Article

Structural components of Chetumal grass at different grazing management

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Abstract

The objective was to study the effect of different grazing frequencies and intensities on the structural components of a *Brachiaria humidicola* grassland. The cutoff frequencies were at 21 and 28 d and the intensities were 9-11 and 13-15 cm high. Variables were analyzed in a randomized block design with a 2 x 2 factorial arrangement. Forage accumulation, stem dynamics and leaf growth rate were determined. In the rainy season 67 and 64% of the annual forage production were concentrated, grazing on 21 and 28 d, respectively. Stem density during the rainy season was 11% higher in the first cycle, 11 and 20% in the north of both cycles when grazing every 21 days. The rate of appearance of stems in the rainy season decreased 21% by expanding the interval between grazing from 21 to 28 days, respectively. The greatest forage accumulation, leaf tissue turnover and weight per stem, was obtained by grazing at a light intensity of 13-15 cm in height every 28 days.

Keywords: forage accumulation, frequencies, grazing intensities.

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Introduction

Forages are the main source of food in grazing production systems and the lack of them in dry seasons, as well as partial use when there is surplus forage production in rainy seasons, largely attributed to their management (Nantes *et al*., 2013). Therefore, management must be strategic, thus making efficient use of pastures, it is a challenge to maintain the production of feed for ruminants.

However, the recommendations regarding management in grasses are generalized, without considering the degree of defoliation (residual leaves after grazing), the frequency of grazing (the time between the first and second grazing), their growth habit and their structural components (Gastal and Lemaire, 2015; Cruz-Hernández *et al*., 2017). With light and less frequent defoliation, plants express rapid recovery in the growth of their leaves, while the opposite occurs when the grassland is defoliated severely more frequently (Lemaire *et al*., 2009).

Changes in the structural components of plants are attributed to the degree of defoliation that depends on the remaining leaf area after harvest by mechanical means or by the animal (Nantes *et al*., 2013; Assis *et al*., 2014). This modifies the stem density, the weight per stem, the leaf elongation, the leaf appearance rate and the forage yield (Difante *et al*., 2011; Cruz-Hernández *et al*., 2017).

It is evident that with severe and frequent defoliation, forage production decreases throughout the year, despite the fact that in rainy seasons there are favorable conditions for grasslands to express their forage potential (Gastal and Lemaire, 2015). In grasslands cultivated with *B. humidicola* grass, higher forage production has been demonstrated with high stem densities (Martínez *et al*., 2008).

Similar behavior occurred with Mulato grass (*Brachiaria hibrida* 36061), where it was found that plants with a higher percentage of leaves in the grasslands that had higher stem density (Asis *et al*., 2014). Since the grass *Brachiaria humidicola* cv. Chetumal has high forage quality, considered by producers as an alternative, in addition to its adaptation to waterlogged soils in the tropics.

Due to the above, it is necessary to know the seasonal growth patterns of each forage species that are used in tropical regions; thus, the objective of this research was to determine the effect of grazing intensity and frequency on forage accumulation, morphological and structural components of *Brachiaria humidicola* grass.

Materials and methods

The study was carried out from November 2007 to May 2009, in the experimental area of the Academic Division of Agricultural Sciences of the Autonomous University Juarez of Tabasco (UJAT), which is located at 17º 46’ 56” north latitude and 92º 57’ 28” west longitude, at 10 masl, in the Centro municipality, Tabasco, Mexico. The climate is Am (f) (i’) gw, with precipitation and annual average temperature of 2 010 mm and 27.2 °C, respectively (García, 2004).

Precipitation presented the following distribution at different times of the year: norths, dry and rain (25, 10 and 65% respectively) with the highest precipitation in September (Figure 1). The maximum and minimum precipitation and temperature data were obtained with the UJAT meteorological equipment. The floor corresponds to chromic luvisol with a slight slope (Palma and Cisneros, 1996).

