Nutritive value and physical characteristics of Xaraes palisadegrass as affected by grazing strategy

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Abstract

The aim of this study was to ascertain whether the defoliation frequency based on a fixed rest period would generate variable sward structural and physiological conditions at each subsequent grazing event. The relative importance of the physiological age was established in comparison with the chronological age in the determination of the forage nutritive value of Xaraes palisadegrass [*Brachiaria brizantha* (Hochst ex A. RICH.) STAPF. cv. Xaraes]. Two grazing frequencies were defined by light interception (LI) at initiation of grazing (95% LI – "target grazing" [TG] or 100% LI – "delayed grazing" [DG]) and one based on chronological time, grazing every 28 days (28-d). Forage produced under the TG schedule was mostly leaves (93%) with a higher concentration of crude protein (CP; 138 g/kg in the whole forage), a lower concentrations of neutral detergent fibre (NDF) in the stems (740 g/kg), and higher *in vitro* dry matter digestibility (IVDMD) of the leaves (690 g/kg), compared to the other treatments. Lower grazing frequency strategies (DG and 28-d) resulted in forage with higher proportions of stems (10 and 9%, respectively). Strategies based on light interception did not produce pre-graze forage with a uniform nutritive value, as the indicators varied across grazing cycles. The treatment based on fixed days of rest did not result in uniformity.

Keywords: Digestibility, light interception, shearing resistance, forage quality
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Introduction

Ruminant performance depends directly on forage quality (nutritive value and voluntary intake) and its interaction with rumen microorganisms in the digestion process. Normally, high concentrations of crude protein and digestible dry matter are not easily found in tropical forages (Wilson, 1993; 1997) and, although this has been associated with intrinsic tropical grass characteristics, in most cases this is magnified by the fact that the management of these species under grazing is inadequate and results in overly mature forage being offered to the grazing animal. In this context, maturity is a main factor affecting tropical forage nutritive value, and the environment can markedly affect maturity by modifying the chemical composition of plant parts, or acting on plant morphology, such as on leaf : stem ratios (Sinclair & Seligman, 1995).

In most forage evaluation protocols, plant adaptation and yield potential are often emphasised and, only in the final stages before commercial release, nutritive value and intake are ascertained in animal trials. This can result in the early discarding of genotypes that, although not as well adapted or productive as others, can produce high-quality forage.

Studies to better characterize the quality of forages by their physical properties have considered techniques such as the resistance to grinding (Minson & Cowper, 1974) and to shearing (Mackinnon *et al*., 1988). Evidence exists that shearing resistance is related to chemical composition, especially to the cell wall and its components (Wilson, 1997; Hughes *et al*., 2000; Nave *et al*., 2009). These evaluations can help to explain the reasons that lead to differences in feed degradation in materials of similar composition but contrasting physical characteristics, which can affect the access and colonization of feedstuffs by ruminal microorganisms (Giger-Reverdin, 2000). Therefore, understanding the interplay between quantitative (e.g. productivity) and qualitative (e.g. chemical composition and digestibility, plus the physical traits that can affect nutritive value) characteristics of forages, is key to the identification of the variables that impact the outputs of a forage production system, namely animal performance and productivity.

Xaraes palisadegrass [*Brachiaria brizantha* (Hochst ex A. RICH.) STAPF. cv. Xaraes] was released as a promising option for the Brazilian beef cattle industry, and has potential for use in many other tropical/subtropical locations around the globe. However, data on its productive (Pedreira & Pedreira, 2007; Pedreira *et al*., 2009) and qualitative responses to defoliation management are still scarce (Euclides *et al*., 2000, Flores *et al*., 2008) under a wide range of grazing management practices. The objective in this study was to ascertain whether the defoliation frequency based on a fixed pasture rest period ("chronological age") would generate variable sward structural and physiological conditions at each grazing as compared with grazing schedules based on fixed sward conditions ("physiological age"), expressed as levels of light interception by the sward. In addition, an attempt was made to establish the relative importance of the physiological age in comparison with the chronological age in determining the indicators (chemical and physical) of the forage nutritive value of Xaraes palisadegrass.

