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Forage and vegetal characterization of three native mexican grasses in Tulancingo de Bravo, Hidalgo

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ABSTRACT
Objective: To carry out an agronomical assessment and a quantitative description of the yield components of switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and alkali sacaton (*Sporobolus airoides*) under rainfed conditions in Tulancingo, Hidalgo, Mexico.
Design/Methodology/Approach: A completely randomized block design was used in 31-month-old pastures to determine forage production, morphological composition, seed yield, and weight of 1,000 caryopses. The plants were characterized in 7-month-old pastures, recording (per plant) the number of total and floral stems, as well as the basal twigs in alkali sacaton and switchgrass. Meanwhile, in the case of eastern gamagrass, the dome number and androecium sections were recorded.
Results: The highest forage dry matter production was observed in switchgrass: 9,322 kg ha^{-1} ($P<0.05$). Eastern gamagrass had a higher leaf ratio (1:3). The highest number of seeds was recorded in alkali sacaton: 211 kg ha^{-1}, with 43% physical purity. After 7 months of sowing, a total of 250, 355, and 280 stems and 193, 150, and 87 floral stems were recorded in switchgrass, alkali sacaton, and eastern gamagrass, respectively.
Study Limitations/Implications: Eastern gamagrass produces a low number of seeds; therefore, it must be propagated by plant material. In rainfed soils, grasses help to recover pasture areas, since rainfed agriculture poses a risk in many places as a result of poor rainfall distribution or early frosts.
Findings/Conclusions: The three grasses studied are productive due to the amount of forage accumulated. Alkali sacaton produces more seeds.

Keywords: *Panicum virgatum*, *Sporobolus airoides*, *Tripsacum dactyloides*, agricultural to livestock conversion.

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INTRODUCTION

Quero-Carrillo *et al.* (2014) and Hernández-Guzmán *et al.* (2021) mention that the diversity of climates in Mexico means that each microsite has endemic plants that improve the diversity of plants, including grasses (Poaceae). Moreover, overgrazing of the common rangeland areas (rangelands) has eliminated perennial forage species from certain sites in semi-arid Mexico (Quero-Carrillo *et al.*, 2014).

Rodríguez-Ortega *et al*. (2021) reported dry matter yields of 3,584, 720, and 1,159 kg ha^{-1} of switchgrass (*Panicum virgatum*), alkali sacaton (*Sporobolus airoides*), and eastern gamagrass (*Tripsacum dactyloides*), respectively, during the first year that they were established in Tulancingo de Bravo, Hidalgo, Mexico. In addition, Marra *et al*. (2013) reported 9,222 kg ha^{-1} of switchgrass in the third year of establishment in West Virginia, USA. In Winsconsin, USA, Coblentz *et al*. (2014) reported 4,950 kg ha^{-1} of eastern gamagrass three years after it had been established. Cox *et al*. (1990) reported a 23-145 g plant^{-1} forage yield of alkali sacaton in Arizona, USA. Yield components in grasses include number of total and flowering stems, number of branches, number of twigs, and number of spikelets per branch or twig (Sánchez-Arroyo *et al*., 2020); these elements help to assess forage plant materials —useful in agricultural to livestock conversion— since, in many places of Mexico, staple crops are destroyed by prolonged intraestival drought or early frosts. On the one hand, the objective of the study was to carry out an agronomical assessment of switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and alkali sacaton (*Sporobolus airoides*), 31 months after their establishment, and, on the other hand, to describe the yield components of selected plants, seven months after they had been established in Ahuehuetitla, Tulancingo de Bravo, Hidalgo, Mexico.

MATERIALS AND METHODS

The study was conducted in Ahuehuetitla, Tulancingo de Bravo, Hidalgo, at an altitude of 2,120 m. The soil of the site is clayey vertisol (INEGI, 2017). The plots for propagation of switchgrass, eastern gamagrass, and alkali sacaton were established on April 4th, 2020 under irrigated conditions, using a randomized complete block design, at a density of 8,333 plants ha^{-1}.

