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Yield and nutritive value of *Urochloa* hybrids at different regrowth ages

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ABSTRACT

Objective: To evaluate the productive behavior of *Urochloa* hybrids, depending on the regrowth age.

Design/Methodology/Approach: The study was carried out under rainfed conditions during 2018. The Cayman, Mulato II, Convert 330, Cobra, Camello I, and Camello II hybrids were evaluated based on the regrowth age (2, 4, 6, 8, and 10 weeks). The following variables were evaluated: plant height (PH), total dry matter (TDM) yield, dry matter per leaf (DMl) yield, dry matter per stem (DMs) yield, crude protein content (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF). The data obtained were evaluated by means of a randomized complete block design with three repetitions, divided into plots: a large plot for the cultivars and small plot for the regrowth ages.

Results: The Camello II cultivar obtained the highest TDM yields during the sixth and eighth weeks (4.15 and 6.35 t DM ha^{-1}, respectively); however, during the tenth week, the yield was equal to the yield obtained with the Mulato II and Cayman cultivars ($p<0.05$). The highest DMl yield was obtained by the Mulato II cultivar during the sixth, eighth, and tenth weeks (3.37, 4.56, and 3.86 t DM ha^{-1}, respectively). The Mulato II cultivar recorded the highest CP values during the second and fourth weeks (158 and 126 g kg^{-1}, respectively); however, the Camello II cultivar obtained the highest CP values during the sixth, eighth, and tenth weeks (99, 95, and 87 g kg^{-1}, respectively). The NDF and ADF values increased as the regrowth age increased: in the tenth week, the Camello II and Cobra cultivars obtained the highest NDF values, while the Camello II cultivar recorded the highest ADF value during the same period.

Study Limitations/Implications: *Urochloa* cultivars were developed for their establishment in humid tropical conditions, where their productive performance is greater. However, in dry tropical conditions, the Cayman, Mulato II, and Cobra cultivars have had a better performance than other grasses —such as buffel grass (*Pennisetum ciliare*), which is used to feed ruminants. In this sense, other *Urochloa* cultivars (*e.g.*, Camello I and Camello II), which have greater tolerance to droughts, show desirable forage characteristics, such as yield and forage quality.

Findings/Conclusions: The cultivars with the best productive performance were Camello II, Mulato II, and Cayman.

Keywords: Forage production, forage quality, regrowth age, *Urochloa* hybrids.

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INTRODUCTION

Grass cultivars (hybrids) have been developed to increase the productivity of ruminant production systems. Some of them were generated by the Centro Internacional de

Agricultura Tropical (CIAT) through a genetic improvement program. The combination of the desirable characteristics of *Urochloa brizantha* (syn. *Brachiaria brizantha*), *Urochloa decumbens* (syn. *Brachiaria decumbens*), and *Urochloa ruziziensis* (syn. *Brachiaria ruziziensis*) led to the release of three hybrids: Mulato II (CIAT 36087), Cayman (CIAT BR02/1752), and Cobra (CIAT BR02/1794) (Pizarro *et al.*, 2013). These hybrids have been evaluated in Mexico under semi-arid conditions, during the rainy and drought seasons, and have shown better forage characteristics than *Pennisetum ciliare* (syn. *Cenchrus ciliaris*), the most frequently used forage grass by livestock farmers in semi-arid areas (Garay-Martínez *et al.*, 2017). In this sense, Garay-Martínez *et al.* (2018) reported that hybrid grasses of the genus *Urochloa* have a higher forage yield than *Pennisetum ciliare* during the rainy (9.05 *vs.* 8.34 t ha^{-1}) and drought (1.06 *vs.* 0.79 t ha^{-1}) seasons. Furthermore, the highest protein content (9.2-10.2 *vs.* 7.4%) and digestibility (66.3-67.3 *vs.* 56.3%) were recorded by the hybrids at 8 weeks of regrowth (Garay *et al.*, 2020). The development and release of cultivars is a dynamic process and, in recent years, new *Urochloa* cultivars have been released to increase forage yield, its nutritional value, and the animal production in production systems. However, in order to determine the productive potential of forage grasses, before their integration into a production system, the forage behavior of the new materials must be evaluated (Njarui *et al.*, 2014). In this sense, the biomass accumulation of forage species can be evaluated through a growth analysis, responding to different climatic and management conditions (Rojas-García *et al.*, 2018). Therefore, the objective of the present study was to evaluate the yield and nutritional value of forage from *Urochloa* hybrids at different regrowth ages, in semi-arid rainfed conditions.

