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FORAGE YIELD, QUALITY AND UTILIZATION EFFICIENCY ON NATIVE PASTURES UNDER DIFFERENT STOCKING RATES AND SEASONS OF THE YEAR IN THE MEXICAN HUMID TROPIC

[PRODUCCIÓN DE FORRAJE, CALIDAD Y EFICIENCIA DE UTILIZACIÓN DE PASTOS NATIVOS BAJO DIFERENTE CARGA ANIMAL Y ÉPOCA DEL AÑO EN EL TRÓPICO HÚMEDO MEXICANO]

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SUMMARY

This study aimed to evaluate the effect of season of the year (SY) and stocking rate (SR) on forage yield, utilization efficiency, development of plant components, crude protein (CP), cell wall content (CWC), ruminal degradation of dry matter (DM), acid detergent fiber (ADF) and neutral detergent fiber (NDF) of native grasses, in two consecutive years, in Veracruz, Mexico. Treatments included 2, 3 and 4 cows ha^{-1} during the rainy, windy and dry seasons. For each SR, 10 Holstein x Zebu cows were used in 10 paddocks of 0.5, 0.33 and 0.25 ha for SR 2, 3 and 4 cows ha^{-1}, respectively. Each paddock was grazed for three days and had a rest period of 27 days. A randomized design with two replications was used. Stocking rate did not affect forage yield (6171 kg DM ha^{-1}), CP of leaves (9.9 %) and stems (7.2 %), CWC, ruminal degradation of DM of leaves (69.8 %) and stems (70.7 %), nor NDF of leaves (69.6 %) and stems (73.5 %), whereas SY did affect these variables. The SY was the main factor affecting forage yield and nutritive quality. The density and length of stems, and the length of leaves were higher at a lower SR in the rainy season.

Key words: Forage yield and quality; humid tropics; native grasses; rumen degradation.

RESUMEN

Se evaluó el efecto de época del año (SY) y carga animal (SR) sobre producción de forraje, eficiencia de utilización, desarrollo de componentes vegetales, proteína cruda (CP), contenido de pared celular (CWC), degradación ruminal de materia seca (DM), fibra detergente ácido (ADF) y fibra detergente neutro (NDF) de pastos nativos, durante dos años consecutivos, en Veracruz, México. Los tratamientos incluyeron 2, 3 y 4 vacas ha^{-1} en las épocas lluviosa, de nortes y seca. Para cada SR se usaron 10 vacas Holstein x cebú en 10 potreros de 0.5, 0.33 y 0.25 ha para SR de 2, 3 y 4 vacas ha^{-1}, respectivamente. Cada potrero fue pastoreado tres días y tuvo 27 días de descanso. Se usó un diseño al azar con dos repeticiones. La SR no afectó el rendimiento de forraje (6171 kg MS ha^{-1}), CP de hojas (9.9 %) y tallos (7.2 %), CWC, degradación ruminal de DM de hojas (69.8 %) y tallos (70.7 %), ni NDF de hojas (69.6 %) y tallos (73.5 %), mientras que la SY sí afectó estas variables. La SY fue el principal factor que influyó en la producción y calidad nutritiva del forraje. La densidad y longitud de tallos, y la longitud de hojas fueron mayores a una menor SR en la época lluviosa.

Palabras clave: Rendimiento y calidad del forraje; trópico húmedo; pastos nativos; degradación ruminal.

INTRODUCTION

In the humid tropics, there are large land areas (above 50 % of the livestock area) covered with native grasses, mainly from the genera *Paspalum* and *Axonopus*. Despite their low quality, native grasses are the most important forage source in animal production systems (Fike *et al.,* 2003; Améndola *et al.,* 2005), due to their adaptation to the tropical environment. Forage quality is influenced by environmental conditions and plant age. A negative correlation has been found between dry matter (DM) *in vitro* digestibility and forage age, which suggests a rapid decline of forage quality as the plant matures (Dabo *et al.,* 1987). This reduction in forage quality is related to the increment on fiber content and the reduction of crude protein (CP) and leaf:stem ratio as the plant matures (Juarez-Lagunes *et al*., 1999), so management techniques are required to maintain active grass growth that allows a better animal performance (Dabo *et al.,* 1988).

An important strategy to maintain active grass growth is the manipulation of stocking rate (SR) (Ackerman *et al.,* 2001). An increment in SR reduces the amount of available forage per animal, but it could increase the amount of forage produced per unit of area (Macdonald *et al.,* 2008) and its utilization efficiency. Also, forage quality could be positively correlated with intensity of defoliation (Lee *et al.,* 2008).