In the genetic improvement progress context, switchgrass, eastern gamagrass, and alkali sacaton genotypes were established in the "El Frijol 1" plot, Ahuehuetitla, Tulancingo, Hidalgo in 2020 (year 1, site 1), following the guidelines of Rodríguez-Ortega *et al*. (2021). In addition, during the anthesis, plants that did not meet the species and genotype characteristics were eliminated; the main characteristics included: forage height versus plant height, anther color, leaf shape, color distribution in stems, internode shape, anthocyanin color in leaves, color of glumes at anthesis, and color and shape of veins. At the end of November 2020, switchgrass, eastern gamagrass, and alkali sacaton seeds were collected from uniform plants and preserved at 13% humidity with the help of the LDS-1G moisture meter with LCD display (Beijing). The seeds were then placed in paper bags in the shade, inside plastic containers with lids. In year 2 (2021), site 2 was established 500 m away from site 1 in "El Arroyo"; the soil was prepared according to the recommendations of Quero-Carrillo *et al*. (2014). On June 26th, seeds from site 1 were sown, under rainfed conditions, in two 50-m long furrows separated 1.2 m apart from each other. From September to October 2021, plants that, for various reasons, did not show any of the abovementioned forage and genotype characteristics were eliminated. In summary, 300 original plants per species were counted and seeds were preserved at 13% humidity, in paper bags within plastic containers with lids.

In the year 2022, seeds were sown in the "El Frijol 2" plot (site 3), under drip irrigation conditions; the seeds came from plants of site 2 as homogenous genotype with characteristics specifics. These plants were used to assess the yield components on April 6^{th}.

The first stage was the determination, under rainfed conditions, of the forage and morphological distribution of site 1 in the second week of October 2022. Yield component data was collected at site 3, under drip irrigation conditions from the first to the second week of October 2022. The variables at site 1 were:

Forage production. It was determined in two 5-m long furrows (2.4×5 m$=12$ m^2). Forage was cut 10 cm above the base of the soil and weighed in a Truper® 0.5021 scale model (0.0 kg; 5,000 g capacity; Mexico); a 300 g subsample was then separated into leaves, stems, inflorescences, and dead material. Subsequently, each component was placed in paper bags and arranged in a greenhouse with air flow. A Ciderta R© forced-air oven (Huelva, Spain) was used for total drying at 55 °C for 6 h and the result was immediately weighed on a Hanchen BSM220 digital scale 4 (0.0001 g, Beijing).

Morphological composition. This variable was the result of the morphological distribution (%) of leaves, stems, dead material, and inflorescences.

Leaf:stem ratio. This variable was the result of the division of the dry weight of leaves by the weight of stems.

Seed production. Harvesting was carried out when the inflorescence per block (especially in the glumes) of each species clearly turned beige. Seeds (complete dispersal units) of the three species were placed on paper in a greenhouse with air flow for 14 days and the humidity was determined with a LDS-1G humidity determiner. Once 13% humidity was recorded, yield was calculated according to the methodology developed by Rodríguez-Ortega *et al.* (2021).

Physical purity. To determine this variable, 3 g of complete dispersal units per species and block of switchgrass and alkali sacaton were weighed, according to the methodology developed by Alvarez-Vázquez *et al.* (2022). Subsequently, caryopses were extracted over a corrugated rubber using friction with mat covered with the same material and weighed. Data for this variable did not have a normal distribution; therefore, they were transformed to a square root function + 0.5. In addition, due to its low caryopsis content and poor feeling, eastern gamagrass was not considered. Therefore, propagation with plant material is recommended.

Weight of 1,000 caryopses and dimension. Eight replicates of 100 caryopses per block were weighed and the mean was multiplied by 10 (Hernández-Guzmán *et al.*, 2021). Twenty-five caryopses per block were measured to determine caryopsis dimensions (length, width, and thickness) with a Truper® IP64 digital vernier. Data for both variables were transformed to a square root function + 0.5. The GLM procedure of SAS (2004) was used to analyze the data and the means were compared with Tukey's test ($\alpha=0.05$).