Material and Methods

The experiment was carried out at Piracicaba, Sao Paulo, Brazil (22,42 S; 47,30 W; elevation 580 m). The soil is classified as Kandiudalfic Eutrudox (Soil Survey Staff, 2006), and was highly fertile, requiring no corrections or amendments when the experiment started. Only production fertilizations, totalling 120 kg N/ha and 100 kg K/ha during the experimental period were applied as $(NH_4)_2SO_4$ and KCl, respectively. Rainfall and temperature data were collected at a weather station located 1 km from the experimental site.

The trial was set as a completely randomized design with three treatments and three field replications. Nine experimental units (14 x 8.5 m paddocks) were mob-grazed so as to mimic paddocks under rotational stocking, according to treatments assigned to each paddock. Treatments corresponded to three grazing strategies; one of a fixed rest period (grazing every 28 days, 28-d) and two with variable rest periods. The variable rest periods were defined based on what would supposedly be a target, optimum interval, established so that the sward intercepted 95% of incoming radiation, and this was named a "target grazing" (TG) strategy. The other variable rest period strategy was chosen so as to represent a condition where grazing is delayed ("delayed grazing" [DG]), either voluntarily (e.g. stockpiling or deferred grazing) or involuntarily (e.g. intensive production not adequately accompanied by timely harvest or grazing). This was defined as when light interception (LI) by the pasture canopy was almost complete, in our case equal or above 97.5% in two consecutive, twice-a-week measurements. In each paddock, whenever the specific treatment condition was achieved, animals (2 to 6) were brought in and grazed until a15 cm stubble was reached.

The grazing cycles occurred on the following dates: TG strategy (13 Oct. 2005 - cycle 1; 01 Nov. 2005 - cycle 2; 02 Dec. 2005 - cycle 3; 20 Dec. 2005 - cycle 4; 09 Jan. 2006 - cycle 5; 06 Feb. 2006 - cycle 6); DG strategy (24 Oct. 2005 - cycle 1; 05 Dec. 2005 - cycle 2; 02 Jan. 2006 - cycle 3; 20 Dec 2005 - cycle 4; 08 Feb. 2006) and 28-d (20 Oct. 2005 - cycle 1; 18 Nov. 2005 - cycle 2; 15 Dec. 2005 - cycle 3; 13 Jan. 2006 - cycle 4; 14 Feb. 2006 - cycle 5). Measurements of LI and sward height were made during every regrowth (rest period), initiating immediately after grazing, continuing weekly, and immediately before the following grazing, in order to characterize the structural variations of the sward. Light interception was measured using a model LAI 2000 canopy analyzer (LI-COR, Lincoln Nebraska, EUA) (Welles & Norman, 1991).

After the swards were conditioned to their respective grazing schedules (for two months prior to the beginning of data collection) forage samples were collected immediately before each grazing. Within each paddock 15 to 20 sites that represented mean sward condition were selected and hand-plucked samples were collected above the 15 cm stubble and taken to the laboratory. Each composite sample, weighing approximately 2 kg (fresh forage), was then separated and a sub-sample of 700 g was dried in a forced air oven at 60 °C to a constant weight (48 - 72 h). The remaining material (approximately 1.3 kg) was separated in its plant-part components (green stems, green leaves and dead material). The dead material was dried at 60 °C to a constant weight. From the leaf fraction another sub-sample was taken, including leaves of all categories (young to mature) for a total of 20 leaf blades. Shearing resistance of these leaf blades was measured in a Warner-Bratzler Meat Shear at the midpoint of their length. The same procedure was followed for the stem fraction. The sheared material was subsequently returned to their respective sub-samples and dried at 60 °C to a constant weight.

Dried samples of the leaves and whole forage were tested for grinding resistance. For that evaluation, samples were first ground in a Wiley mill to pass a 5 mm screen. Twenty grams of this material were then ground through a 1 mm screen, for 25 seconds. The ground material (1 mm) and the unground residue (5 mm that did not pass the screen and remained in the grinding chamber) of these sub-samples were then collected and weighed. Grinding resistance was calculated as the proportion of the initial 20 g that did not pass through the 1 mm screen. Thus, material with higher resistance to grinding was those where the 5 mm residue (not ground to 1 mm) was higher (Hughes *et al*., 1998).