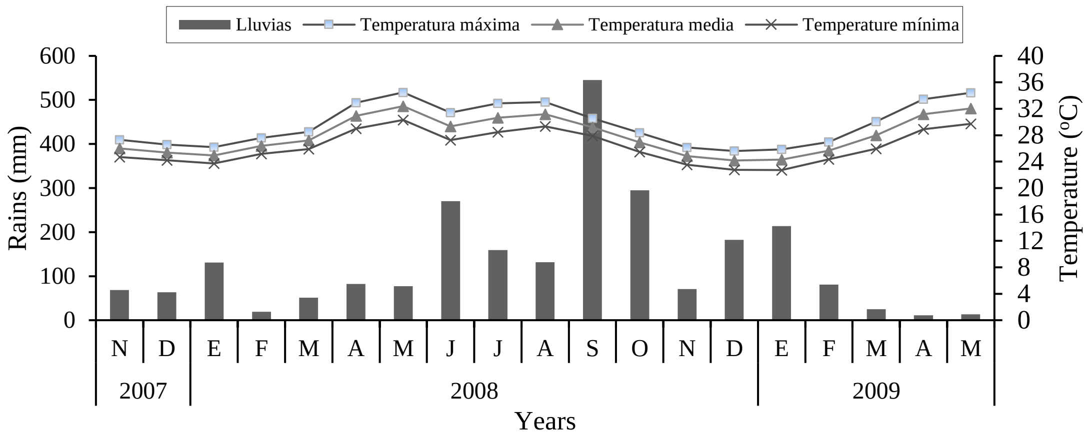

Figure 1. Monthly data on rainfall and maximum, average and minimum temperatures during the experimental period, north (Nov.-Feb.), Dry (Mar.-May.), Rains (Jun.-Oct.). Source: UJAT.

An area of 37.5 x 48 m was delimited, which was divided into 18 experimental units of 12.5 x 8 m that were distributed in a randomized block design with three replications. Glyphosate herbicide was applied at a concentration of 41% to eliminate weeds. Grass sowing *Brachiaria humidicola* cv. Chetumal was carried out manually, in July 2006, with a distance between bushes and furrows of 50 cm and a planting density of 6 kg ha^{-1} of seed.

Fifteen days before the start of the study, a uniform grazing was carried out in all the experimental units, the factors were grazing frequency (FP: 21 and 28 d) and intensity (severe: 9-11 cm and light: 13 -15 cm). 10 calves of 180 to 230 kg live weight per plot were used as foliators, until grazing intensity was reached. The animals remained from 4 to 8 h in each experimental unit depending on the time of year.

To evaluate the seasonal and annual performance of the forage, one day before starting the study, two fixed quadrants of 50 x 100 cm were randomly placed in each repetition, which were harvested one day before each grazing at the corresponding intensity and frequency. Subsequently, the weight of the fresh forage was recorded with a Scout® granataria scale, placed in paper bags and dried in a forced air stove, at a temperature of 55 °C, for 72 h. The dry weight of the forage was recorded and the yield per unit area (kg DM ha^{-1}) was determined.

Population dynamics of stems, in each experimental unit, two rings of 20 cm in diameter were placed at ground level and were fixed during the experimental period and the stems inside the ring were marked with wire rings of the same color that were considered as the initial population; live and dead stems were recorded at 30-day intervals and new stems were marked with a new color, each color representing a generation of stems.

Individual data in each ring were used to calculate changes in stem dynamics, emergence rate, and stem death rate; subsequently, stems m^{-2} were calculated for subsequent analysis, assuming that the entire surface of the m^2 would be occupied with the same density as that obtained in the sample (Cruz-Hernández *et al*., 2017). 20 stems were also randomly harvested at ground level to obtain the weight per stem.

The leaf tissue exchange rate was carried out in the middle of each season, one day after grazing, in each experimental unit, 10 stems were randomly selected, which were identified with colored plastic rings and with a graduated ruler in mm, the length of the leaf blade (from the ligule to the apex in green leaves or to the base of the chlorotic tissue in senescent leaves) was measured on each leaf, on each stem.

