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PASTURE AND FORAGE UTILIZATION

Leaf tissue flows and defoliation patterns of Alexandergrass grazed by heifers receiving energy supplement

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ABSTRACT. The study was carried out to evaluate defoliation patterns and to quantify leaf tissue flows in Alexandergrass (*Urochloa plantaginea* (Link.) Hitch) grazed by beef heifers receiving whole rice bran in three levels of supplementation (0, 0.5 and 1 % of body weight). A rotational stocking grazing method and two area replications were utilized. The experimental design was completely randomized following a repeated measure arrangement. The supply of rice bran to heifers grazing Alexandergrass increased the stocking rate by 13%. Regardless of the feeding system, the heifers grazed the expanding leaf blades in the top stratum of the canopy more frequently compared to other types of leaf. Leaf tissue flows, leaf blade intake and grazing intensity have not been changed by supplement fed.

Keywords: Defoliation intensity; defoliation frequency; *Urochloa plantaginea* stocking rate.

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Introduction

When tropical forage species are used for rearing of beef heifers, coupled with energy supplementation, they allow the reduction of age at first mating of heifers and increase profits per animal and per area. Alexandergrass is a tropical species of genus *Urochloa,* considered the most cultived genus in Brazil, approximately 85% of total cultivated forages (Moreira et al., 2011). Alexandergrass has demonstrated its potential as forage for beef heifers (Sichonany et al., 2015), allowing values of average daily gain of 0.734kg and the development of these animals for mating at 18 months of age (Oliveira Neto et al., 2013). The use of energy supplement for heifers in Alexander grass could allow an increase in stocking rate, caused by a substitution effect of forage by supplement intake. This greater stocking rate can interfere on defoliation frequency of individual tillers and may modify the canopy structure (Hodgson, 1990).

The understanding of the effects of additional supplements given to herbivores and their ability to change the sward dynamics of pasture requires knowledge of growth, intake, and senescence of the forage species through study of leaf tissue patterns. Determination of biomass flows can be useful so that different supplementation strategies can be adopted in order to use grazing lands as efficiently as possible (Eloy et al., 2014).

Defoliation patterns of forage plants define the canopy structure which, in turn, is crucial for the forage intake process (Hodgson, 1981). In situations of rotational stocking grazing method, higher grazing intensity directly contributes to a more efficient use of available forage and, indirectly, contributes to a reduction in losses by senescence and death of tissues during the period of plant regrowth (Gomide & Gomide, 1999). Knowledge of the variables involved in the plant-animal-supplement interface helps to define management strategies that allow greater efficiency of use of forage produced (Gastal & Lemaire, 2015), resulting in better economic results and zootechnical indexes.

In a study on Alexander grass, Eloy et al. (2014) evaluated biomass flows and defoliation patterns and found no difference in defoliation intensity of leaf blades when the animals received mineral salt supplements or not. According those authors, the interval between two consecutive defoliations on the same tiller is longer (one day) when the heifers received protein supplements, as a result of substituting forage intake by supplement intake.

Few studies have shown how the provision of energy supplements to beef cattle in tropical forages can interfere in forage intake and change leaf tissue flows. Therefore, the objective of this study was to evaluate defoliation patterns and to quantify leaf tissue flows in Alexandergrass, grazed by beef heifers receiving different levels of whole rice bran as energy supplement, under rotational stocking grazing method.

Material and methods

The study was conducted at the Universidade Federal de Santa Maria (UFSM), located in the physiographic region called Depressão Central / RS. The Köppen climate classification in the region is humid subtropical (Cfa) and the soil is classified as Paleudalf (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2006), a type of Alfisol. The mean values for the chemical characteristics of the soil on the experimental area were: pH- SMP: 5.6; pH- H_2O: 5.1; % clay: 21 m V^{-1}; P: 14.4 mg L^{-1}; K: 98 mg L^{-1}; % MO: 2.36 m V^{-1}; Al saturation: 7.4%; Ca^{2+}: 5.3 cmol L^{-1}; Mg^{2+}: 2.57 cmol L^{-1}; CTC pH 7: 11.9. The data of precipitation and temperature from December 2014 to April 2015 were obtained from the UFSM Meteorological Station.

