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Evaluation of three Buffel grass varieties, in northern Tamaulipas

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ABSTRACT

Objective: To evaluate the vegetative, reproductive, production, and forage quality characteristics of three Buffel grass varieties from northern Tamaulipas.

Design/Methodology/Approach: A pot trial was established under open field conditions, at CERIB-CIRNE-INIFAP in Río Bravo, Tamaulipas, on 04/15/2016 and 03/10/2017; the experiment was carried out with a completely randomized design, with 30 replications by material. The morphological, reproductive, production, and chemical composition characteristics of Milenio, Regio, and Titán Buffel grass varieties forage were evaluated.

Results: The year accounted for 62.3% of the variation in the stem and leaf characteristics. The genotype contributed 35.4% and G*Y interaction, 2.3%. Regarding the reproductive variables, the genotype accounted for 62% of the results, the G*Y interaction, 25%, and the year, 13%. The genotype and the year accounted for 44% and 47% of the variance in forage production and quality, respectively. The G*Y interaction had no statistical effect.

Limitations/Implications: The evaluation was carried out under pot conditions, which implies that the roots of the plants have limited growth and that the expression of some of the characteristics of the material may be restricted.

Findings/Conclusions: The major differences between the three varieties were found in their morphological characteristics: duration of the flowering stage, reproductive stems proportion, panicle length, exertion of the panicle from the main stem, number of florets per panicle, and seed weight.

Keywords: Forage, apomictic, elite, adaptation, alternative.

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INTRODUCTION

The semi-arid zone covers central and northeastern Tamaulipas, northern Nuevo León, and northeastern Coahuila. The most representative plant communities are the sclerophyll

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shrubland or chaparral. In southern Texas and northeastern Mexico, the herbaceous stratum has low diversity and is mainly composed of grasses such as: Relaxgrass [*Aegopogon cenchroides* (Humb. & Bonpl. ex Willd.)], Blue Grama [*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Steud.)], Hairy Grama (*Bouteloua hirsuta* Lag.), Deergrass (*Muhlenbergia rigida* Kunth), Woodland Muhly [*Muhlenbergia rigens* (Benth) A.S. Hitch.], and *Setaria* sp. (González, 2003). Buffel grass (*Cenchrus ciliaris* or *Pennisetum ciliare* (L.) Link) is a perennial, bunchgrass, rhizomatous species native to Africa (Ibarra *et al.*, 2013). In the state of Tamaulipas, Buffel grass is used to modify two types of natural vegetation: the thorn scrub in the northern part and the thorn lowland rain forests in the center and south of the state (Garza *et al.*, 2010). In addition, it is a drought-tolerant grass; drought is a recurring phenomenon especially in northern Tamaulipas that is aggravated by the presence of the midsummer heat (Sánchez *et al.*, 2018). Currently, erratic precipitation accompanied by temperatures above 38 °C has spread to the central and southern areas (SMN-CONAGUA, 2021), where most of the state's livestock is raised. This fast-growing species is resistant to intensive grazing and has a higher seed production than native species; these characteristics make it valuable as forage in the state of Tamaulipas (Garay *et al.*, 2017). Therefore, as a result of this evaluation, we expect to find the contrasting differences between the three varieties; these differences are caused by their genetic origin and the adaptation area where they have been tested. The objective of this experiment was to evaluate seed production and yield and forage quality of three Buffel grass varieties in northern Tamaulipas.

MATERIALS AND METHODS

Vegetable material

Milenio Buffel grass variety is apomictic and was obtained by selection of accessions from the Germplasm Bank of Buffel grass from Texas A&M University, USA. These lines come from an initial collection carried out in South Africa in 1976 by North American researchers (García, 2003). In 2007, this variety was registered in the National Catalog of Plant Varieties (NCPV) of the National Seed Inspection and Certification Service of México Department of AgricultureNational Seed Inspection and Certification Service of México Department of Agriculture, with the number CEN-003-060608. Titán and Regio varieties were also obtained in 2007 from a regional collection of germplasm in the highlands of San Luis Potosí, México (Beltrán *et al.*, 2017) and have CVV registration numbers CEN00160608 and CEN00260608, respectively. The morphological variables were measured using the SAGARPA-SNICS technical guide (2014), during the early cycle of seeds sown in April (2016) and March (2017) at the Campo Experimental Río Bravo, Tamaulipas (25° 57' N and 98° 01' W; 25 m.a.s.l.). This experiment was established under open field conditions in 40×40 cm pots with approximately eight kilos of substrate. Thirty pots were planted of each variety (Titán, Regio, and Milenio). The pots were irrigated every 10 days. The reported data correspond to the average of two years. During the experiment, ambient temperature data (maximum, minimum, and average) and precipitation (mm) were taken at the weather station located in the experimental field.