All samples were subsequently ground in a Wiley mill with a 1 mm screen and taken to the laboratory for chemical analyses. Crude protein (CP) concentration was determined using the Dumas combustion method, with a LECO FP-528 automatic nitrogen (N) analyzer (Wiles *et al*., 1998). *In vitro* dry matter digestibility (IVDMD) was determined by the ANKOM Fibre Analyzer (ANKOM Technology Corporation, Fairport, NY) protocol described by Holden (1999). Concentrations of neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using the sequential method of the ANKOM Fibre Analyser (ANKOM Technology Corporation, Fairport, NY), described by Holden (1999). The results of IVDMD were atypically high and a correction factor was applied after the analysis of IVDMD by the Tilley & Terry (1963) method in half of the samples. The correction factor was generated by regressing the IVDMD values measured by the ANKOM method against those of the same samples estimated by the Tilley & Terry (1963) method. The regression model generated was $y = 27.4193 + 0.055061\ x$, where y is the value of the corrected digestibility and x is the value of the digestibility found by the ANKOM method.

The data were analysed using the MIXED procedure of SAS (Littell *et al*., 2006). In this analysis "grazing cycle" (the sequence of grazing events within each treatment) was considered a random effect, while the "grazing method" was considered a fixed effect. Significance was detected at the 0.05 level of probability.

Results and Discussion

The pastures grazed every 28 days or under the DG strategy resulted in forage with different plant part compositions compared with that in paddocks managed at TG (Table 1). The TG strategy resulted in six grazing cycles, with shorter rest periods and a higher accumulation of leaves. The other treatments resulted in longer intervals between grazing, and lower leaf : stem ratios. During the experiment it became evident that the stem fraction was proportionally higher in treatments with low grazing frequencies, whereas the forage in paddocks grazed more frequently (e.g. 95% LI) consisted mostly of leaves (93%). In a companion study in the same experimental area, DG resulted in a longer mean interval between grazings and higher herbage accumulation (22760 kg DM/ha) than the other two treatments (mean = 17700 kg DM/ ha) (Pedreira *et al*., 2007).

Long rest periods increase the possibilities for a plant community to replenish the reserves needed to restore the canopy. If, however, intervals are too long, allowing for the canopy to intercept almost all the incident light, stem elongation is triggered, changing the dynamics of forage accumulation and often resulting in ever-increasing post-graze stubble mass, especially in tropical grass species (Da Silva & Sbrissia, 2001; Braga *et al*., 2009). The proportion of stems in rotational grazing are more closely related to defoliation frequency, as reported for Mombaça guineagrass (*Panicum maximum* Jacq.) by Carnevalli *et al*. (2006), who measured higher proportion of stem on pastures grazed less frequently (DG). In the present study, TG resulted in the lowest proportion of stems (5%) and DG and 28-d resulted in higher proportions (10%) in the pre-graze forage.

Concentration of CP (Table 2) differed among treatments for the stem (P = 0.021) and whole forage (P = 0.023), but not for the leaf (P = 0.095). Paddocks under the TG strategy produced forage with higher

Table 1 Proportion (± s.e.) of leaf, stem and dead material of pre-graze forage above 15 cm in Xaraes palisadegrass pastures under three grazing strategies (n = 6, 4, and 5, for TG, DG and 28-d, respectively)

Strategy	Leaf (%)	Stem (%)	Dead Material (%)
TG	$92.5^a \pm 0.7$	$5.4^b \pm 0.5$	2.2 ± 0.3
DG	$88.4^b \pm 0.9$	$9.7^a \pm 0.9$	1.9 ± 0.3
28-d	$88.4^b \pm 1.0$	$9.4^a \pm 1.0$	2.2 ± 0.4
P-value	0.001	0.001	0.744

[a,b] Column means with different superscripts differ significantly at P <0.05.
TG - Target grazing; DG - Delayed grazing; 28-d - Fixed rest period.