We evaluated the intensity and frequency of defoliation and leaf tissue flows in Alexandergrass (*Urochloa plantaginea* (Link) Hitch) when heifers received levels of 0; 0.5 or 1% of body weight (BW) of whole rice bran (WRB). The experimental area (4.8 hectare) was divided into six paddocks and each paddock was subdivided into four plots of 0.2 ha each. Pasture was established through disking an area with an Alexandergrass seed bank, on December 5th, 2014. Fertilization consisted of 250 kg ha^{-1} of 5-20-20 formula (N-P-K) and three applications of urea of a similar amount, totaling 100 kg ha^{-1} nitrogen (N).

We adopted a rotational stocking grazing method with successive grazing (five days) and rest periods (15 days), on average. Grazing cycle was characterized as the sum of the rest plus the grazing period. The rest period was established considering a thermal sum of 200 degree- days (Eloy et al., 2014). The trial comprised four grazing cycles, the first cycle from February 6- 22, the second from February 22 to March 10, the third from March 10 to 26 and the last grazing cycle from March 26 to April 19, 2015. For the morphogenic variables and tissue flows, to be evaluated in the vegetative period, two grazing cycles were considered cycle 1 = February 6- 22 and cycle 2 = February 22 to March 10. For the beginning of grazing, it was established a forage mass around 2,500 kg ha^{-1} DM. The number of animals was variable using Angus heifers with initial age of 15 months and body weight of 282.11 ± 22.3 kg. Each experimental unit contained three tests and a varied number of put and take animals in order to maintain post-grazing canopy height (25 ± 5 cm).

The supplement was given daily at 9:30 am. The chemical composition of WRB was 89.7% dry matter (DM), 14.4% of ether extract (EE), 14.1% crude protein (CP), 69.3% of total digestible nutrients (TDN) and 76.8% of *in situ* digestibility of DM. To the supplement was added 4% of limestone.

Forage mass (kg ha^{-1} DM) was determinate by cutting the forage at ground level in places representative of the canopy height in area bounded by a square of 0.25 m^2. Forage from cuts was separated manually into its botanical and structural components. After weighing the samples were dried at 65°C for 72h, and, afterwards, the pre-grazing leaf blade-to-stem ratio and leaf blades mass were calculated.

The heifers were weighed at the first and the last grazing cycles with a 12-hour solid and liquid fasting. The average daily gain was obtained by weight difference of test heifers between the final and initial weighing divided by the number of grazing days.

The stocking rate (SR; kg ha^{-1} of live weight), in each cycle, was obtained by the sum of the average mean live weights of test animals plus the sum of the average weight of heifers used for adjustments in the stocking rate, multiplied by the number of days they were kept in the experimental unity and divided by the number of days in the trial period. The forage allowance (FA; kg DM 100 kg^{-1} BW) was calculated using the equation:

FA = [(initial forage mass + final forage mass in the paddock)/2]/occupation days of the paddock /instantaneous stocking rate*100.

The tillers population density (tillers m^{-2}) was evaluated in areas bounded by three 0.625 m^2 quadrats located in each experimental unit. Tillers were hand clipped at ground level and counted. This material was dried at 55°C for 72 hours and then weighed; this weight was divided by the number of tillers to obtain the weight / tiller.

For determination of morphogenetic and structural variables, we used the technique of marked tillers (Carrere, Louault, & Soussana, 1997) and 20 tillers were marked per paddock. Evaluations were daily performed during the stocking period. During the days of paddocks rest, the evaluations were performed twice a week. The leaf blades size, the canopy height and the pseudo stem size were measured, in cm. From this information, the following variables were calculated (Lemaire & Chapman, 1996): leaf blades appearance rate (LBAR, degree days^{-1}), leaf blades expansion rate (LBER; cm degree day^{-1}), leaf blades senescence rate (LBSR; cm degree day^{-1}), phyllochron (degree days^{-1}), leaf lifespan (degree days^{-1}) and number of leaf blades expanding and expanded. The flows of growth (GF), intake (IF) and senescence (SF), the actual efficiency of use (AEU), potential efficiency of use (PEU) of forage, net balance (NB) and forage intake (% BW) were determined according to the methodology described by Pontes, Carvalho, Nabinger, and Soares (2004).

The grazed leaf blades were identified, and measures of defoliation intensity and frequency were carried out during stocking period for determination of defoliation patterns. The intensity and frequency of defoliation were calculated considering an average of all leaves (intensity and frequency total) and, separately, for each type of leaf. The defoliation leaf blades intensity (DI; % length of the leaf removed) was obtained by the equation:

DI = [(initial length-final length) / initial length-1] * 100.

The defoliation frequency (DF; return days to the same leaf blade) was obtained by the equation:

DF = 1 / (number of touches / (number of possible touches x duration of the evaluation).