MATERIALS AND METHODS

Location of the experimental site

The research was carried out at the Posta Zootécnica Ingeniero "Herminio García González," Facultad de Ingeniería y Ciencias, Universidad Autónoma de Tamaulipas. The experimental site is located in Güémez, Tamaulipas, Mexico (23° 56' 26.5" N and 99° 05' 59.9" W), at 193 meters above sea level (INEGI, 2015).

Climatic and edaphic characteristics of the experimental site

The site has a type BS1 (h') hw (BShw) climate (Vargas *et al.*, 2007). The average annual temperature is 23.9 °C and the average annual precipitation is 719 mm (SMN, 2010). During the evaluation period, the temperature and precipitation were recorded at the evaluation site (Figure 1).

Prior to the evaluation, a soil sampling was carried out, in order to determine the physical and chemical characteristics of the soil (Table 1).

Plant material, treatments, and agronomic management

The materials evaluated were six *Urochloa* hybrids: Cayman, Mulato II, Cobra, Camello I (GP3025), Camello II (GP3207), and Convert 330. The botanical seeds were sown in April 2018, with a manual seeder; the distance between plants and rows was 0.1 and 0.3 m, respectively. Eighteen 3×3 m experimental plots (9 m^2) were used; each experimental

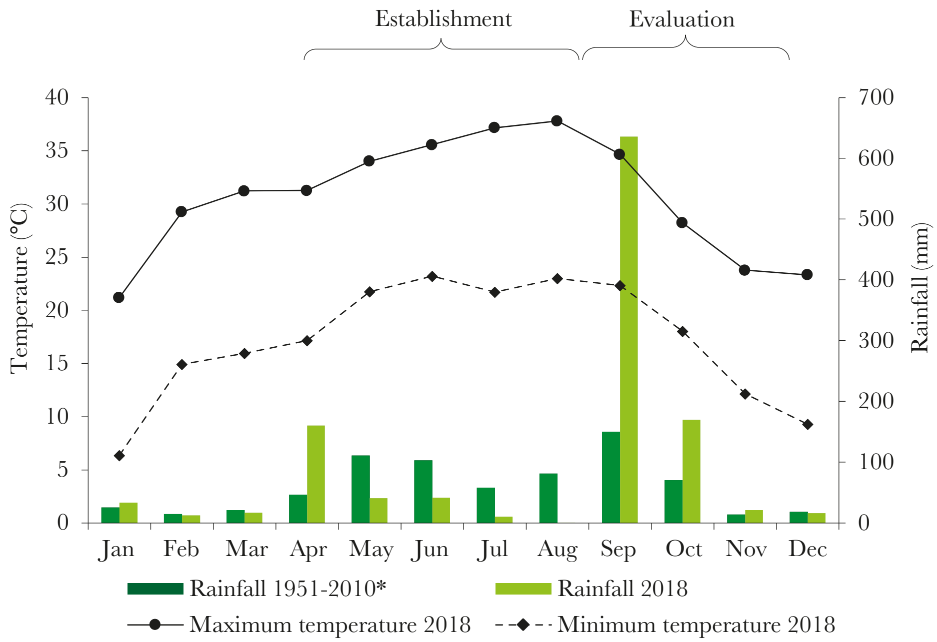

Figure 1. Accumulated monthly precipitation and average maximum and minimum monthly temperature recorded in Güémez, Tamaulipas (2018).
*Accumulated monthly precipitation, 59-year average (1951-2010; SMN, 2020).

Table 1. Physical and chemical characteristics of the soil of the Posta Zootécnica "Herminio García González" experimental site in Tamaulipas, México

pH	TN	OM	TCa	P	K	Fe	Zn	Sand	slime	clay	
	%			mg kg^{-1}				%			SAR
8.3	0.25	4.27	38.2	7.46	288.6	1.43	0.46	11.3	23.3	65.4	0.19

TN: total nitrogen; OM: organic matter; TCa: total carbonates; P: phosphorus; K: potassium; Fe: iron; Zn: zinc; SAR: sodium adsorption ratio.

plot consisted of ten furrows. One linear meter was delimited in each of the five central furrows to form the useful plot (experimental unit) for each regrowth age. Each treatment consisted of three repetitions. No fertilization was applied to the cultivars during the 5-month establishment period. Prior to the evaluation, a uniformization cutting was made at 15 cm and, subsequently, another cutting was made at the same height in each sampling (regrowth age: 2, 4, 6, 8, and 10 weeks).