The objective of the present study was to evaluate the influence of SR and season of the year (SY) on forage yield, components, quality, and utilization efficiency of native grasses, mainly of the genera *Paspalum* and *Axonopus,* in a region of the Mexican humid tropic.

MATERIALS AND METHODS

The present study was carried out from September 2005 to August 2007 at the Centro de Enseñanza, Investigación y Extensión en Ganadería Tropical, located in Tlapacoyan, Veracruz, Mexico, (Lat. 20° 02' N, Long. 97° 06' W, altitude 112 m), with mean annual temperature of 23.5 °C and mean annual rainfall of 1991 mm. Climatic classification is Af(m)w"(e), equivalent to the warm and humid type, with rain throughout the year (García, 1981). In Fig. 1, fluctuations on temperature and rainfall during the evaluation period are presented. According to these fluctuations, three seasons of the year (SY) were identified: rainy (July - October), windy (November - February) and dry (March - June). The pasture used in the study included 86.9 % native grasses, mainly *Paspalum* spp. and *Axonopus* spp., 2.9 % introduced grasses, mainly *Cynodon nlemfuensis* and *Brachiaria arrecta*, 1.7 % native legumes, mainly *Desmodium* spp., and 8.5 % broadleaf weeds.

Soil type in the experimental site was acid (pH 4.5 - 5.2), Ultisol (Udults; Toledo, 1986) with low N (0.032 %), P (2.32 ppm), and K (8.5 ppm) contents. It had a shallow (2 - 5 to 25 cm) arable layer, limited at the bottom by a harsh layer locally known as "tepetate", which has acid silicates that limits root penetration and causes deficient drainage (Toledo, 1986).

Treatments consisted of three SR, which were 2, 3 and 4 cows ha^{-1} with two replicates. Each treatment had 10 F1 Holstein x Zebu cows (489.9±67.5 kg live weight) and areas of 5, 3.3 and 2.5 ha, respectively, for SR 2, 3 and 4 cows ha^{-1}, which were divided in 10 paddocks of 0.5, 0.33 and 0.25 ha, respectively. Each paddock was grazed for three days, and had a rest period of 27 days. Of the 10 paddocks for each repetition, two paddocks were used to take measurements for each variable evaluated, and the remaining eight paddocks were used to complete the grazing cycle. The paddocks had not being fertilized since four years before the start of the study. Cows were kept in their respective paddocks all the time, except when they were milked. All samplings were taken in the last two months of each season, which included two grazing cycles. The same cows were used throughout the study. Cows in each treatment received 2 kg of a concentrate feed (12 % CP) at milking time only for two months during winter.

Available forage (kg ha^{-1}) before and after grazing was assessed with the comparative yield method (Haydock and Shaw, 1975). The calibration curve was generated with five double sampling points (visual scale *vs* harvested forage), while the average visual assessment was generated with 100 randomly selected sampling points, cut at ground level. From the forage material obtained from the five sampling points, a subsample (250 g fresh basis) was taken to estimate the leaf:stem ratio.

To estimate the utilization efficiency (UE) of the pasture, the available forage in DM (leaves and stems) before (BG) and after (AG) grazing, was considered as follows:

$$UE (\%) = [(DM\ BG – DM\ AG)/DM\ BG] * 100$$

In both experimental years, forage harvested before grazing was chemically analyzed to quantify the content of CP (N x 6.25) by the Kjeldahl procedure (AOAC, 1980), lignin (LIG), neutral detergent fiber (NDF), and acid detergent fiber (ADF) with the technique described by Van Soest *et al.* (1991), using an Ankom digestor (Ankom^{2000} fiber analyzer). Ruminal DM and NDF degradability were assessed (Orskov and McDonald, 1979) using three rumen-cannulated (Bar Diamond Idaho, USA) cows, in which nylon bags containing each a sample of 5 g DM of the forage evaluated (dry and grounded at 3 mm), were incubated by triplicate for 48 h.

To estimate tiller density, two 20 x 20 cm quadrants randomly allocated in the *P. notatum* and *A. compressus* areas were used in each repetition. Tiller counting was carried out every 27 days before and after the paddock was grazed (Islam and Hirata, 2005), in each SY. To measure tiller height and leaf length before grazing, two permanent 2 m transects were randomly allocated in each repetition for both native grasses. Within each transect, 10 tillers were tagged using fine-gauge wires. Tiller and leaf measurements were carried out in two grazing cycles (Islam and Hirata, 2005), towards the end of each SY.