This same determination was made every week until one day before the next grazing. The leaf elongation rate (LER; cm $stem^{-1}$ d^{-1}), was calculated for the expanding leaves, by the difference between the length of the final leaf blades (LFBf) minus the initial (LFBi), at the end of two successive measurements divided by the number of days (T) that elapsed between both successive measurements with the following formula LER = (LFBf-LFBi)/T.

The leaf senescence rate (LSR; cm $stem^{-1}$ d^{-1}), was obtained for mature leaves and in the process of senescence, as the difference between the length of the green leaf blades at the beginning (GLBi) and at the end of two measurements (GLBf), divided by the number of days (T) that elapsed between both measurements. LSR = (GLBi-GLB)/T. The net leaf growth rate per stem (NLG; cm $stem^{-1}$ d^{-1}), was calculated as the difference between the leaf elongation rate (LER) and the leaf senescence rate (LSR), NLG= LER- LSR.

The data was analyzed with the PROC MIXED model (SAS, 2009).

The effects of frequencies, grazing intensity, times of the year and their interactions were considered fixed and the block effect was considered random. The comparison of means was made with the Tukey test, α= 0.05 (Steel and Torrie, 1988).

Results and discussion

Grazing frequency increased ($p< 0.01$) dry matter (DM) production throughout the experimental period. In the first cycle, the annual DM production of *Brachiaria humidicola* increased by 42% by increasing the frequency of grazing from 21 to 28 days ($p< 0.05$), with forage production of 67 and 64% in the rainy season when grazing at 21 and 28 days, respectively (Table 1).

Regarding grazing intensity, harvesting with less intensity increased annual forage production by 16% ($p< 0.01$) compared to severe grazing (Table 1). For the second cycle, in both seasons, by increasing the grazing frequency from 21 to 28 days to light grazing intensities, the accumulation of DM increased 39% in the north and 127% in the dry season (Table 1). In the second cycle, the light intensity was 10 and 56% higher ($p< 0.05$) than the severe intensity in norths and dry, respectively (Table 1).

Table 1. Seasonal and annual accumulation of dry matter *Brachiaria humidicola* cv. Chetumal subjected to different grazing frequencies and intensities (kg DM ha^{-1}).

Treatments		Cycle 1			Annual yield	Cycle 2	
Frequencies (days)	Intensity	Norths£	Dry£	Rains£		North£	Dry£
21		1702 b	367 b	4298 b	6368 b	1365 b	190 b
28		2371 a	834 a	5849 a	9054 a	2022 a	376 a
	Severe	1840 b	521 a	4782 b	7143 b	1612 a	221 b
	Light	2233 a	680 a	5365 a	8278 a	1775 a	345 a
SEM		38.5	32.4	51.6	40.3	51.4	19.8
GF		**	*	**	**	*	**
GI		**	*	**	**	ns	**

£= seasons of the year; norths (nov.-feb.), dry (mar.-may.), rains (jun-oct). Severe (9-11 cm) and Light (13-15 cm); ns= not significant; **= $p \leq 0.01$; *= $P \leq 0.05$; ab= different lowercase literal, in each column, indicate difference ($p < 0.05$); SEM= standard error of the mean; GF= grazing frequency; GI= grazing intensity.

Regardless of the management, the highest DM production was obtained in the rainy season and was due to the higher precipitation and temperature that favored conditions for the humidic grass to increase forage accumulation (Figure 1). There is evidence that shows a greater growth of forage if the ambient temperature is between 25 and 35 °C (Candido *et al*., 2006; Sage and Kubein, 2007). On average, the temperature in the present study was 25.5 °C, so the response of the pasture to changes in the seasons with respect to precipitation and temperature was as expected for hot humid climate conditions in the state of Tabasco, Mexico.