Table 2 Mean seasonal nutritive value (chemical composition and digestibility; ± s.e.) of Xaraes palisadegrass forage (leaf and stem fractions, and whole forage) under three different grazing strategies (n = 6, 4, and 5, for to TG, DG, and 28-d, respectively) (Dry matter basis)

Strategy	Leaf (g/kg)	Stem (g/kg)	Whole forage (g/kg)
		Crude protein	
TG	141 ± 6	89^{a} ± 4	138^{a} ± 6
DG	133 ± 7	79^{ab} ± 5	122^{ab} ± 6
28-d	123 ± 5	72^{b} ± 5	116^{b} ± 4
		Neutral detergent fibre	
TG	675 ± 7	740^{b} ± 5	678 ± 6
DG	688 ± 7	769^{a} ± 8	682 ± 7
28-d	685 ± 5	758^{a} ± 5	692 ± 5
		Acid detergent fibre	
TG	348 ± 5	396^{b} ± 4	349 ± 5
DG	355 ± 4	414^{a} ± 6	351 ± 4
28-d	356 ± 4	416^{a} ± 4	360 ± 3
		In vitro dry matter digestibility	
TG	693^{a} ± 4	660^{a} ± 5	698 ± 4
DG	680^{b} ± 5	635^{b} ± 7	695 ± 5
28-d	678^{b} ± 3	657^{a} ± 5	689 ± 4

[a,b] Means within a plant fraction and within a nutritive value indicator (CP, NDF, ADF and IVDMD) with different superscripts differ significantly at P <0.05.
TG - Target grazing; DG - Delayed grazing; 28-d - Fixed rest period.

concentrations of CP in both the stem and whole forage, contrasting with paddocks grazed every 28 days, where forage CP levels were lower. There was a cyclic effect (P = 0.042) on whole forage CP concentration for paddocks grazed at TG (Table 3), but not for leaf (P = 0.071) nor for stem (P = 0.013). Forage from paddocks grazed every 28 days (Table 4) had CP concentrations affected by cycle in leaves (P = 0.0001), stems (P = 0.0002) and whole forage (P = 0.0001). In the DG strategy, there was a cyclic effect for CP in all plant components (Table 5), with P = 0.007, P = 0.004 and P = 0.031 for leaves, stems and whole forage, respectively. Research on Marandu palisadegrass clipped at increasing rest intervals (Mari *et al*. 2003) showed a trend for reduction in CP concentration with increasing maturity (varying from 132 to 67 g/kg). The higher CP concentration found in forage harvested early in the vegetative stage was associated with a high proportion of leaves.

Concentrations of NDF (Table 2) differed among treatments in the stems (P = 0.007), but not in the leaves nor in the whole forage (P = 0.401 and P = 0.173, respectively). The TG treatment resulted in forage with lower NDF concentrations in the stems. The concentration of ADF in pre-graze forage (Table 2) was similar to that of NDF, and the DG and 28-d treatments resulted in forage with higher ADF concentrations in stems. There was no effect of treatments on leaf ADF (P = 0.377) and whole forage ADF (P = 0.091).

There was no grazing cycle effect on paddocks under the DG strategy (Table 5) for NDF concentration in the leaves (P = 0.267, mean = 688 g/kg), stems (P = 0.134, mean = 769 g/kg) and whole forage (P = 0.653, mean = 682 g/kg). Under the TG strategy (Table 3) there was a cyclic effect on NDF concentrations in the leaf (P <0.001), whole forage (P = 0.001) and stem (P = 0.032). Paddocks grazed every 28 days (Table 4) produced forage with NDF concentrations varying over cycles in stems (P = 0.001) and whole forage (P = 0.003), but not in leaves (P = 0.280). NDF in leaves and whole forage did not differ across treatments, and this is consistent with the NDF concentration in the whole forage, which was the same, since the relative amount of stem in whole forage samples was quite low. NDF concentrations increased as autumn approached, mainly in the TG and in the 28-d treatments, but were lower (ranging from 679 g/kg to 694 g/kg) than the 734 g/kg found by Euclides (2002) in Xaraes palisadegrass. Higher NDF levels at the end of the growing season were likely associated with increased flowering. Considering all grazing cycles, although there was a treatment effect on the concentration of NDF in stems, this cannot account for NDF differences in whole forage, because the proportion of stems was very low. The same happened in ADF concentration.