A complete randomized design with two replicates was used. An analysis of variance was performed using the MIXED procedure of SAS for repeated measurements; seasons of the year were considered as the repeated measurement. The covariance structure for symmetric components for the variables total forage yield and quality were considered (Littell *et al.,* 1998). Sampling for total forage yield was made twice for each replicate. Treatment means were tested with PDIFF LSMEANS of the MIXED procedure of SAS.

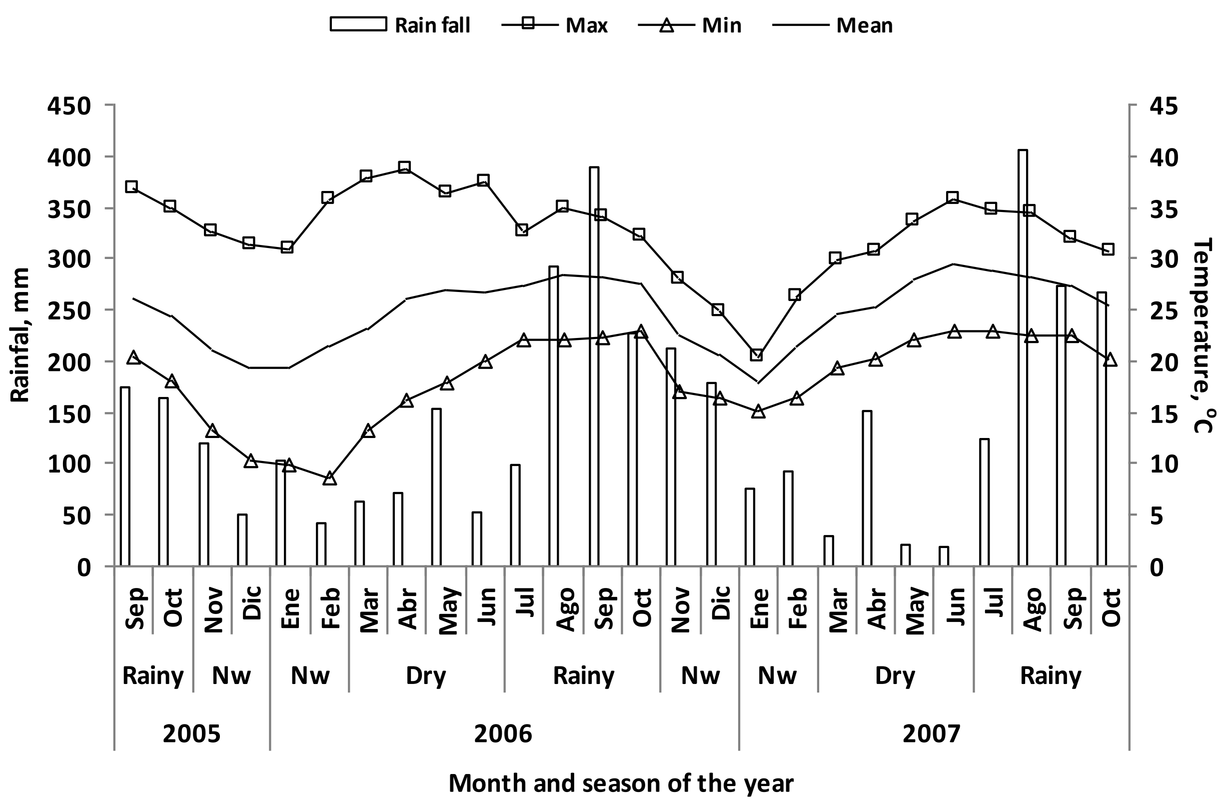

Figure 1. Maximum (Max), minimum (Min), mean (Mean) temperature and total rainfall in the rainy, windy (Nw) and dry seasons of the year, from September 2005 to October 2007, in the Mexican humid tropic.

RESULTS AND DISCUSSION

Forage yield components

In the first year, total forage, leaf and stem yields averaged 6171, 2349 and 1979 kg DM ha^{-1}, respectively, and were not affected (P > 0.05) by SR.
In the second year, during the rainy season total forage and leaf yields were increased (P < 0.05) by about 28 % in the medium SR (3 cows ha^{-1}) compared with the low SR (2 cows ha^{-1}), but were similar to those in the high SR (4 cows ha^{-1}). During the windy season, total forage and leaf yield were reduced (P < 0.05) 39 % and 62 %, respectively, in the high SR, compared with the low SR. During the dry season, no differences (P > 0.05) were found for yields among different SR (Table 1).