Changes in DM accumulation are also attributed to management since the highest forage accumulation was obtained by grazing every 28 days with a residual height of 13 to 15 cm (Table 2). The opposite occurred, when grazing the prairie at a high and frequent intensity and it was due to the fact that there was a lower index of remaining leaf area to carry out photosynthesis (Difante *et al*., 2011), which affected the regrowth speed.

Table 2. Seasonal changes in the density, appearance rate and mortality rate of *Brachiaria humidicola* cv. Chetumal, subjected to different frequencies and intensities of defoliation.

Treatments		Cycle 1			Cycle 2	
Frequency (days)	Intensity	Norths£	Dry£	Rains£	Norths£	Dry £
		Density (Stems m^{-2})				
21		1 879 a	2 554 a	4 227 a	5 705 a	5 052 a
28		1 693 a	2 417 a	3 795 a	4 743 b	3 837 b
	Severe	1 932 a	2 696 a	4 282 a	5 528 a	4 709 a
	Light	1 639 a	2 276 b	3 740 b	4 919 b	4 179 a
SEM		62.1	59.9	83.3	106.8	1 12.7
GF		ns	ns	ns	ns	*
GI		ns	ns	*	*	*

Treatments		Cycle 1			Cycle 2	
Frequency (days)	Intensity	Norths£	Dry£	Rains£	Norths£	Dry £
		Occurrence rate (stems m^{-2} day^{-1})				
21		20 a	7 a	29 a	17 a	4 a
28		19 a	6 a	24 b	14 b	3 a
	Severe	22 a	7 a	28	16 a	4 a
	Light	17 b	6 a	25	14 a	3 a
SEM		0.8	0.5	0.6	0.7	0.4
GF		ns	ns	**	*	ns
GI		**	ns	*	ns	ns
		Mortality rate (stems m^{-2} day^{-1})				
	Severe	3 a	3 a	11 a	24 a	11 a
21	Light	4 a	4 a	9 a	15 b	7 a
	Average	3	4	10	19	12
	Severe	4 a	3 a	10 a	15 b	12 a
28	Light	2 a	2 a	9 a	18 ab	12 a
	Average	3	2	9	16	9
	Severe	4	3	10	19	11
Average $\bar{x}$						
Light		3	3	9	16	10
S E M		0.7	1.2	1.1	1.4	1.5
Grazing frequencies (GF)		ns	ns	ns	*	ns
Grazing intensity (GI)		ns	ns	ns	ns	ns
Interaction (GF X GI)		ns	ns	ns	*	ns

£= seasons of the year; norths (nov.-feb.), dry (mar.-may.), rains (jun-oct). Severe (9-11 cm) and light (13-15 cm); ns= not significant; **= $p\leq 0.01$; *= $p\leq 0.05$; ab= different lowercase literal, in each column, indicate difference ($p< 0.05$); SEM= standard error of the mean; GF= grazing frequency; GI= grazing intensity.

The highest stem density during the rainy season was 11% (first cycle) and 20% in norths (second cycle) when grazing every 21 days compared to the 28 days ($p< 0.05$). During the norths season the lowest stem density was recorded (first cycle). A similar record was observed in the dry season in both cycles (Table 2). Grazing intensity affected the density of stems in the norths, dry and rainy seasons, which exceeded severe grazing by 17, 18 and 14% to light, respectively in the first cycle. In the second cycle the density was 12 and 13% in north and dry ($p< 0.05$).

Management is a factor that influences stem density and this increases with frequent cuts; it also occurs when much of the leaf tissue is removed (Nantes *et al*., 2013; Cruz-Hernández *et al*., 2017), as happened with the pasture when grazing at an intensity of 9-13 cm in height. The previous results make evident that the intensity with which a pasture is grazed is the most important variable that determines the appearance and changes in the density of stems (Lara and Pedreira, 2011). The results obtained in the present study of the density (Table 2) and individual weight of stems (Table 3).