Table 3 Grazing cycle effect on qualitative responses of Xaraes palisadegrass forage (leaf and stem fractions, and whole forage) managed under the "target grazing" (TG) strategy (Dry matter basis)

Response	Grazing cycle						s.e.m.
	1	2	3	4	5	6	
CP leaf (g/kg)	165	155	131	163	125	105	26
CP stem (g/kg)	100	98	81	104	80	72	14
CP whole (g/kg)	164^{a}	149^{b}	130^{bc}	156^{ab}	124^{cd}	103^{d}	26
NDF leaf (g/kg)	650^{b}	645^{b}	700^{a}	654^{b}	710^{a}	692^{a}	30
NDF stem (g/kg)	728^{b}	728^{ab}	743^{ab}	741^{ab}	747^{ab}	755^{a}	22
NDF whole (g/kg)	645^{b}	645^{b}	692^{ab}	698^{a}	698^{a}	697^{a}	26
ADF leaf (g/kg)	334^{b}	321^{b}	365^{a}	336^{b}	372^{a}	357^{a}	21
ADF stem (g/kg)	389	393	404	404	383	392	18
ADF whole (g/kg)	328^{b}	327^{b}	359^{a}	357^{a}	360^{a}	361^{a}	20
IVDMD leaf (g/kg)	705	699	695	686	697	673	16
IVDMD stem (g/kg)	678	684	654	642	645	660	23
IVDMD whole (g/kg)	701	719	690	687	697	697	16
SR Leaf (kgf)	3.5^{bc}	3.3^{c}	4.3^{ab}	3.7^{bc}	4.3^{ab}	4.9^{a}	0.7
SR Stem (kgf)	8.0	7.8	9.6	9.2	9.2	10.4	1.6

[a,b] Row means with different superscripts differ significantly at P <0.05.
CP - Crude protein; NDF - Neutral detergent fibre; ADF - Acid detergent fibre; IVDMD - *In vitro* dry matter digestibility; SR - shearing resistance.

Grazing frequency affected IVDMD (Table 2) of the stems (P = 0.013) and leaves (P = 0.014), but not the whole forage (P = 0.211). TG resulted in forage with a higher IVDMD in both stems and leaves, with the lowest values found under DG. There was no grazing cycle effect on forage IVDMD in paddocks grazed under TG (P_{leaf}= 0.143; P_{stem}= 0.110; P_{whole}= 0.149), or every 28 days (P_{leaf}=0.593; P_{stem}= 0.208; P_{whole}= 0.124). On the DG paddocks there was a cyclic effect (Table 5) on IVDMD of leaves (P = 0.043), but not of stems (P = 0.462) or whole forage (P = 0.312). Stems and leaves of tropical forage species are often more lignified, and thus more resistant to the penetration of ruminal microorganisms, and this leads to low potential digestibility of leaves. Immature tropical forage species show similar digestibility of stems and leaves, but with increases maturity, stems become less digestible than leaves (Monson *et al.*, 1969). In the present study, stem IVDMD (656 to 660 g/kg) was lower than that of leaves (679 to 693 g/kg). The decrease in digestibility from the first to the second cycle within the DG strategy is probably related to the longer rest period on the second cycle (42 days), whereas the first, third and fourth cycles had rest periods of 31, 28 and 37 days, respectively.

Treatments based on a structural condition of the sward (% LI) were hypothesized to "standardize" the qualitative characteristics of whole forage (minimal variation over cycles), but the results showed that this was not achieved. Terry & Tilley (1964) showed that leaf proportion has a low correlation with digestibility, because leaves can have variable digestibility. Probably, for this reason, no differences were found in digestibility of leaves over grazing cycles in the TG strategy (mean 693 g/kg) where pre-graze forage had a higher leaf proportion (93%). The TG management produced forage with a higher nutritive value, with a higher concentration of CP in the stems and whole forage, lower concentration of NDF and ADF in the stems, and higher IVDMD of leaves and stems. The DG and 28-d treatments produced forage with a lower nutritive values, whereas the higher grazing frequency (TG) resulted in shorter rest periods (22 days on average), more grazing cycles (Pedreira *et al*., 2007), forage with high leaf proportions (Pedreira *et al*., 2009) and higher photosynthetic capacity at the initial phase of re-growth (Pedreira & Pedreira, 2007).