In order to determinate the values of defoliation percentages, the average values of all types of leaves (leaf blade in expansion, expanded and senescent leaf blade) were considered. To calculate the defoliation number before the leaf blade senescence, the value of leaf blades lifespan was divided by the degree- days $^{-1}$ accumulation value between defoliations.

To determine the daily grazing area (DGA), the paddock area was regarded as 100% and divided by the defoliation frequency average (number of days). The grazing area per animal (m^2) was obtained by

GA= [Ap*(DGA/N)] *100 formula

where: GA=per animal grazing area; Ap= area of the paddock; DGA= daily grazing area; N=average number of animals per treatment.

The experimental design was completely randomized with repeated measurements over time, with three treatments and two area replications. To compare treatments, variables with normality of residue were subjected to analysis of variance by mixed procedure of the Statistical Analysis System (SAS, 2013).

We performed a structure selection test using the Bayesian information criterion (BIC) to determine the model that best represented the data. The interaction between feeding systems and grazing cycles was broken down when significant at 5%. The variables were subjected to Pearson correlation analysis.

Results and discussion

Meteorological date showed that during the experimental period the average temperature was higher than the historical average in the months of February (5%), March (9%) and April (9%). Rainfall in the months of February and April was 29% and 5% lower, respectively, compared with the historical average. In March, average precipitation was 2% higher than the historical average. These values of climatic variables (Table 1), however, provided suitable conditions for the development of the plants.

Stocking rate was similar ($p > 0.10$) when the animals received whole rice bran (WRB; 2,778.9±82.5kg ha^{-1} BW), regardless of the level, and 316.1 kg ha^{-1} of BW higher ($P < 0.10$) than the exclusive use of Alexander grass. Based on this result, the levels of supplement 0.5% and 1% were grouped into a single feeding system (Alexander grass + WRB). So, the treatments began to be regarded as two feeding systems, called Alexander grass (animals exclusively on pasture) and Alexandergrass+ WRB. The stocking rate did not differ between the grazing cycles ($p > 0.10$).

Table 1. Rainfall and average temperature from February to April 2015 and historical averages, Santa Maria/RS.

	February	March	April
Average temperature (°C)	25.2	24.3	20.6
Historical temperature(°C)[1]	24	22.3	18.9
Rainfall (mm)	84.3	132.4	129.8
Rainfall historical (mm)[1]	108.74	129.80	136.29

[1]Historical average 1985-2015.

Pre-grazing canopy height (41.8 ± 0.9 cm) and post-grazing canopy height (23.7 ± 0.37 cm) were similar (p > 0.10) in the paddocks of different feeding systems. Pre-grazing canopy height was greater in the third grazing cycle (50.3 ± 1.3 cm), intermediate in the second (42.5 ± 1.3 cm) and lower in the first and fourth cycles (37.2 ± 1.3 cm). Post-grazing canopy height was higher in the third grazing cycle (27.8 ± 0.5 cm), different from the second (25 ± 0.5 cm), which in turn differed from the first and fourth cycles (21.2 ± 0.5 cm). Post-grazing canopy height was used as a criterion for management and its observed values were according the experimental protocol.

There was no interaction for forage mass and forage allowance between feeding systems and grazing cycles (p > 0.05). Forage mass (3,963.5 ± 128.9 kg ha^{-1} of dry matter (DM) and forage allowance (8.3 ± 0.6 kg DM 100 kg of body $weight^{-1}$ (BW) were similar in the paddocks of different feeding systems. The variables forage mass and forage allowance differed between the grazing cycles (p < 0.10) and the smallest forage mass (2,740.5 kg ha^{-1} DM) was observed in the first cycle. Forage mass in other cycles was similar (4,371.1 kg ha^{-1} DM; p > 0.10). The greatest forage allowance was observed in cycles 2 and 3 (9.6 kg ha^{-1} BW), and it was lower and similar in the other cycles (6.9 kg ha^{-1} BW). For animals receiving supplements the forage allowance should be twice as high as expected DM intake (2.5-3.0 kg DM 100 kg BW^{-1}; Bargo, Muller, Kolver, and Delahoy (2003). The forage allowance was slightly higher than the value described by these authors in booth system.

There was no interaction between feeding systems and grazing cycles for the variables leaf: stem ratio, height of pseudostem, tiller population density (p > 0.10). The variables leaf: stem ratio, height of the pseudostem, tiller population density were similar in the paddocks of different feeding systems. The leaf:stem ratio was higher in the first grazing cycle, similar in the second and third and lower in the fourth cycle. The height of pseudostem was higher and similar in cycles 1 and 2 and lower and similar among themselves in the other cycles. The highest tiller population density was found in the third grazing cycle and the lowest in the first cycle without differences of the other cycles (Table 2).