The fresh biomass was divided into stem, leaves, and panicle and the weight of each component was obtained. Subsequently, they were dried in an oven at 60 °C for 72 h.

Once dehydrated, they were ground in a Revolving Knife Mill for laboratory use (Thomas Model 4 Wiley® Mill) with a 1-mm sieve. The crude protein (CP) content of the forage was determined by the Kjeldahl method. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin in leaves and stems were analyzed using the method described by Van Soest *et al.* (1991). The proximal analysis was performed based on the official data of the AACC Methods. Total protein content (official method 46-13.01) and crude fiber (official method 32-10.01) were determined by the Kjeldahl method. The combined analysis of variance was performed with a completely randomized model; the variation sources were varieties or genotypes and years, with 30 repetitions by variety. Simple Pearson correlations were also made between vegetative and reproductive variables using the statistical analysis system version 9.31 (SAS, 2006). Mean comparisons were made with Tukey test ($p<0.05$). This work does not include tables of the correlations between the variables; only some results are quoted.

RESULTS AND DISCUSSION

Morphological differences between varieties

The analysis of variance (Table 1) showed that the effect of the year was the factor with the highest statistical value: it accounted for 62.3% of the variation of the stem's and the leaf's 12 vegetative characteristics, while the genotype contributed 35.4% and the G*Y interaction, less than 2%. The variation sources did not have a significant effect on the number of axillary bayonets (NAB); consequently, the stability of this varieties is considered a good descriptive characteristic. In contrast, the main stem height was highly variable. In this experiment, the 2016 and 2017 ambient temperature records were: 33 and 34 °C (maximum); 28 and 28 °C (average); and 22 and 22 °C (minimum), respectively. Total rainfall ranged from 155 mm in 2016 to 131 mm in 2017. The climatic variable that showed a difference was the amount of rainfull: 15% more in 2016 than in 2017.

Table 1. Mean squares for vegetative variables.

SV	df	PH (cm)	MSH (cm)	NB	NN	DT (mm)	NAB
G	2	388.1 ns	1129.7*	6 ns	16.9 ns	14.7*	0.3 ns
Y	1	74.9 ns	2155.5*	1229**	326.9*	31.0*	0.2 ns
G*Y	2	1305.3**	1951.9*	11 ns	9.0 ns	1.7*	2.1 ns
CV		14.6	15.9	15.3	19.6	20.8	13.5
SV	**gl**	**L3L**	**W3L**	**LFL**	**WFL**	**LA3L**	**LAFL**
		(cm)				**(cm^2)**	
G	2	193.8*	25.8*	426.3*	62.3*	72368**	125662*
Y	1	49.0 ns	0.02 ns	2492.4**	202.3*	5683 ns	342605**
G*Y	2	125.3*	17.3*	90.0 ns	3.5 ns	295 ns	7063 ns
CV		17.9	11.4	9.8	19.2	13.6	15.3

SV: source of variation; df: degrees of freedom; G: genotype; Y: year; G*Y: genotype per year interaction. PH: plant height; MSH: main stem height; NB: number of bunches; NN: number of nodes in the main stem; DT: Diameter of stem; NAB: number of axillary bayonets; 3L: third leaf; FL: flag leaf (L: length, W: width, and LA: leaf area). CV: Coefficient of variation. Statistical significance: ns=not significant; *=.001; **0.001.