Variables evaluated

Plant height

Prior to each sampling, the plant height (cm) was measured with a wooden ruler from the ground to the ligule of the last fully expanded leaf.

Forage yield as dry matter

The forage was harvested in each useful plot and weighed on a CQT 2601 analytical balance (ADAM®, USA). A 200 g subsample was then taken and separated into its morphological components: leaf (leaf blade+pod) and stem. The subsamples were placed in a Heratherm™ OMS60 forced air oven (Thermo Scientific®, USA) at 60 °C, until constant weight was obtained. At the end of the drying period, the dry weight of each subsample was recorded, and the dry matter yield was estimated: total (TDM) and per morphological component [leaf (DMl) and stem (DMs)]. For each regrowth age, the yield obtained in 1 linear m was extrapolated to 1 ha and reported in t ha^{-1}.

Bromatological analysis

The crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) content (g kg^{-1}) was determined. The protein content was determined following the method described by AOAC (2000), while the neutral detergent fiber (NDF) and acid detergent fiber (ADF) content was established using the method of Van Soest *et al.* (1991).

Statistic analysis

The data obtained were analyzed with PROC GLM (general linear models) in the Statistical Analysis System software (SAS, 2002), by means of a randomized complete block design with three repetitions, divided into plots: a large plot for the cultivars and a small plot for the regrowth ages. Tukey's mean comparison test was performed (α=0.05).

RESULTS AND DISCUSSION

Until the eighth week, the average plant height increased as the regrowth age increased ($p<0.05$); subsequently, it decreased due to the lodging of the plants caused by the wind (Table 2). The differences in plant height between the hybrids were recorded after 8 weeks of regrowth ($p<0.05$), because their growth habit is generally modified by environmental and management conditions (González *et al.*, 2020).

In this sense, Hare *et al.* (2015) reported that the Cobra hybrid has an erect growth habit, while Enríquez *et al.* (2015) determined that the Cayman hybrid grows in a semi-recumbent manner —a similar behavior to that observed in this research. Meanwhile, the Camello II hybrid showed a more erect growth than Camello I; therefore, wind incidence had a greater effect on this cultivar, lodging the plant after 10 weeks of regrowth. Consequently, in the tenth week, the Camello I cultivar surpassed Camello II in plant height.

In general terms, total dry matter (TDM) production in all cultivars increased as regrowth age increased. The highest TDM yields were recorded in the tenth week ($p<0.05$). Total dry matter increased by 52, 49, 32, and 17%, when the regrowth age increased from 2 to 4, 4 to 6, 6 to 8, and 8 to 10 weeks, respectively.

In the second regrowth week (Table 2), the Cayman and Mulato II cultivars obtained the highest TDM yields (0.95 and 0.88 t ha^{-1}, respectively); meanwhile, in the fourth regrowth week, Cayman obtained 15% more TDM than Mulato II. In general, the greater accumulation of TDM observed during the second and fourth weeks (52 and 49%, respectively) was caused by the favourable temperature (22-34 °C) and precipitation (635 mm) that led to a greater grass growth (Maia *et al.*, 2014). The yields in this research are higher than those reported by Garay-Martínez *et al.* (2018) for Cayman (1.3 t DM ha^{-1}),

Table 2. Plant height (PH), total dry matter (TDM) yield, leaf dry matter (DMl) yield, and stem dry matter (DMs) yield of *Urochloa* cultivars at different regrowth ages evaluated in Güémez, Tamaulipas.