Table 2. Structural characteristics of Alexander grass in different feeding systems (Alexander grass (A) or Alexander grass + whole rice bran (A+WRB)).

Feeding systems	Grazing cycles* 1	2	3	4	Average	P **	P ***	SD
	Leaf :stem ratio							
A	1.1	0.6	0.5	0.3	0.6	0.5040	0.7641	0.03
A+WRB	1.0	0.6	0.5	0.4	0.6			
Average	1.0a	0.6b	0.5b	0.3c		<0.0001		0.03
	Tiller population density							
A	1,196	1,368	2,316	1,184	1,516	0.6647	0.1671	93.5
A+WRB	1,088	1,222	1,866	1,639	1,453			
Average	1,142b	1,295b	2,091a	1,411b		0.0019		133.6
	Height of pseudostem							
A	22.0	28.8	19.8	12.8	20.8	0.2450	0.2448	1.3
A+WRB	27.9	27.1	18.6	19.8	23.3			
Average	24.9a	27.9a	19.2b	16.3b		0.0032		1.8
	Leaf blade depth							
A	9.9	5.3	13.7	12.5	10.3	0.1266	0.2177	1.0
A+WRB	7.0	7.5	10.8	5.0	7.6			
Average	8.4b	6.4b	12.2a	8.8ab		0.0835		1.4
	Basal tiller weight							
A	0.4	0.4	0.3	0.5	0.4	0.1043	0.1289	0.03
A+WRB	0.3	0.5	0.4	0.5	0.5			
Average	0.3	0.5	0.4	0.5		0.1043		0.03
	Axillary tiller weight							
A	0.1	0.2	0.1	0.2	0.2	0.3145	0.4757	0.03
A+WRB	0.1	0.2	0.2	0.2	0.2			
Average	0.1c	0.2ab	0.1b	0.2a		0.0078		0.03

*Grazing cycles 1= 06/02 to 22/02, 2=22/02 to 10/03, 3=10/03 to 26/03, 4=26/03 to 19/04; **Probability of feeding systems or grazing cycles; ***Probability interaction between feeding systems and grazing cycles; Values followed by letters on the line indicate difference by the lsmeans test at the 10% level; SD = stander error.

Tiller production is influenced by the interaction of several factors such as light and nutrients. The similarity of forage mass and canopy height in the different feeding systems were probably the main factors determining the similar number of tillers that remained alive.

We observed no interaction between feeding systems and grazing cycles for the variables leaf blade depth, basal and axillary tiller weight ($p > 0.10$). Leaf blade depth, basal tiller weight and axillary tiller weight were similar in the paddocks of different feeding systems (Table 2). Animals concentrate grazing activity on pasture strata that mainly have leaves (Hodgson, 1990) and as the leaf blade depth was higher in the third and lower in the other grazing cycles probably, in the third cycle, the greatest leaf participation in the canopy was concomitant with increasing in grazing depth. The basal tiller weight was similar between the grazing cycles and the axillary tiller weight was higher in the fourth, and similar to cycle two. The second and third were lower in the first grazing cycle (Table 2). The effect of the Alexandergrass phenological cycle advancement with an increase in the cell wall/cellular content ratio and the higher content of dry matter were observed mainly in the axillary tillers, making them heavier.

There was no interaction between feeding systems and grazing cycles ($p > 0.05$) for the variables leaf appearance rate, phyllochron, leaf lifespan, senescence rate and leaf expansion rate of Alexandergrass. These variables were similar ($p > 0.10$) when the heifers were submitted to different feeding systems (Table 3).

The appearance and expansion rates and leaf lifespan are considered morphogenic characteristics and are influenced by temperature, nutrient supply, soil moisture and determine the sward structural characteristics (Lemaire & Chapman, 1996). The product of the structural characteristics determines the leaf area index of the pasture that has high correlation with the responses of plants and animals in the pasture environment and it is modified by grazing management (Difante, Nascimento Júnior, Silva, Euclides, & Montagner, 2011). The increase in the stocking rate, which occurred when the animals received supplement, did not cause alterations in the process of defoliation, thus changes in the morphogenic characteristics of the Alexander grass were not expected.