In contrast to the vegetative characteristics, the genotype had a greater effect on the reproductive variables (62%), followed by the G*Y interaction (25%). Finally, the year had a lower statistical weight in the expression (13%). The three sources of variation had a highly significant effect on seed weight, unlike the rest of these characteristics (Table 2). This result can be expected, because grasses produce seed in a staggered manner and part of that production is vain or of very low weight, as a result of changes in the length of the seed filling period. This period can be affected by intra-plant competition between bunches and translocation of photoassimilates to the grain (Ryan *et al.*, 2018). The effect of the genotype is associated with this response. Genetic variability influences the components of seed yield, as Lopes *et al.* (2017) have reported for *Paspalum* genus interspecific hybrids.

The characteristic that best differentiates the Milenio variety was the height of the main stem (98.0 cm); in contrast, the stems of the Regio and Titán varieties were 8.1 cm and 10.8 cm longer, respectively. The rest of the stem and the leaf morphological characteristics showed no statistical differences or very little contrast (Table 3). Greater differences were expected in this evaluation, as a consequence of the genetic origin of the Milenio variety. This material was derived by introduction of accession PI409443,

Table 2. Mean squares for reproductive variables.

SV	df	DA	DFS	RSP	LP (cm)	EX (cm)	NFP	W1000S (g)
G	2	6311**	33*	19 ns	41**	30.1 ns	1737.2*	5.8*
Y	1	609*	132**	595**	89**	298.5**	0.13 ns	5.2*
G*Y	2	8 ns	2 ns	48*	11 ns	51.3 ns	3162.8**	4.4*
CV		2.0	12.0	23.5	11.1	17.5	21.2	16.6

SV: source of variation; df: degrees of freedom; G: genotype; Y: year; G*Y: genotype per year interaction. DA: days to anthesis; DFS: duration of the flowering stage; RSP: reproductive stems proportion; LP: length of the panicle; EX: exertion of the panicle from the main stem; NFP: number of florets per panicle; and W1000S: weight of 1000 seeds. CV: Coefficient of variation. Statistical significance: ns=not significant; *=.001; **0.001.

Table 3. Comparison of means between Buffel grass varieties. Phenotypic characteristics of the stem and leaf. Río Bravo, Tamaulipas, México, 2016 and 2017.

Variety	MSH (cm)	ATS (cm)	NB	NN	NAB	DT (cm)
Milenio	80.0±13.3 a	98.0±19.3 a	7.2±6.2 c	10.4±1.9 a	10.3±2.7 a	4.0±1.8 a
Regio	72.5±12.2 b	87.9±14.6 b	11.1±7.4 a	10.3±2.1 a	9.9±2.5 a	3.5±1.6 b
Titán	73.0±12 ab	87.7±14.3 b	9.8±7.8 b	9.8±1.9 a	10.5±2.6 a	3.3±1.2 b
	L3L (cm)	**W3L (cm)**	**LFL (cm)**	**WFL (cm)**	**LA3L (cm^2)**	**LAFL (cm^2)**
Milenio	2.8±0.7 a	34.0±6.1 a	8.5±2.3 a	24.3±7.9 a	294±21 a	192±58 a
Regio	1.9±0.6 b	33.7±6.7 a	8.4±2.5 a	25.3±8.3 a	277±34 a	173±61 a
Titán	1.9±0.7 b	30.0±6.8 b	7.5±2.6 b	21.4±8.1 b	222±48 c	107±77 b

MSH: main stem height; NB: number of bunches; NN: number of nodes; NAB: number of axillary bayonets; DT: Diameter of stem; 3L: third leaf; FL: flag leaf (L: length, W: width, and LA: leaf area). Values with different literals between columns are statistically different (Tukey, p=0.05).

collected in Aberdeen, Cape Province, South Africa (32° 29''0''' S, 24° 4''0'' E, at an altitude of 915 m.a.s.l.), where the average temperature is 16.7 °C (USDA-ARS-GRIN, 2021). The Regio and Titán varieties were derived from regional collections in the highlands of San Luis Potosí, México at altitudes ranging from 1,800 to 1,950 m.a.s.l. (Beltrán *et al.*, 2017). Meanwhile, the Milenio variety formed 31% and 20% less bunches by plant than the Regio and Titán varieties (García *et al.*, 2003). The Milenio variety has adapted to the extreme climatic conditions of northeastern Mexico (Coahuila, northern Nuevo León, and Tamaulipas), in localities with an altitude between 50 and 200 m.a.s.l., an average temperature of 23.5 °C, and rainfall ranged 400 and 750 mm. In this experiment, the mean temperature during the growing season was 28 °C, both in 2016 and 2017. According to these data, the mean temperature was 4.5 °C higher than the temperature recorded during the past decade (García *et al.*, 2003).