In contrast, total forage, leaf and stem yields were influenced (P < 0.05) by SY (Table 1). In the first year, during the windy season total forage, leaf and stem yields were 5198, 1783 and 1457 kgDM ha^{-1}, respectively, and were lower (P < 0.05) than in the other two seasons: 6657, 2632 and 2241 kgDM ha^{-1}, respectively. In the second year, total forage, leaf and stem yields were significantly higher (P < 0.05) in the rainy season.

Table 1. Means of standing dry biomass (kg DM ha^{-1}) of leaf blade and stem (true stem and leaf sheath) of native grasses before grazing of 2, 3 and 4 cows ha^{-1} during three seasons of the year, in two consecutive years, in the Mexican humid tropic.

Plant components	Year 2005-2006 Cows ha^{-1}				Year 2006-2007 Cows ha^{-1}			
	2	3	4	LSD$^{(1)}$	2	3	4	LSD
				Rainy season				
Leaf	3190^{a}	2901^{a}	3007^{a}	NS	2517^{a}	3514^{b}	2630^{ab}	691
Stem	2076^{a}	2234^{a}	2491^{a}	NS	2919^{a}	3821^{b}	2291^{a}	1034
Total	7594^{a}	6294^{a}	7103^{a}	NS	6931^{a}	8855^{b}	6068^{a}	1607
				Windy season				
Leaf	1935^{a}	2184^{a}	1232^{a}	NS	2422^{a}	2384^{ab}	1467^{b}	842
Stem	1520^{a}	1732^{a}	1119^{a}	NS	1976^{a}	1478^{ab}	820^{b}	632
Total	5430^{a}	5471^{a}	4694^{a}	NS	7642^{a}	5940^{a}	2870^{b}	2658
				Dry season				
Leaf	2229^{a}	2658^{a}	1812^{a}	NS	727^{a}	915^{a}	1045^{a}	NS
Stem	2476^{a}	2451^{a}	1720^{a}	NS	1022^{a}	791^{a}	1107^{a}	NS
Total	7304^{a}	7225^{a}	4427^{a}	NS	3058^{a}	2387^{a}	2671^{a}	NS

^{a,b}Means with different superscript within row by year and season are statistically different (P < 0.05).
$^{(1)}$LSD = Least significant difference.

The lack of effect of SR on forage yield in each SY, could be associated with some compensatory changes on the plant attributes (*e.g.* plant height, tiller density, leaf length, rate of appearance and growth, etc.). Low SR resulted in taller plants, but with lower tiller density than the medium and high SR. Castillo *et al.* (2009) reported a high correlation between plant height and forage yield. Consequently, it could be expected that the low tiller density found in the low SR treatment was compensated by the plant height and, therefore, reduced the expected differences on yield associated with the changes on SR.

Similarly, Hirata (2000) reported that as the cutting height is reduced as a consequence of increasing the defoliation intensity (*e.g.* in a high SR condition), the rate of leaf appearance is increased, but the rate of growth is reduced, resulting in more but smaller leaves. The contrary could be expected. The reduction in defoliation intensity would result in a reduction on leaf appearance and an increase in the rate of leaf growth, which is a mechanism to level off the yield. Also, the self-thinning law indicates the negative relationship between plant density and size under competitive conditions; it is to say that the increment on plant density results on a reduction on plant weight (Yoda *et al.*, 1963; Xue *et al.*, 1999). Although leaf attributes were not recorded in this study, they could be expected to also have an important role in the reduction of the SR impact on forage yield. This level of effect over plant attributes on forage yield of pastures under different SR has been reported by several authors (Ayala *et al.*, 2000; Baker and Leaver, 2006; Kennedy *et al.,* 2007).

Tiller density and height

In both experimental years, *A. compressus* tiller density and length were 5548 tillers m^{-2} and 4.8 cm, respectively, and were not influenced ($P > 0.05$) by SR. On the other hand, *P. notatum* tiller density and height were affected ($P < 0.05$) by SR, but only in the second year, resulting in 3068, 4549 and 4892 tillers m^{-2}, and 9.9, 7.5 and 6.3 cm of height, respectively, for the low, medium and high SR. Similarly, *P. notatum* tiller height was influenced ($P < 0.05$) by SR, but only in the windy season.