There was no interaction between feeding systems and grazing cycles for the variables number of green leaves, length of expanding and of expanded leaves. Number of green leaves (3.8 ± 0.3 leaf tiller^{-1}), length of expanding leaves (14.7 ± 0.7 cm) and length of expanded leaves (19.7 ± 0.4 cm) were similar in the paddocks of the different feeding systems. The experimental protocol keeping canopy height and forage mass similar between feeding systems has resulted in similar sward structural characteristics. The number of green leaves (3.8 ± 0.3 leaves) did not differ between grazing cycles. Lengths of expanding (16.6 ± 0.7 cm) and of expanded leaves (21.8 ± 0.4 cm) were greater ($p < 0.10$) in the first grazing cycle. In the second cycle, these values were lower in the expanding (12.8 ± 0.7 cm) and in the expanded leaves (17.6 ± 0.4 cm). At every stage of development of the forage species, the structural characteristics of the plant may vary, depending on local availability of nutrients, physiological age of the tiller and potential response of these tillers to management practices (Paiva et al., 2012).

No interaction was found between feeding systems and grazing cycles ($p > 0.05$) for the variables growth, senescence and intake flow and leaf intake as a percentage of BW. Leaf tissue flows (Figure 1) were similar when the heifers were supplemented or not, with average values of growth flow (50.9 ± 3.9 kg ha^{-1} day^{-1} DM), senescence flow (38.8 ± 3.1 kg ha^{-1} day^{-1} DM) and intake flow (58.7 ± 4.0 kg ha^{-1} day^{-1} DM). Pompeu et al. (2009) reported that, in rotational management with sheep, biomass flows components of Tanzania grass were hardly affected by different levels of supplementation, which had greater influence on leaf elongation rate, growth rate, accumulation rate and the residual leaf area index. Senescence flow was similar between feeding systems, regardless of the increase in stocking rate, because the type of management in use has ensured similar values pre and post-grazing canopy height between the feeding systems. Thus, shading in the lower layer of the canopy was also similar and did not interfere with senescence flow. According to Bircham and Hodgson (1983), the process of mutual shading accelerates senescence of green leaves.

Growth flow (63.3 ± 3.8 kg ha^{-1} day^{-1} DM) and intake flow (68.84 ± 4.0 kg ha^{-1} day^{-1} DM) were higher in the second grazing cycle ($p < 0.10$). Growth flow was correlated with pre-grazing canopy height ($p = 0.02$; $r = 0.68$) and with leaf blade mass ($p = 0.08$; $r = 0.55$). The greatest initial height combined with the greatest leaf blade mass in the second grazing cycle may have maximized photosynthesis, as a result of greater interception of solar radiation into the canopy, thus leading to greater growth flow.

Table 3. Morphogenetic characteristics of Alexander grass in different feeding systems (Alexandergrass (A) or Alexandergrass + whole rice bran (A+WRB)).

Variable	A	A+WRB	P*	P*T**	EP[1]
Leaf appearance rate[2]	0.012	0.011	0.7619	0.2032	0.001
Phyllochron[3]	84.43	96.11	0.1973	0.2904	5.9
Leaf lifespan[3]	307.6	361.2	0.2932	0.9606	31.0
Senescence rate[4]	0.067	0.067	0.5793	0.9337	0.003
Expansion rate[4]	0.04	0.04	0.9337	0.6880	0.003

*Probability between feeding systems, **Probability of interaction between feeding systems and grazing cycles, [1]standard error;[2]leaf degree^{-1}-day; [3]degree-day; [4]cm degree^{-1}-day.

The variables growth flow and intake flow are positively correlated (p = 0.01; r = 0.72). The increase by 64% in growth flow in the second grazing cycle resulted in a 30% increase in leaf blade mass, leading to an increase by 41.6% in intake flow in the same cycle. The similarity in senescence flow among the grazing cycles can be explained by the increase in defoliation intensity of senescent leaf blades in the second cycle, showing that the heifers have harvest a greater amount of leaf blades before the onset of its senescence. Leaf blade intake (2.4 ± 0.1% BW) did not differ between feeding systems and grazing cycles (p > 0.10). Due to maintenance of leaf blades intake it is probable that the substitution of forage by supplement intake, which increased the stocking rate by 13%, was caused by greater ingestion of the stems. The low leaf:stem ratio (0.83) found in the first two grazing cycles could justify this intake of stems. The substitution rates, in cool season pastures, when the leaf:stem ratio in these grasses is about 1.2, are around 25% (Pötter et al., 2010). Although Alexander grass is a tropical climate species, its nutritional value allowed that the substitution effect took place.