Cultivar	Regrowth ages (weeks)									
	2	4	6	8	10	2	4	6	8	10
	PH (cm)					DMT (t ha^{-1})				
Cayman	39 a	47 a	75 a	78 a	65 b	0.95 a	2.17 a	3.48 b	4.67 c	6.32 a
Mulato II	35 a	47 a	66 b	81 a	84 a	0.88 ab	1.86 b	3.49 b	5.54 b	6.26 a
Convert*	32 a	43 a	61 c	69 b	77 a	0.85 b	1.78 c	2.44 e	3.73 e	5.86 b
Cobra	32 a	45 a	56 c	61 c	61 b	0.83 b	1.27 f	2.53 d	2.99 f	3.56 d
Camello I	31 a	44 a	66 b	72 b	62 b	0.66 c	1.63 d	2.80 c	4.44 d	4.61 c
Camello II	32 a	48 a	76 a	71 b	49 c	0.63 c	1.47 e	4.15 a	6.35 a	6.47 a
Mean	36 D	46 C	70 AB	75 A	70 B	0.80 E	1.70 D	3.15 C	4.62 B	5.51 A
	DMs (t ha^{-1})					DMl (t ha^{-1})				
Cayman	-	0.06 b	1.12 a	1.21 b	2.11 a	0.95 a	2.06 a	2.42 c	2.58 e	3.42 c
Mulato II	-	-	0.07 e	0.68 e	1.62 d	0.88 ab	1.84 b	3.37 a	4.56 a	3.86 a
Convert*	-	-	0.14 d	0.54 f	2.01 b	0.85 b	1.76 c	2.27 d	3.10 c	2.91 d
Cobra	-	0.09 a	0.48 b	0.76 d	0.76 f	0.83 b	1.02 f	1.68 f	1.79 f	2.18 f
Camello I	-	0.06 b	0.44 c	1.09 c	1.33 e	0.66 c	1.46 d	2.18 e	3.00 d	2.82 e
Camello II	-	0.06 b	0.63 a	1.71 a	1.97 c	0.63 c	1.35 e	3.24 b	4.14 b	3.59 b
Mean	-	0.04 D	0.40C	1.00 B	1.63 A	0.80 E	1.60 D	2.50 C	3.20 A	3.10 B

(-): absence of the component at the time of sampling; Convert*: Convert 330. Different literals between cultivars (a, b, c, d, e, f) and regrowth ages (A, B, C, D, E) indicate a significant statistical difference (Tukey; α=0.05).

Cobra (2.2 t DM ha^{-1}), and Mulato II (3.2 t DM ha^{-1}) at 4, 6, and 8 weeks of regrowth, respectively. The said yields are mainly attributed to the management and distribution of precipitation during that year (Garay-Martínez *et al.*, 2018). In this evaluation, the Camello II cultivar surpassed Cayman and Mulato II in dry matter yield, during the sixth and eighth weeks; however, the yield was similar in the tenth week.

From week 2 to week 8, the increase of the average DMl production depended on the regrowth age; subsequently, it recorded a 2% decrease ($p<0.05$). From week 2 onwards, leaf production differed in all cultivars (Table 2). The highest leaf yield in weeks 2 and 4 was obtained by the Cayman cultivar, while, in weeks 6, 8, and 10, it was obtained by the Mulato II cultivar (Table 2). The decrease in the average DMl yield from week 8 (Table 2) is attributed to the increase in senescent leaves, since prolonging the cutting or grazing periods leads to an increase in forage losses, as a result of leaf senescence (Cruz -Sánchez *et al.*, 2018). Consequently, Garay-Martínez *et al.* (2018) have suggested that, during the rainy season, forage from the Cayman, Mulato II, and Cobra cultivars should be used between 4 and 6 weeks of regrowth. In this regard, the Camello II cultivar obtained higher leaf yields than the Cayman cultivar; however, these yields were lower than with the Mulato II cultivar, which matches the findings of Bernal *et al.* (2016), who mention that the Cayman and Mulato II hybrids produce a greater number of leaves. Therefore, it can be assumed that the Camello II hybrid also has this forage quality.

The presence of stems was recorded from the fourth week, except in the Mulato II and Convert 330 cultivars, where the stems appeared from the sixth week. The highest stem yields were obtained in the tenth week, when the Cayman cultivar recorded the greatest ($p<0.05$) stem accumulation (Table 2). The stem accumulation was greater in Cayman than in Camello II. In this regard, Rojas *et al.* (2017) have mentioned that the increase in the accumulation of stems is caused by the elongation and increase in weight and greater population density of the stems, resulting from longer exploitation periods. In this sense, Lucio-Ruíz *et al.* (2021) have reported that the stem density of the Cayman cultivar ranges from 2,227 to 2,553 stems m^2, when they are harvested at 15 cm of residual height, at 4-week cutting intervals. Meanwhile, the Camello II cultivar record stem densities that ranged from 1,802 to 4,099 stems m^2, when they are harvested at 10 cm, at 4-week cutting intervals (Lucio *et al.*, 2023). Therefore, the greatest accumulation of stem in the Cayman cultivar can be attributed to the weight of the stems. For their part, Cruz-Hernández *et al.* (2017) and Silva *et al.* (2016) have documented that using grasses with greater frequency and light cutting intensities reduces the accumulation of stem and dead matter in the forage, which favours obtaining more nutritious forage.