Table 3. Dry weight per stem (mg stem) of the *Brachiaria humidicola* cv. Chetumal, subjected to different frequencies and grazing intensities.

Treatments		Cycle 1			Cycle 2	
Frequency (days)	Intensity	Norths£	Dry£	Rains£	Norths£	Dry£
21		326 a	299 a	383 b	376 b	239 a
28		393 a	328 a	488 a	449 a	315 a
	Severe	344 a	309 a	424 a	392 a	267 a
	Light	374 a	318 a	448 a	433 a	287 a
SEM		38.7	25.2	19.3	16.6	26
GF		ns	ns	*	*	ns
GI		ns	ns	ns	ns	ns

£= seasons of the year; norths (nov.-feb.), dry (mar.-may.), rains (jun-oct). Severe (9-11 cm) and light (13-15 cm); ns= not significant; **= $p \leq 0.01$; *= $p \leq 0.05$; ab= different lowercase literal, in each column, indicate difference ($p < 0.05$); SEM= standard error of the mean; GF= grazing frequency; GI= grazing intensity.

They explain the changes in biomass accumulation, as they state (Gastal and Lemaire, 2015) that the increase in forage production can be attributed to an increase in stem density, weight per stem or the combination of both. The intensity of grazing affected the rate of appearance of stems (RAS) of the *B. humidicola* grass ($p < 0.05$) in the norths and rainy seasons of the first cycle (Table 2). Frequency effect ($p < 0.05$) was only recorded in the rainy seasons (first cycle) and norths (second cycle). RAS in the rainy season decreased by 21% by expanding the grazing interval from 21 to 28 days, respectively (Table 2).

During the norths seasons, RAS decreased by 5% (first cycle) and 21% (second cycle) as the interval between pastures increased from 21 to 28 days, respectively. Similar behavior was observed in the dry season in both cycles. In general, RAS with severe grazing was 18, 17 and 12% higher than light grazing in norths, dry and rainy seasons ($p < 0.05$) in the first cycle.

Environmental conditions influenced the rate of appearance of stems, mainly in September and October, where the highest rainfall occurred (Figure 1), leading to the generation of new stems in the months of November, December and January of the second cycle (Table 2). Management plays an important role, since by intensively grazing a grassland the removal of leaf lamina is greater, allowing light to enter the grass stem bases and thus promoting the activation of axillary buds and the appearance of new stems (Difante *et al*., 2011; Gastal and Lemaire, 2015).

Regarding the stem mortality rate (SMR), the effect of frequency and frequency x intensity interaction ($p < 0.05$) of grazing was only recorded in the norths season of the second cycle (Table 2). When performing severe grazing, the SMR was 15.7% higher ($p < 0.05$) compared to light grazing in norths of the second cycle, respectively (Table 2). Regardless of the management, in the north of the second cycle the highest mortality rate was obtained, this is attributed to the high rate of appearance of stems and the greater leaf elongation (Table 4) that occurred in the rainy season.

Table 4. Seasonal changes in the rate of elongation, senescence and net leaf growth of *Brachiaria humidicola* cv. Chetumal subjected to different frequencies and intensities of defoliation.