Table 4 Grazing cycle effect on qualitative responses of Xaraes palisadegrass forage (leaf and stem fractions, and whole forage) grazed every 28 days (Dry matter basis)

Response	Grazing cycle					s.e.m.
	1	2	3	4	5	
CP leaf (g/kg)	155[a]	126[b]	106[c]	121[b]	103[c]	20
CP stem (g/kg)	96[a]	71[b]	60[bc]	67[b]	55[c]	16
CP whole (g/kg)	134[a]	127[a]	103[bc]	112[b]	93[c]	16
NDF leaf (g/kg)	679	671	695	687	703	20
NDF stem (g/kg)	734[c]	753[bc]	762[b]	765[b]	805[a]	27
NDF whole (g/kg)	673[b]	675[b]	703[a]	706[a]	710[a]	19
ADF leaf (g/kg)	350	349	365	354	363	14
ADF stem (g/kg)	399[b]	407[b]	422[ab]	421[ab]	445[a]	20
ADF whole (g/kg)	357[ab]	344[b]	368[a]	366[ab]	367[a]	12
IVDMD leaf (g/kg)	677	681	667	685	683	14
IVDMD stem (g/kg)	674	643	661	663	640	20
IVDMD whole (g/kg)	705	684	679	690	688	13
SR Leaf (kgf)	3.7[c]	4.4[b]	4.4[b]	4.6[abc]	5.3[a]	0.5
SR Stem (kgf)	8.6[b]	11.2[a]	11.8[a]	11.8a	12.8[a]	1.6

[a,b] Means within rows with different superscript letters differ significantly at $P < 0.05$.
CP - Crude protein; NDF - Neutral detergent fibre; ADF - Acid detergent fibre; IVDMD - *In vitro* dry matter digestibility; SR - shearing resistance.

The intended standardization of pre-graze sward conditions in treatments based on light interception did not result on uniformity of qualitative determinants of the forage on offer (i.e. pre-graze, above the stubble), as the TG and DG strategies resulted in differences among grazing cycles, mainly in whole forage. The 28-d treatment, as expected, produced forage that was highly variable, qualitatively.

Strategies affected shearing resistance (Table 6) of the stems (P = 0.001), but not of the leaves (P = 0.162). The TG strategy produced forage with stems that were less resistant to shearing. Across grazing cycles the TG treatment (Table 3) resulted in uniform shearing resistance of stems (P = 0.363), but variable shearing resistance of leaves (P = 0.022). This did not happen in the 28-d treatment (Table 4), where differences were found for leaves (P = 0.001) and stems (P = 0.002). There was no variation in shearing resistance across grazing cycles for stems (P = 0.074), but there was for leaves (P = 0.001) on pastures subjected to the DG strategy (Table 5). There was no difference in grinding resistance of the leaves (P = 0.701) or whole forage (P = 0.067).

Paddocks under the TG strategy produced forage that was less resistant to shearing in both the stems and leaves. This forage was younger, since the rest periods were, on average, 22 days. This lower shearing resistance of stems would likely favour a higher forage intake rate, as shearing resistance has been shown to be highly correlated with intake (Minson & Wilson, 1994). With increased maturity, shearing resistance also increased. Nave *et al*. (2009) established canonical correlations among chemical, morphological and physical characteristics of Xaraes palisadegrass and found that forage with lower shearing resistance in leaves

Table 5 Grazing cycle effect on qualitative responses of Xaraes palisadegrass forage (leaf and stem fractions, and whole forage) under the “delayed grazing” (DG) strategy (Dry matter basis)