In this evaluation, the earliest variety was Milenio with 68±3 days at anthesis, while the Regio and Titán varieties were later with 78±4 days and 89±5 days, respectively (Table 4). These results match the findings of Beltrán *et al.* (2017), who indicate that the Titan variety is less precocious. A characteristic of the panicle structure of the Milenio variety is the length of the peduncle. In this case it was measured on the main stem, but all the reproductive stems show that it is longer (9.2±5.2 cm). The panicle measured 11.5±2.3 cm. The Regio variety had similar results (Table 4). Kizima *et al.* (2014), using a direct seeding method, report that seed production has the following components: proportion of fertile stems (0.50); stem diameter (2.35 cm), stem height (88 cm), length (12 cm), and inflorescence width (13.2 cm). Meanwhile, the average data of the three varieties in this experiment was as follows: proportion of fertile stems (0.29); stem diameter (2.2 cm), stem height (76.3 cm), panicle length (11.1 cm), and number of florets per panicle (87) (Table 4). No significant correlation was observed between the number of florets per panicle and the following variables: stem diameter, plant height, and number of total stems. The correlation values were less than 5%. Conde *et al.* (2011) report differences between genotypes regarding the production of florets per panicle. The materials with the highest number of florets were Nueces (82) and T-1754 (80), while Común (41) and Formidable (52) had a lower production and the average number of florets (64) was recorded in

Table 4. Comparison of the means of reproductive characteristics between Buffel grass varieties. Río Bravo, Tamaulipas, México 2016 and 2017.

Variety	DA	DFS	RSP	LP (cm)	EX (cm)	W1000S (g)	NFP
Milenio	68±3 c	9±3 a	0.33 a	11.5±2.3 a	9.2±5.2 a	3.6±0.6 a	92±20 a
Regio	78±4 b	9±3 a	0.29 b	11.9±2.5 a	7.3±3.8 b	3.2±0.8 b	90±21 a
Titán	89±5 a	8±2 b	0.25 b	10.0±2.5 b	7.4±3.8 b	3.1±0.7 b	80±22 b
mean	78	8	0.29	11.1	7.9	3.3	87

DA: days to anthesis; DFS: duration of the flowering stage; RSP: reproductive stems proportion; LP: length of the panicle; EX: exertion of the panicle from the main stem; NFP: number of florets per panicle; and W1000S: weight of 1000 seeds. Values with different literals between columns are statistically different (Tukey, p=0.05).

Victoria, Tamaulipas, México. Meanwhile, during this experiment, an average of 87 was obtained over two years. In this evaluation, no incidence of rice blast disease (*Pyricularia grisea*) was observed; this is the main disease of susceptible genotypes such as the Buffel Común and its incidence and severity increase under drought stress (Díaz *et al.*, 2007). The presence of panicle ergot (*Clavices* sp.) may be registered when the temperature drops by 15 °C during the flowering stage. This disease affects seed production.

Agronomic and chemical characteristics of the forage

In this experiment, a significant effect of the genotype was detected on yield and forage quality variables (Table 5). This effect helped to explain 44% of the variance, while the year factor accounted for 47% and the G*Y interaction had no statistical weight in any of these variables. The sources of variation had no effect on the amount of lignin in the biomass. Unlike the vegetative and reproductive variables, the genotype significantly contributed to explain the results.