Although in the first year SR did not influence tiller density and height, both variables were affected ($P < 0.01$) by SY, resulting in 3158, 4054 and 6876 tillers m^{-2} and 6.4, 4.0 and 4.1 cm of height for *A. compressus*, and 1632, 1946 and 4245 tillers m^{-2} and 12.4, 6.9 and 6.6 cm for *P. notatum*, during the rainy, windy and dry seasons, respectively. However, in the second year, *P. notatum* tiller height was not affected by SY.

It was expected that the high SR treatment would result on shorter but denser tiller population, mainly due to more light reaching the base of the plant, as it has been reported by Hirata *et al*. (2002). The lack of response on *A. compressus* tiller attributes found in the present study could be associated with the high variability on tiller length and tiller ability to share energy and nutrients throughout the interconnected stolons, as has been previously reported by Hirata and Pakiding (2003).

In the second year, *P. notatum* tiller density and height were strongly ($P < 0.01$) influenced by SR and SY, particularly in the windy season. It is likely that the different response among the grasses studied to changes on SR could be associated with animal preference for one of them (*i.e. P. notatum*). When grasses are associated, it is common to find that cattle select one of the species over the other (Briske and Richards, 1995).

In the first year, shorter tillers found on both grass species during the windy and dry seasons, compared with the rainy season, could be associated with higher biomass availability during the rainy season, which could also have affected tiller density. Higher biomass availability during the rainy season, compared with the windy and dry seasons, resulted in bigger tillers remnant after grazing, since the same SR was used throughout all seasons. These tillers strongly competed for assimilates with the newly emerged ones and reduced (by shading effect of the bigger tillers) the amount of light reaching the base of the plant, resulting in fewer and taller tillers, compared with the other two seasons. This is in agreement with Richards (1993) and Lemaire and Agnusdei (2000), who reported that light has a definitive effect on the ability of the plant to produce tillers.

In contrast, in the second year, *P. notatum* tiller height was not affected by SY and SR. This difference between years could be associated with increments of about 78 % and 13 % on the amount of rainfall during the windy and rainy seasons, respectively, and an increase of 31 % on minimum ambient temperature in the second year.

Leaf length

In the first year, leaf length of *P. notatum* and *A. compressus* was influenced by SY ($P < 0.01$), but not by SR ($P > 0.05$). Also, in the rainy season and in the low SR, *P. notatum* had longer leaves (in average 14 cm) than in the medium (9.5 cm) and high (8.4) SR. In contrast, in the second year, *A. compressus* leaf length was not influenced by SR or SY, which could be a response to the low solar radiation recorded in that year, whereas *P. notatum* leaf length was affected by SR, resulting in 7.5, 5.8 and 4.9 cm in the low, medium and high SR, respectively.

Leaf-stem ratio (LSR)

In the first year, LSR was not influenced ($P > 0.05$) by SR or SY. This lack of response on LSR could be due to the unaffected leaf size and number per tiller, as it has been previously reported (Ayala *et al*., 2000; Hirata, 2000). However, in the second year, LSR in the low SR (0.95 ± 0.06) was lower ($P < 0.05$) than in the medium and high SR (1.30). Also, LSR was lower ($P < 0.0001$) in the rainy and dry seasons (0.98 ± 0.05), than in the windy season (1.59 ± 0.11). In the second year, the reduction of *P. notatum* leaf length as SR increased agrees with the report by Hirata (2000). Tiller height (and probably tiller size) was reduced as increments on SR occurred, therefore tiller components (*e.g*. leaf) could be expected to be reduced. In contrast, tiller density and leaves per tiller increased as the SR increased, attaining LSR compensation.

In the second year, LSR increased 35 % in the medium SR. Tiller density increased as the SR increased, and consequently, more leaves were produced in the medium SR. Similarly, in the second year, LSR increased about 62 % in the windy season. This effect could be associated with the increments on the amount of rainfall recorded in the second year. Although this effect was observed in both rainy and windy seasons, it was more evident in the windy season due to a greater increase (78 %) of rainfall compared to the rainy season. On the other hand, rainfall in the dry season was reduced, resulting in a reduction of LSR. Lack of humidity in the soil could lead to plant stress and reduction on its development and forage quality (Wilson, 1983).

Utilization efficiency (UE) of pasture components

In both years, UE of leaves (36.8 %), stems (28.9 %) and total forage (26 %) was not affected by SR ($P > 0.05$).

