circulating metabolites, such as leptine, which seems to be associated with the control of appetite in ruminants (ROCHE et al., 2008), leading heifers supplemented with protein salt to change intake behavior, reducing the defoliation frequency. This longer interval could also characterize what is called substitution effect, which means the replacement of forage intake by concentrate supplement.

Table 1. Mean values and standard deviation for frequency and intensity of defoliation and efficiencies of actual and potential use in Alexandergrass pasture grazed by beef heifers receiving protein salt or not.

Variable	Alexandergrass	Alexandergrass + Protein Salt	P[1]	TxP[2]
Defoliation frequency[3]	5.4±0.8	6.4±1.1	0.050	0.440
Defoliation intensity[4]	62.2±5.0	57.3±6.5	0.211	0.530
Actual utilization efficiency	0.8±0.2	1.0±0.2	0.573	0.647
Potential utilization efficiency	-0.5±0.5	-0.6±0.9	0.777	0.173

[1]Probability; [2]Probability of interaction between treatment and period; [3]days; [4]%.

As consequence of the longer interval between consecutive defoliations, heifers that received protein salt grazed daily 15.6% of total available grazing area, i.e., each heifer used a 152.1 m^2 area. On the other hand, heifers exclusively on pasture used 18.5% of total available grazing area, with each animal using a 180.4 cm^2 area daily. As a function of the stocking rate adjustment, to maintain the same forage mass (FM) in paddocks with heifers that received protein salt or not, the lower tiller defoliation frequency in paddocks where heifers received protein salt did not change stocking rate, with an average of 2,648 ± 152.36 kg ha^{-1} BW ($p > 0.10$). Machado et al. (2011) reported a relationship between stocking rate and frequency of tiller defoliation and the greater is the stocking rate, the greater is the number of defoliation events on each tiller.

Considering that leaf lifespan was 39 days, supplemented animals returned to the same leaf, during its lifespan, 6.08 times before it had started the process of senescence. On the other hand, heifers kept exclusively on grazing were more efficient in forage collection and visited the same leaf 7.14 times, before its senescence. For heifers supplemented with protein salt, the thermal accumulation between forage defoliation was 104.22 degree-days, equivalent to the appearance of 0.90 new leaves between defoliation intervals. Heifers exclusively on Alexandergrass pasture, when returned to same tiller, found 0.77 new leaves per tiller. These values demonstrate that heifers supplemented with protein salt were able to select a greater amount of highly nutritive new leaf blades. Regarding the position in the tiller, in the upper sward horizon, these leaves are more accessible to grazing.

No interaction was detected between feeding systems and evaluation periods for intake, growth and forage senescence flows ($p > 0.10$; Figure 1). Leaf blade intake flow, for heifers exclusively on pasture, was 18% higher than the intake flow in paddocks where heifers were supplemented with protein salt, which was of 17.3 kg DM leaves ha day^{-1} ($p < 0.10$). The lower grazing frequency and the lower efficiency of leaf blade collection were responsible for the reduction in leaf blade intake by 3.75 kg day^{-1} DM, for heifers supplemented with protein salt. In forage as grazed, average crude protein was 15.07 ± 0.5%. Intake of forage with crude protein content above 8% does not limit rumen microbial activity (VAN SOEST, 1994). Crude protein content (CP) in forage as grazed was 34.8% superior to requirement of heifers, which is

9.82% CP (NRC, 1996), for an average daily gain (ADG) of 0.860 kg. Taking into account the average intake value for this animal category of 2.3% BW of DM (NRC, 1996), the forage allowance corresponded to 4.4 times the predicted intake, within the range preconized to maximize the forage intake (BARGO et al., 2003).

There was no difference ($p > 0.10$; Table 1) for leaf growth flow (27.48 ± 1.05 kg DM leaves ha day^{-1}) between heifers that grazed exclusively on Alexandergrass and those receiving protein salt. Leaf growth flow was reduced daily during the evaluation period of Alexandergrass:

($\hat{Y} = 57.13 - 0.84x$; r2 = 72.6%; $p < 0.0004$).

Leaf elongation process is dependent on environmental factors, such as temperature, water, nitrogen and especially luminosity (FAGUNDES et al., 2005). The reduction in monthly average temperature, together with the annual cycle of Alexandergrass can explain the daily reduction observed for leaf growth rate. Allowance of leaf presented a decreasing linear function according to days of pasture utilization

($\hat{Y} = 5.60 - 0.07x$; r2 = 70.3%; $p = 0.0007$).

With the advance in phenological cycle and decrease in leaf allowance, nutrients were allocated to internode expansion and afterwards for development of reproductive structures. Grass leaf senescence, with average of 36.5 kg DM leaf blades ha^{-1} day^{-1} was similar between heifers exclusively on pasture and those grazing plus supplementation with protein salt, with no effects of evaluation periods ($p > 0.10$).

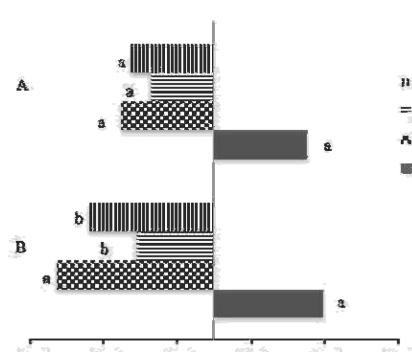

Figure 1. Flow of biomass in kg DM ha day-1 according to different feeding systems (A = alexandergrass+protein salt; B = alexandergrass).

Differences were observed for the net balance when heifers were kept exclusively grazing on Alexandergrass and when received protein salt ($p < 0.10$; Figure 1). Net balance was 49% superior for the feeding system 'Alexandergrass+protein salt' in comparison to Alexandergrass only ($p < 0.06$). This can be attributed to the greater leaf intake flow observed when heifers remained exclusively on pasture. This smaller net balance when heifers grazed exclusively on Alexandergrass is related to senescence and leaf growth flow, which were equivalent in both systems. A daily reduction occurred in net balance

($\hat{Y} = 12.04 - 0.97x$; r2 = 88.0%; $p < 0.005$)

when heifers received protein salt. With heifers kept exclusively on Alexandergrass, the net balance was not affected by days of pasture utilization.

Potential utilization efficiency showed a negative value (-0.59), since the leaf growth flow was 24.7% lower in relation to leaf senescence flow. Potential utilization efficiency presented a linear response as a function of days of pasture utilization

($\hat{Y} = 0.91 - 0.04x$; r2 = 61.2%; $p = 0.0026$).

For each additional day of pasture utilization a 0.04 decrease in potential utilization efficiency is expected. This can be explained by the reduction in leaf allowance along the phenological cycle of Alexandergrass.

No difference was found ($p > 0.10$; Table 1) for actual utilization efficiency (0.91 ± 0.18) between heifers kept in either one of the two feeding systems, showing a value lower than one, once the leaf growth was 43.14% superior to leaf intake flow. The actual utilization efficiency fitted to a decreasing linear model

($\hat{Y} = 0.37 + 0.03x$; r2 = 54.6%; $p = 0.0060$),

according to days of pasture utilization. For each additional day of pasture utilization, a 0.03 increase is expected for the actual utilization efficiency.

Conclusion

The supply of protein salt for heifers grazing Alexandergrass changes the herbivore-plant relationship, reducing the leaf blade intake flow and defoliation frequency. Changes in the sward structure during the phenological cycle of Alexandergrass were insufficient to modify defoliation intensity when beef heifers received protein salt or not.

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Received on September 4, 2013.
Accepted on November 27, 2013.