The growing season or seasonal variations have an effect on the amount of NDF and ADF, factors that determine the forage quality (Flores, 2009). The growing season influences the production of dry biomass: the highest forage production was obtained during the spring (4.7 t MS ha^{-1}), subsequently decreasing in winter (0.7 t MS ha^{-1}) (Garza *et al.*, 2005; Flores, 2009; Garza *et al.*, 2010). In this experiment the year factor led to significant variations on yield and forage quality. Dumont *et al.* (2015) point out that climate change has a twofold impact on livestock: (i) on the chemical characteristics of forages and (ii) on animals themselves (intake and digestive processes). The production of fresh and dry weight per plant in 2016 was 10% and 19% higher than in 2017 (Table 6). The chemical composition of the fiber portion of the forage (NDF, ADF, LIG, HE, and CE) was 3-6% higher in 2016 than in 2017. On the one hand, there was no difference in crude protein between years (average: 7.3%). On the other hand, differences between genotypes were observed. The Regio variety produced the highest amount of protein (8.1%).

Table 5. Mean squares of forage production and chemical composition.

SV	df	BFW (g)	BDW (g)	CP	NDF	ADF	LIG	HE	CE	AS
					(%)					
G	2	3463.4*	895.1*	4.7*	16.0**	5.8**	0.108 ns	10.4**	6.4**	0.36*
Y	1	94508.3**	29670.1**	0.04 ns	21.8**	7.6**	0.088 ns	3.6**	6.1**	2.88**
G*Y	2	2361.0 ns	811.0*	0.03 ns	2.3 ns	1.4 ns	0.008 ns	1.6 ns	2.4 ns	0.22 ns
CV		14.9	16.4	9.3	0.41	1.6	6.1	1.9	1.6	2.2

SV: source of variation; df: degrees of freedom; G: genotype; Y: year; G*Y: genotype per year interaction. BFW: total biomass fresh weight; BDW: total biomass dry weight (biomass data per plant); CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; LIG: lignin; HE: hemicellulose; CE: cellulose; and AS: ash. CV: Coefficient of variation. Statistical significance: ns= not significant; *=.001; **0.001.

Table 6. Means comparison between Buffel grass varieties. Characteristics of forage production and chemical composition. Rio Bravo, Tamaulipas, México, 2016 and 2017.

Variety	BFW (g)	BDW (g)	CP	NDF	ADF	LIG	HE	CE	AS
				(%)					
Milenio	57.3 b	24.2 c	7.5 b	65.4 c	40.1 b	4.9 a	25.3 b	35.2 c	11.9 b
Regio	62.6 a	30.5 a	8.1 a	68.6 a	41.0 b	4.7 a	27.6 a	36.4 b	12.9 a
Titán	56.5 b	27.9 b	6.3 c	67.4 b	42.1 a	4.8 a	25.3 b	37.2 a	12.8 a
Year									
2016	61.9 a	30.4 a	7.3 a	68.2 a	41.7 a	4.9 a	26.5 a	36.8 a	13.1 a
2017	55.8 b	24.5 b	7.3 a	66.0 b	40.4 b	4.7 a	25.6 b	35.7 b	12.3 b
mean	58.8	27.5	7.3	67.1	41.1	4.8	26.1	36.2	12.5

BFW: total biomass fresh weight; BDW: total biomass dry weight (biomass data per plant); CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; LIG: lignin; HE: hemicellulose; CE: cellulose, and AS: ash. Values with different literals between columns are statistically different (Tukey, p=0.05).

CONCLUSIONS

The year factor accounted for 62.3% of the variation of the stem's and the leaf's 12 vegetative characteristics, while the genotype contributed 35.4% and the G*Y interaction, 2.3%. Regarding the reproductive variables, the genotype accounted for 62% of the results, the G*Y interaction, 25%, and the year, 13% (the lowest statistical value). The characteristic that best differentiates the Milenio variety from the Regio and Titán varieties was the height of the main stem (98.0 cm). The rest of the stem and the leaf morphological characteristics showed no statistical differences or very little contrast The earliest variety was Milenio (68±3 DA). The genotype accounted for 44% of the variance in forage production and quality; meanwhile, the year factor accounted for 47% and the G*Y interaction was not significant. In 2016, the production of fresh and dry weight per plant was 10% and 19% higher than in 2017. The chemical composition of the fiber portion of the forage (NDF, ADF, LIG, HE, and CE) was 3-6% higher in 2016 than in 2017. The variations in this experiment were attributed to the genotype. The Regio variety produced the highest amount of protein (8.1%).

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