Response	Grazing cycle				s.e.m.
	1	2	3	4	
CP leaf (g/kg)	151[a]	115[b]	153[a]	113[b]	23
CP stem (g/kg)	94[ab]	69[bc]	87[a]	62[c]	18
CP whole (g/kg)	137[a]	105[b]	139[a]	108[b]	21
NDF leaf (g/kg)	676[a]	714[a]	679[a]	683[a]	26
NDF stem (g/kg)	767[a]	774[a]	754[a]	782[a]	15
NDF whole (g/kg)	680[a]	698[a]	673[a]	676[a]	25
ADF leaf (g/kg)	354[b]	372[a]	352[b]	341[b]	14
ADF stem (g/kg)	407[a]	429[a]	405[a]	416[a]	16
ADF whole (g/kg)	354[a]	352[a]	350[a]	349[a]	15
IVDMD leaf (g/kg)	686[ab]	665[b]	699[a]	671[b]	18
IVDMD stem (g/kg)	650[a]	634[a]	639[a]	618[a]	23
IVDMD whole (g/kg)	705[a]	679[a]	696[a]	699[a]	17
SR Leaf (kgf)	3.9[c]	4.8[b]	3.9[c]	5.3[a]	0.7
SR Stem (kgf)	10.0	11.7	9.1	11.3	1.4

[a-c] Row means with different superscripts differ significantly at $P < 0.05$.
CP - Crude protein; NDF - Neutral detergent fibre; ADF - Acid detergent fibre; IVDMD - *In vitro* dry matter digestibility; SR - shearing resistance.

Table 6 Shearing resistance (± s.e.) of Xaraes palisadegrass forage components (leaf and stem) under three different grazing strategies (n = 6, 4, and 5, for TG, DG, and 28-d, respectively)

Strategy	Leaf	Stem
	SR (kgf)	SR (kgf)
TG	4.00 ± 0.14	9.01[b] ± 0.37
DG	4.48 ± 0.24	10.51[a] ± 0.47
28-d	4.38 ± 0.14	11.16[a] ± 0.39

[a,b] Column means with different superscripts differ significantly at $P < 0.05$.
TG - Target grazing; DG - Delayed grazing; 28-d - Fixed rest period; SR - shearing resistance.

and stems had higher concentrations of crude protein in the leaves and whole forage, lower concentrations of NDF in the leaves and whole forage, and higher digestibility of the leaves and stems. Hughes *et al*. (1998) studied shearing resistance of leaves in four species of *Brachiaria* spp., sampled at two maturities (4 and 6 weeks), and found differences among species (*B. brizantha* = 2.73 kgf, *B. humidicola* = 1.9 kgf, *B. decumbens* = 1.4 kgf and *B. ruziziensis* = 1.2 kgf) but not between maturities, which is consistent with our results.

In the present work, we studied a single material under three treatments, and grinding resistance did not differ among treatments or grazing cycles. Herrero *et al*. (2001) studied physical characteristics and their relationship with chemical composition of *B. brizantha, B. ruziziensis*, *B. humidicola* and *B. decumben*s, and found no correlation between shearing resistance and grinding resistance. One advantage of shearing resistance as an indication of nutritive value is that it can be measured when the forage is still fresh, keeping intact the anatomical structure of plant parts as well as the cell wall constituents; whereas grinding resistance evaluation uses dried and coarsely ground samples (Wilson, 1997; Wilson & Hatfield, 1997). This is important in the determination of physical descriptors of the forage, as tissue integrity and fibre characteristics may be lost in analysis of dried material. For the physical characterisation methods evaluated, shear strength showed more consistent results when compared to grinding resistance. The TG strategy produced forage that was less resistant to shearing in stems, characterizing younger stems.

Conclusions

Grazing strategies based on light interception did not produce forage with a uniform nutritive value at pre-graze. The use of the TG strategy resulted in more grazing cycles (younger forage) and produced forage with less stem and better nutritive value. Longer rest periods (DG and 28-d) decreased the leaf proportion and nutritive value of the forage on offer. This can be a valuable alternative for forage systems where animals have high nutritional requirements (lactating cows or growing beef animals). When a high yield (forage mass and accumulation) is needed. However, longer intervals (DG) may be advantageous, allowing for high stocking rate, despite lower forage nutritive value. Further research is needed to quantify qualitative responses of Xaraes palisadegrass under controlled sward conditions and rotational grazing, as well to quantifying animal responses, including voluntary intake and performance.

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