In the first year, UE of pasture components (*i.e*. leaf 36 %, stem, 33 %, and total forage 26 %) was not affected ($P > 0.05$) by SY; however, in the second year, UE of leaves was lower (23 %) in the rainy than in the dry season (39 %) ($P < 0.03$), while UE of stems and total forage (21 % and 26 %, respectively), was not affected ($P > 0.05$) by SY.

Although UE was not affected ($P > 0.05$) by SR, a linear increment with a high correlation (R^2 = 0.92 - 1.00) between SR and UE was found (Table 2). The low UE recorded in the low SR could result in a selection of forage of better quality (Hodgson, 1990). However, the high UE registered in the high SR is related to the forage availability per animal (Table 3). Also, a high SR has lower amount of dead material per animal, compared with the medium and low SR. It has been reported the influence of UE on the proportion of green material (Ayala *et al.*, 2000).

In the second year, the quadratic relationship between SR and UE (Table 2) indicates an increment on UE in the low and medium SR, but a reduction in the high SR, which could be related to the climatic conditions that prevailed in the windy and dry seasons of the second year (Figure 1), when total forage yield tended to diminish in the high SR (Table 1).

Table 2. Correlation coefficients (R^2) and fitted equations for the utilization efficiency percentage (y) of native pastures grazed by 2, 3 and 4 cows ha^{-1} (x) in two consecutive years, in the Mexican humid tropic.

Year	Plant component	Equation	R^2
2005-2006	Leaf	$y= 5.3917x +19.652$	0.92
	Stem	$y= 12.872x -5.8832$	0.99
	Total forage	$y= 9.9962x -3.5737$	0.99
2006-2007	Leaf	$y= -5.5721x^2 + 33.865x – 9.9004$	1.00
	Stem	$y= -4.359 x^2 + 22.029x + 1.2483$	1.00
	Total forage	$y= -5.5465 x^2 + 29.381x – 7.1225$	1.00

Table 3. Total standing dry matter available (SDA) per paddock, and dry matter available per live weight (LW) and metabolic weight (MW) in a native pasture during the rainy, windy and dry seasons of the year, grazed by 2, 3 and 4 cows ha^{-1}, in the Mexican humid tropic.

Season	Rainy			Windy			Dry		
Cows ha^{-1}	2	3	4	2	3	4	2	3	4
SDA (kg DM ha^{-1}	7263	7575	6586	6536	5706	3783	5182	4806	3549
Area (ha) $paddock^{-1}$	0.50	0.33	0.25	0.50	0.33	0.25	0.50	0.33	0.25
Kg DM $paddock^{-1}$	3631	2525	1646	3268	1902	946	2591	1602	887
Kg LW $paddock^{-1}$	5410	5310	5010	5410	5310	5010	5410	5310	5010
Kg DM kg LW^{-1}	0.671	0.476	0.329	0.604	0.358	0.189	0.479	0.302	0.177
Kg $MW^{0.75}$ $paddock^{-1}$	630.8	622.0	595.5	630.8	622.0	595.5	630.8	622.0	595.5
Kg DM kg MW^{-1}	5.8	4.1	2.8	5.2	3.1	1.6	4.1	2.6	1.5

Forage chemical composition

In both years, leaf CP content was not influenced ($P > 0.05$) by SR (Table 4), but it was influenced by SY ($P < 0.05$; Table 5).

Stem CP was influenced ($P < 0.04$) by SR only in the first year, when the low SR resulted in lower ($P < 0.02$) stem CP (5.5±0.2 %), compared with that obtained in the medium (6.8±0.6 %) and high (7.2±0.5 %) SR, respectively. On the other hand, the effect of SY on stem CP was significant in both years ($P < 0.05$). In the first year, stem CP recorded in the rainy season was the lowest (5.6%) ($P < 0.05$), but in the second year, it was the highest (9.1 %) ($P < 0.05$). Also, stem CP in the windy season was higher (7.8 %) ($P < 0.05$), compared with the dry season (7.1 %; Tables 4 and 5).

Table 4. Nutritive quality of leaves and stems of native pastures grazed by 2, 3 and 4 cows ha^{-1}, in two consecutive years in the Mexican humid tropic.