Treatments		Cycle 1			Cycle 2	
Frequency (days)	Intensity	Norths[£]	Dry[£]	Rains[£]	Norths[£]	Dry[£]
		Folia elongation (cm stem^{-1} day^{-1})				
21		1.92 a	1.26 a	2.72 a	1.78 a	1.31 a
28		2.06 a	2.19 a	3.28 a	2.59 a	1.8 a
	Severe	1.92 a	1.72 a	2.82 a	1.82 a	1.4 a
	Light	2.06 a	1.73 a	3.18 a	2.55 a	1.71 a
SEM		0.29	0.12	0.35	0.31	0.15
GF		ns	ns	ns	ns	ns
GI		ns	ns	ns	ns	ns
		Foliar senescence (cm stem^{-1} day^{-1})				
21		0.28 a	0.1 a	0.16 a	0.11 a	0.07 a
28		0.43 a	0.45 a	0.53 a	0.21 a	0.15 a
	Severe	0.36 a	0.29 a	0.33 a	0.12 a	0.11 a
	Light	0.35 a	0.25 a	0.36 a	0.2 a	0.1 a
SEM		0.08	0.1	0.08	0.04	0.05
GF		ns	ns	ns	ns	ns
GI		ns	ns	ns	ns	ns
		Net foliar growth (cm stem^{-1} day^{-1})				
21		1.62 a	1.16 a	2.55 a	1.67 a	1.24 a
28		1.64 a	1.74 a	2.75 a	2.37 a	1.65 a
	Severe	1.55 a	1.44 a	2.49 a	1.69 a	1.29 a
	Light	1.71 a	1.46 a	2.81 a	2.35 a	1.6 a
SEM		0.25	0.16	0.27	0.28	0.15
GF		ns	ns	ns	ns	ns
GI		ns	ns	ns	ns	ns

[£]= seasons of the year; norths (nov.-feb.), dry (mar.-may.), rains (jun-oct). Severe (9-11 cm) and light (13-15 cm); ns= not significant; **= $p \leq 0.01$; *= $p \leq 0.05$; ab= different lowercase literal, in each column, indicate difference ($p < 0.05$); SEM= standard error of the mean; GF= grazing frequency; GI= grazing intensity.

Some researchers relate the higher mortality rate with the increase in the rate of stem emergence (Lemaire *et al*., 2009; Lara and Pedreira 2011), this behavior was observed in the rainy and norths seasons in the first and second cycles, respectively. The weight per stem was increased by expanding the grazing interval from 21 to 28 days with light grazing (Table 3). In rains, the weight decreased 27% by reducing the interval between grazing from 28 to 21 days, ($p < 0.05$).

In the norths season, the reduction was 21% (first cycle) and 19% (second cycle) as the interval between pastures decreased from 28 to 21 days, respectively. Despite the fact that the weight per stem in the grasslands that were lightly grazed was higher than that of the severely grazed grasslands, only effects between frequency were registered during the rainy and norths seasons in the first and second cycle ($p < 0.05$).

These results differ from other researchers who mention that the reduction in weight per stem coincides with the increase in the density of stems and vice versa (Gastal and Lemaire, 2015; Cruz-Hernández *et al*., 2107). Likewise, investigations with different grass species have concluded that, with less severe defoliation, the stem weight is greater (Asis *et al*., 2014).

The lowest accumulation of foliar biomass of the *B. humidicola* grass was observed when grazing every 21 days (Table 1); which coincided with the highest stem density and the lowest weight per stem. However, when grazing every 28 days, a higher weight per stem was observed, although the density was lower, a condition that favored the increase in the flow of foliar tissue, which increased the net accumulation rate of the forage, which explains the differences in the accumulation of foliar biomass (Table 1).

No effect of frequency or grazing intensity was recorded on the leaf elongation rate ($p > 0.05$) throughout the evaluation period (Table 4). In the rainy season, when the environmental conditions were favorable for growth, the greatest elongation of foliar tissue of the *B. humidicola* grass was presented, but the frequency and intensity of the grazing, to which the grassland was subjected, favored the units experimental that were slightly harvested every 28 days respectively.

In general, a progressive increase in the leaf elongation rate was observed with increasing the interval from 21 to 28 days, where the leaf senescence rate also began to manifest, so that the net leaf growth was similar to that recorded in 21 days of regrowth age, in both grazing intensities (Table 4).

Conclusions

The greatest forage accumulation, leaf tissue changes and weight per stem, was obtained by grazing at a light intensity of 13-15 cm in height every 28 days. The forage potential of *Brachiaria humidicola* cv. Chetumal was expressed in the rainy season and was followed by the north and dry, with greater forage accumulation, stem density, rate of emergence of stems and net leaf growth in the rainy season.

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