The crude protein content (CP) decreased ($p<0.05$) with an increase in regrowth age from 136 to 73 g kg^{-1}, from the second to the tenth weeks (a 47% reduction). The Mulato II cultivar had the highest ($p<0.05$) protein content in weeks 2 and 4 (158 and 126 g kg^{-1}, respectively); meanwhile Camello II recorded the highest CP in weeks 6, 8, and 10 (99, 95, and 87 g kg^{-1}, respectively). Despite the decrease in protein content as the regrowth age increases, only the Cobra, Camello I, and Camello II cultivars have adequate CP values that actually meet the requirements of ruminants. Animals must be offered a minimum protein content of 70 g kg^{-1} to promote the ruminal activity of the microorganisms responsible for degrading the fiber and obtaining the energy and protein from structural carbohydrates, hemicellulose, and cellulose (Lazzarini *et al.*, 2009; Belachew *et al.*, 2013), consequently ensuring the adequate productivity of ruminants in production systems. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) increased as the regrowth age increased (Table 3). The decrease in protein content and increase in NDF and ADF content in the leaves is the result of the increase in cell walls, as the age of the plant increases, and the degradability of the forage diminishes (Lara *et al.*, 2010). This phenomenon is a consequence of the decrease in the bacterial population in the rumen (Galindo *et al.*, 2011). However, the Camello II hybrid recorded higher protein content during the sixth, eighth, and tenth weeks than the rest of the hybrids, which makes its use a viable option for feeding ruminants.

The NDF values obtained at 4, 6, and 8 weeks in the Cayman and Mulato II cultivars are similar to those reported by Garay *et al.* (2020) in their research about different grasses of the genus *Urochloa* (including Cayman and Mulato II), at different regrowth ages. At 4, 6, and 8 weeks of regrowth, Garay *et al.* (2020) obtained, on the one hand, 567, 587, and 593 g kg^{-1}, and 596, 627, and 648 g kg^{-1} NDF values for Cayman and Mulato II, respectively; on the other hand, they recorded 23.6, 28.4, and 27.8 g kg^{-1}, and 24.7, 26.1, and 27.1 g kg^{-1} ADF values for Cayman and Mulato II, respectively. These values were different from those obtained in the present research.

Table 3. Crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) concentration in *Urochloa* hybrids at different regrowth ages, under semi-arid rainfed conditions, in Tamaulipas, México.

Cultivar	**Regrowth ages (weeks)**				
	2	**4**	**6**	**8**	**10**
	CP (g kg^{-1})				
Cayman	149 b	107 e	78 d	79 d	65 d
Mulato II	158 a	126 a	87 e	71 e	66 c
Convert 330	140 c	107 e	76 f	65 f	64 d
Cobra	130 d	112 c	91 b	85 b	78 b
Camello I	114 f	109 d	89 c	81 c	78 b
Camello II	124 e	120 b	99 a	95 a	87 a
Mean	136 A	113 B	85 C	79 D	73 E
	ADF (g kg^{-1})				
Cayman	257 e	358 c	414 a	437 a	436 c
Mulato II	276 d	334 f	387 c	413 d	451 a
Convert 330	274 d	341 e	367 d	421 b	445 b
Cobra	292 c	347 d	406 ab	418 c	424 d
Camello I	321 a	386 a	398 b	402 f	424 d
Camello II	302 b	364 b	383 c	411 e	452 a
Mean	292 E	360 D	402 C	429 B	443 A
	NDF (g kg^{-1})				
Cayman	548 d	572 d	656 a	685 c	694 d
Mulato II	550 d	637 bc	651 a	679 d	714 c
Convert 330	562 c	645 ab	687 a	711 b	734 a
Cobra	538 e	628 c	644 a	664 f	677 e
Camello I	654 a	659 a	667 a	722 a	733 a
Camello II	645 b	647 ab	662 a	677 e	721 b
Mean	590 E	632 D	669 C	695 B	718 A

Different literals between cultivars (a, b, c, d, e, f) and regrowth ages (A, B, C, D, E) indicate significant statistical difference (Tukey; $\alpha=0.05$).

CONCLUSIONS

Under semi-arid conditions and during the period of greatest precipitation, the Camello II, Mulato II, and Cayman cultivars had the best productive performance, in terms of total dry matter and leaf dry matter. In previous evaluations, the Cayman and Mulato II hybrids had recorded the best agronomic characteristics. In conclusion, the Camello II hybrid could be an alternative for feeding ruminants in semi-arid conditions, due to its TDM performance and nutritional value.

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