The value of foliar leaf consumption (2.4% CP) and nutrient value of Alexander grass provided an average daily gain of 1.007 kg day^{-1} when heifers received supplement and of 0.865 kg day^{-1} for heifers exclusively on pasture. Rouquette Junior (2016) pointed out that forage mass, along with nutritional value (digestibility and crude protein), determines animal performance, especially in C4 grasses, which have a lower leaf:stem ratio as plants grows older.

For the variables net balance, actual efficiency of use and potential efficiency of use, there was no interaction between feeding systems and grazing cycles (p > 0.05). Net balance (-46.6 ± 7.4 kg ha^{-1} day^{-1} MS), actual (1.2 ± 0.09) and potential efficiency of use (0.15 ± 0.7) were similar between feeding systems (p > 0.10). The sum of the values of senescence flow and intake flow exceeds the value of growth flow, leading to a negative net balance (Figure 1). In grazing cycles, net balance and actual efficiency of use were similar (p > 0.10). The potential efficiency of use was lower (-0.05 ± 0.07) in the first cycle compared with the second (0.38 ± 0.07), because senescence flow was greater than intake flow in the first cycle. According to Lemaire and Chapman (1996), the efficiency of forage utilization in pasture systems can be defined as the proportion of accumulated raw forage that is removed by grazing animals before senescence and the higher the amount of forage produced, the optimization of the utilization efficiency corresponds to the minimization of losses of foliar tissues by senescence. By contrast, the opposite occurred in the second cycle; the potential efficiency of use was positive, because of increased intake flow, resulting in better use of forage.

There was no interaction between feeding systems and grazing cycles (p > 0.05; Table 4) for defoliation intensity total, defoliation intensity of expanding, expanded and senescent leaf and defoliation frequency total, defoliation frequency of expanding, expanded blades and senescent leaf blades. The variables defoliation intensity of expanding, expanded and senescent leaf, defoliation frequency of expanded blades and defoliation frequency total did not differ between the feeding systems and grazing cycles (p > 0.10; Table 4). Defoliation frequency of expanding leaf was similar between the feeding systems (1.1 ± 0.01 days; p < 0.10). In the first two grazing cycles, this variable was greater (1.1 ± 0.01 days, p > 0.10) than in the others (1.05 ± 0.01). This probably happened in order to maintain the intake of leaf blades, since there is reduction in the proportion of leaf at the end of the period of use of Alexander grass.

Average defoliation intensity (62.2%) is within the range described by Gastal and Lemaire (2015) in rotational grazing of 50-75%, depending on the type of management utilized. These authors reported that defoliation intensity in rotational grazing is dependent on stocking rate and length of the grazing period when residual canopy height is determined. Defoliation intensity of expanding leaf blades was 33.7% higher than that of expanded and senescent leaf blades. According to Pontes et al. (2004), expanding leaf blades, because of the way animals graze and by the position they occupy in the tiller, are more likely to be consumed than older leaf blades. The defoliation frequency of senescent leaf blades was similar between feeding systems and grazing cycles (1.4 ± 0.1 days, p > 0.10).

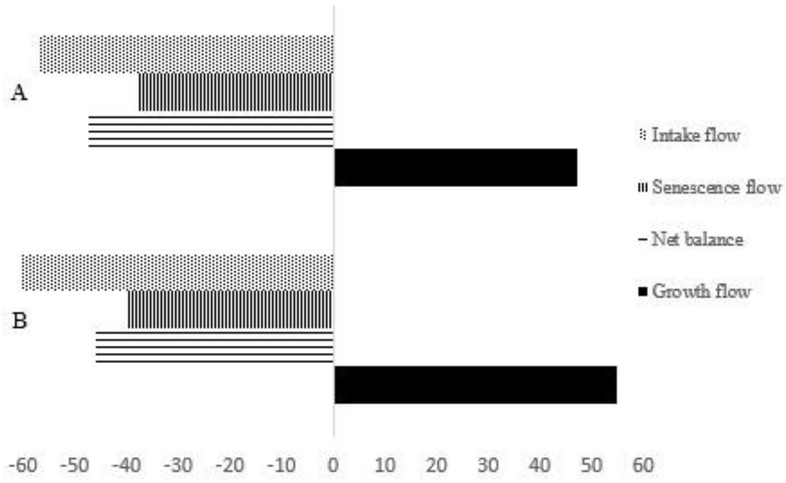

Figure 1. Leaf tissue flows and net balance (kg ha $^{-1}$ day of DM) as a function of different feeding systems (A= heifers exclusively on Alexander grass; B = heifers feeding on Alexander grass + WRB; p > 0.10).