Variable	Leaf				Stem [(1)]			
	2	3	4	LSD [(2)]	2	3	4	LSD
				Year 2005 - 2006				
Crude protein %	9.5 [a]	10.6 [a]	10.7 [a]	NS	5.5 [a]	6.8 [b]	7.2 [b]	1.65
Neutral detergent fiber %	65.1 [a]	65.1 [a]	65.3 [a]	NS	72.1 [a]	72.1 [a]	72.2 [a]	NS
Acid detergent fiber %	37.7 [a]	36.3 [a]	36.5 [a]	NS	37.9 [a]	36.8 [a]	37.1 [a]	NS
Dry matter digestibility %	62.5 [a]	64.8 [a]	66.9 [a]	NS	64.7 [a]	66.8 [a]	68.2 [a]	NS
Lignin %	7.9[a]	8.3[a]	8.9[a]	NS	7.3[a]	7.0[a]	7.9[a]	NS
				Year 2006 – 2007				
Crude protein %	13.0 [a]	14.2 [a]	14.4 [a]	NS	7.2 [a]	8.1 [a]	8.7 [a]	NS
Neutral detergent fiber %	68.1 [a]	67.8 [a]	66.8 [a]	NS	68.5 [a]	66.5 [a]	65.3 [a]	NS
Acid detergent fiber %	34.1 [a]	34.5 [a]	32.1 [a]	NS	35.0 [a]	31.7 [b]	30.9 [b]	2.34
Dry matter digestibility %	73.2 [a]	76.2 [a]	75.4 [a]	NS	70.7 [a]	76.5 [b]	77.5 [b]	3.16
Lignin %	7.7[a]	7.6[a]	7.3[a]	NS	6.6[a]	5.2[a]	4.8[a]	NS

[a,b]Means with different superscripts within row by plant component and period are statistically different ($P < 0.05$).
[(1] Stem = true stem + leaf sheath. [(2)]LSD = Least significant difference.

Table 5. Nutritive quality of leaves and stems from native grazing pastures during the rainy, windy and dry seasons of the years 2005-2007, in the Mexican humid tropic.

Variable	Leaf				Stem [(1)]			
	Rainy	Windy	Dry	LSD [(2)]	Rainy	Windy	Dry	LSD
				2005 - 2006				
Crude protein %	8.2 [a]	12.2 [b]	10.5 [c]	1.60	5.6 [a]	6.8 [ab]	7.1 [b]	1.5
Neutral detergent fiber %	70.8 [a]	62.9 [b]	61.8 [b]	8.34	77.8 [a]	70.6 [b]	67.9 [b]	4.7
Acid detergent fiber %	43.8 [a]	34.5 [b]	32.1 [c]	2.43	44.5 [a]	34.9 [b]	32.3 [b]	2.4
Dry matter digestibility %	59.4 [a]	67.3 [b]	67.4 [b]	5.15	63.0 [a]	68.6 [b]	68.1 [b]	4.1
Lignin %	9.7[a]	8.16[b]	7.2[b]	1.27	9.4[a]	6.6[b]	6.3[b]	1.37
				2006 – 2007				
Crude protein %	15.25 [a]	14.0 [b]	12.4 [c]	1.36	9.1 [a]	7.8 [b]	7.1 [c]	0.81
Neutral detergent fiber %	66.4 [a]	68.5 [b]	67.9 [b]	1.67	69.4 [a]	65.4 [b]	65.6 [b]	1.46
Acid detergent fiber %	31.9 [a]	35.4 [b]	33.3 [c]	1.55	34.1 [a]	33.5 [a]	30.2 [b]	2.08
Dry matter digestibility %	79.1 [a]	73.9 [b]	71.6 [c]	3.32	74.8 [a]	76.3 [a]	73.6 [a]	NS
Lignin %	7.3[a]	8.2[a]	7.0[a]	NS	5.8[a]	5.6[a]	5.3[a]	NS

[a,b,c]Means with different superscripts within row by plant component and season are statistically different ($P < 0.05$).
[(1)]Stem = true stem + leaf sheath.[(2)]LSD = Least significant difference.

In both years, leaf and stem LIG and NDF were not influenced ($P > 0.05$) by SR. In contrast, stem ADF was reduced ($P < 0.05$) from 35 % in the low SR, to 32 % in the medium SR, and 31 % in the high SR, but this effect occurred only in the second year (Table 4). Similarly, in both years, leaf and stem NDF and ADF in the rainy season were 70.8 % and 43.8 %, respectively, and were higher ($P < 0.05$) than in the windy and dry seasons (Table 5). Also, in the rainy season leaf and stem LIG content was 9.7±0.9 % and 9.4±0.1 %, higher ($P < 0.05$) than those obtained in the windy (8.1±0.7 % and 6.6±0.5 %) and dry season (7.2±0.7 % and 6.3±0.3 %), respectively (Table 5).