Table 4. Defoliation intensity of leaf blades and defoliation frequency total and by type of leaf blade in different feeding systems (Alexander grass (A) or Alexander grass + whole rice bran (A+WRB)).

Variables	A	A+WRB	P[1]	P*T[2]	EP[5]
Defoliation intensity					
Expanding leaf blades[3]	72.6	74.8	0.7025	0.7456	3.7
Expanded leaf blades[3]	56.0	57.9	0.7215	0.8128	3.4
Senescent leaf blades[3]	64.4	51.0	0.2008	0.1043	6.0
Total[3]	62.9	61,5	0.2450	0.2448	1.2
Defoliation frequency					
Expanding leaf blades[4]	1.1	1.1	0.9021	0.1608	0.01
Expanded leaf blades[4]	1.8	1.8	0.9459	0.8460	0.1
Senescent leaf blades[4]	1.4	1.4	0.8185	0.0898	0.1
Total[4]	1.4	1.5	0.4305	0.4676	0.05

[1]Probability between feeding systems, [2]Probability of interaction between feeding systems and grazing cycles, [3]%, [4]days of return, [5]standard error of the mean.

Defoliation frequency in expanding leaf blades was 69% lower than in fully expanded leaf blades, reinforcing the idea that animals tend to select the upper leaves of the canopy. There was a negative correlation between stocking rate and defoliation frequency of expanding leaf blades ($p = 0.009$; $r = -0.54$), which also occurs when the pasture is managed under continuous grazing (Hodgson, 1990).

Considering average defoliation frequency of 1.5 days, regardless of the feeding system, the heifers grazed, on average, 66% of the paddock per day. Also, with leaf lifespan of 334.4 degree-days and thermal sum between defoliations of 34.9 degree-days, each leaf was grazed 9.6 times while it remained alive in the tiller. In continuous grazing on Alexander grass with different supplementation frequencies, supplementation frequency was 5.7 days and each leaf was grazed 7.4 times while it remained alive in the tiller (Salvador et al., 2014). According to Lemaire and Chapman (1996), the proportion of leaf blades, which is removed by the animals before entering the stage of senescence, can be called efficiency of forage use.

Conclusion

The supply of whole rice bran to heifers grazing on Alexander grass caused an increase in stocking rate by 13%. Leaf tissue flows, leaf blade intake and grazing intensity have not been changed by supplement fed. Regardless of feeding system, the heifers re-grazed the expanding leaf blades in a smaller interval of time compared to other types of leaf, which allows harvesting of leaf blades from the upper extract of the canopy.

References

Bargo, F., Muller, L. D., Kolver, E. S., & Delahoy, J. E. (2003). Invited review: Production and digestion of supplemented dairy cows on pasture. *Journal of Dairy Science, 86*(1), 1-42. doi: 10.3168/jds.S0022-0302(03)73581-4

Bircham, J. S., & Hodgson, J. (1983). The influence of sward condition on rates of herbage growth and senescence in mixed swards under continuous stocking management. *Grass and Forage Science, 38*(4), 323-331. doi: 10.1111/j.1365-2494.1983.tb01656.x

Carrere, P., Louault, F., & Soussana, J. F. (1997). Tissue turnover within grass-clover mixed swards grazed by sheep. Methodology for calculating growth, senescence and intake fluxes. *Journal of Applied Ecology, 34*(2), 333-348. doi: 10.2307/2404880

Difante, G. S., Nascimento Júnior, D., Silva, S. C., Euclides, V. P. B., & Montagner, D. B. (2011). Características morfogênicas e estruturais do capim-marandu submetido a combinações de alturas e intervalos de corte. *Revista Brasileira de Zootecnia, 40*(5), 955-963. doi: 10.1590/S1516-35982011000500003

Eloy, L. R., Rocha, M. G., Pötter, L., Salvador, P. R., Stivanin, S. C. B., & Hampel, V. S. (2014). Biomass flows and defoliation patterns of alexandergrass pasture grazed by beef heifers, receiving or not protein salt. *Acta Scientiarum. Animal Sciences, 36*(2), 123-128. doi: 10.4025/actascianimsci.v36i2.21815

Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA]. (2006). *Sistema brasileiro de classificação de solos*. Rio de Janeiro, RJ: Embrapa Solos.

Gastal, F., & Lemaire, G. (2015). Defoliation, shoot plasticity, sward structure and herbage utilization in pasture: Review of the underlying ecophysiological processes. *Agriculture, 5*(4), 1146-1171. doi: 10.3390/agriculture5041146

Gomide, C. A. M., & Gomide, J. A. (1999). Growth analysis of *Panicum maximum* Jacq. cultivars. *Revista Brasileira de Zootecnia, 28*(4), 675-680. doi: 10.1590/S1516-35981999000400003

Hodgson, J. (1981). Variations in the surface characteristics of the sward and the short-term rate of herbage intake by calves and lambs. *Grass and Forage Science, 36*(1), 49-57. doi: 10.1111/j.1365-2494.1981.tb01538.x

Hodgson, J. (1990). *Grazing management. Science into practice*. London, UK: Longman Group UK Ltd.

Lemaire, G., & Chapman, D. (1996). Tissue flows in grazed plant communities. In J. Hodgson & A. W. Illius (Eds.), *The ecology and management of grazing systems* (p. 3-36). Wallingford, UK: CAB International.

Moreira, L. M., Santos, M. E., Fonseca, D. M., Martuscello, J. A., Morais, R. V., & Mistura, C. (2011). Produção animal em pastagem de capim-braquiária adubada com nitrogênio. *Arquivo Brasileiro de Medecina Veterinária e Zootecnia, 63*(4), 914-921. doi: 10.1590/S0102-09352011000400017

Oliveira Neto, R. A., Silva, J. H. S., Rocha, M. G., Pötter, L., Sichonany, M. J. O., Biscaíno, L. L., ... Difante, M. V. B. (2013). Ingestive behavior, performance and forage intake by beef heifers on tropical pasture systems. *Revista Brasileira de Zootecnia, 42*(8), 549-558. doi: 10.1590/S1516-35982013000800003

Paiva, A. J., Silva, S. C., Pereira, L. E. T., Guarda, V. D. Á., Pereira, P. M., & Caminha, F. O. (2012). Structural characteristics of tiller age categories of continuously stocked marandu palisade grass swards fertilized with nitrogen. *Revista Brasileira de Zootecnia, 41*(1), 24-29. doi: 10.1590/S1516-35982012000100004

Pompeu, R. C. F. F., Cândido, M. J. D., Neiva, J. N. M., Rogério, M. C. P., Benevides, Y. I., & Oliveira, B. C. M. (2009). Fluxo de biomassa em capim-tanzânia sob lotação rotativa com quatro níveis de suplementação concentrada. *Revista Brasileira de Zootecnia, 38*(05), 809-817. doi: 10.1590/S1516-35982009000500005

Pontes, L. S., Carvalho, P. C. F., Nabinger, C., & Soares, A. B. (2004). Fluxo de biomassa em pastagem de azevém anual (*Lolium multiflorum* Lam.) manejada em diferentes alturas. *Revista Brasileira de Zootecnia, 33*(2), 529-537. doi: 10.1590/S1516-35982004000300002

Pötter, L., Rocha, M. G., Roso, D., Costa, V. G., Glienke, C. L., & Rosa, A. N. (2010). Suplementação com concentrado para novilhas de corte mantidas em pastagens cultivadas de estação fria. *Revista Brasileira de Zootecnia, 39*(5), 992-1001. doi: 10.1590/S1516-35982010000500008

Rouquette Junior, F. M. (2016). Invited review: The roles of forage management, forage quality, and forage allowance in grazing research. *The Professional Animal Scientist, 32*(1), 10-18. doi: 10.15232/pas.2015-01408

Salvador, P. R., Pötter, L., Rocha, M. G., Eloy, L. R., Hampel, V. S., Stivanin, S. C. B., ... Sichonany, M. J. O. (2014). Fluxos de tecidos foliares em papuã sob pastejo de bezerras de corte em diferentes frequências de suplementação. *Revista Brasileira de Saúde e Produção Animal, 15*(4), 835-845. doi: 10.1590/S1519-99402014000400004

Statistical Analysis System [SAS]. (2013). *SAS/STAT User guide, Version 9.4.* Cary, NC: SAS Institute Inc.

Sichonany, M. J. O., Rocha, M. G., Pötter, L., Oliveira, A. P. B. B., Ribeiro, L. A., Silva, M. F., ... Salvador, P. R. (2015). Ingestive behavior of heifers in Alexandergrass pasture receiving different amounts of oat grain as supplement. *Semina: Ciências Agrárias, 36*(4), 2763-2774. doi: 10.5433/1679-0359.2015v36n4p2763