The CP content obtained in the present study for both grass species (9.7 %) could be enough to meet the N requirements of the rumen microbes, since this value is higher than the 7 % suggested by Minson and Milford (1967). Similar CP content of *P. notatum* grass has been reported by other authors (Juarez-Lagunes *et al.,* 1999; Johnson *et al.*, 2001).

Leaf CP was not affected by SR, which could be related to the similar characteristics of tillers in the different SR. It was expected that high SR had had more young tillers, as a consequence of high-intensity defoliation; nevertheless, tillers from the high and low SR did not reach a maturity stage that could have affected the CP content, as it is affected by plant maturity (Hoffman *et al.,* 1993; Mitchel *et al.,* 1997). Similarly, SR did not affect ADF, NDF and LIG, which also could be associated with the similar tiller conditions in the three SR. The results of *P. notatum* fiber content found in this study are in agreement with other authors (Juarez-Lagunes *et al.,* 1999).

Dry mater (DM) rumen degradation

In both years, leaf DM degradation in the rumen at 48 h of incubation was not influenced ($P > 0.05$) by SR. Nevertheless, the interaction SR x SY was significant ($P < 0.05$), and resulted in a lower leaf DM degradation in the low SR, during the windy (70.7±1.0 %) and dry (69.8±0.8 %) seasons, compared with the medium (74.6±1.6 % and 75.0±2.1 %) and high (76.7±1.5 % and 70.1±0.6 %) SR, respectively, for the windy and dry seasons.

In addition, during the first year leaf DM degradation was lower in the rainy season (59.4 %), compared with the other seasons (67.4 %). In the second year, however, leaf DM degradation was higher in the rainy (79.1 %) than in the windy (73.9 %) and dry (71.6 %) seasons.

Stem DM degradation was influenced ($P < 0.05$) by SR only in the second year, when the low SR resulted in a lower stem DM degradation (70.2 %), compared with the medium (76.5 %) and high (77.5 %) SR, ($P < 0.05$). On the other hand, stem DM degradation was reduced ($P < 0.04$) in the rainy season (63.0±1.0 %), in comparison with the other seasons (68.4± %).

In the first year, leaf NDF degradation was slightly lower ($P = 0.05$) in the rainy season (55.0±2.4 %) than in the windy (58.7±3.2 %) and dry (61.5±3.8 %) seasons. In the second year, leaf and stem NDF degradation was lower ($P < 0.0001$) in the windy season (79.8±0.4 % and 82.0±0.1%) than in the rainy (81.3±0.2 % and 84.0±0.3 %) and dry (81.6±0.2 % and 85.0±0.2 %) seasons.

The increment of DM rumen degradation recorded in the dry season could be associated with the plant water stress, which could have resulted in increments on DM digestibility, depending on the time of exposure to water stress, as it has been reported by other authors (Wilson, 1982, 1983; Halim *et al.*, 1989; Dias Filho *et al.,* 1991; Van Soest, 1994). Water stress could result in slow plant growth, and a marked delay on stem development (Wilson, 1982), as well as a reduction of the maturity index (Halim *et al.,* 1989). An important plant adaptation to water stress is the accumulation of several organic compounds, such as sucrose and amino acids, which reduce the plant osmotic potential to avoid limiting the cell enzymatic function (Salisbury and Ross, 1992), but to reduce leaf and stem development and limit the formation of cell wall, which are the main responsible for forage digestibility.

Leaf and stem NDF rumen degradation was not significantly ($P > 0.05$) affected by SR, although there was a tendency to increase NDF degradation as SR increased. This tendency could be related to the ADF content, which is the main responsible for forage rumen degradation, and it was similar in the different SR. Nevertheless, ADF was significantly affected by SY, which could have influenced NDF rumen degradation among seasons.

CONCLUSION

The SR did not affect forage nutritive quality of the native grasses *P. notatum* and *A. compressus*, it only affected the CP content in the stem. The SY was the main factor that affected forage nutritive quality, particularly in the rainy season, due to the high forage yield obtained and, consequently, high CWC, low CP content and low digestibility of cell wall compounds. The similar forage yield found in the different SR could be related to the plant ability to modify forage yield components (*e.g*. tiller density and length and leaf length) as SR was increased.

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