Yield components on site 3

The yield components of each grass were recorded on 10 homogeneous plants. The number of total stems, flower stalks, branches, twigs, and spikelets on the basal branch or twig were counted. In eastern gamagrass, the number of cupules in the gynoecium and the number of sections in the androecium were counted.

RESULTS AND DISCUSSION

Temperature was adequate in the 2022 pasture growth period. Since the average rainfall was 550 mm, a 271-mm accumulation (Figure 1) was considered to represent a dry year (Rodríguez-Ortega *et al.*, 2021). The first significant rainfall (20 mm) occurred on August 27th.

Differences were observed in agronomic variables (Table 1; $P<0.05$): switchgrass (9,322 kg ha^{-1}) was greater than alkali sucaton and eastern gamagrass by 1.8 and 3.3 times, respectively; however, eastern gamagrass had a higher leaf proportion. Forage production in switchgrass was similar to the figures reported by Marra *et al.* (2013), while eastern gamagrass production was 1.76 times lower than that reported by Coblentz *et al.* (2014). Cox *et al.* (1990) just like in this study, considered 8,333 plants ha^{-1} — reported

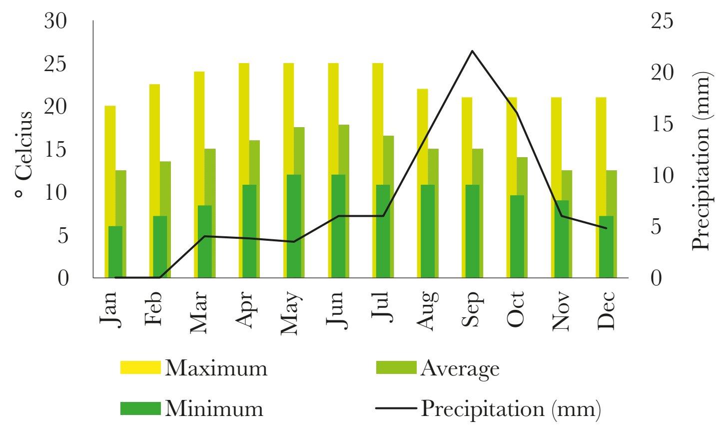

Figure 1. Monthly rainfall (mm) and maximum, average, and minimum temperature in Tulancingo de Bravo, Hidalgo, in 2022.

Table 1. Forage production and its morphological distribution (%), leaf:stem ratio in four pastures under rainfed conditions in Tulancingo, Hidalgo, Mexico.

Especie	**Forage yield (kg ha^{-1})**	**Leaves %**	**Stems %**	**Inflorescens**	**Dead material (%)**	**Leavs:stems**	**Seed yield (kg ha^{-1})**	**Wight of 1000 seeds (mg)**	**Phisic purity (%)**	**Pure seed (kg ha^{-1})**
Tripsacum dactyloides	2818 b[†‡]	52.8 a	40.6 b	4.4 a	2.1 c	1.39 a	No aplica	17.0 a	No aplica	No aplica
Sporobolus airoides	5075 b	31.1 b	30.1 c	0.56 b	38.2 a	1.05 a	211.5 a	0.87 b	43.42 a	91.8
Panicum virgatum	9322 a	20.0 c	53.0 a	1.1 b	25.8 b	0.38 b	159.9 a	0.39 b	2.94 b	4.7
Significancia	***	***	***	***	***	**	NS	***	***	***

[†] Equal lowercase letters per column indicate similar averages ($P>0.05$). ***$P<0.001$. **$P<0.01$. NS=Not significant ($P>0.05$). No aplica (Not applicable)=seed yield is incipient.

a lower dry matter level in the forage production of alkali zacaton (1,208 kg ha^{-1}). Regarding seed yield, there was no difference (P>0.05) between alkali zacaton (211 kg ha^{-1}) and switchgrass (159.9 kg ha^{-1}). However, this yield was 2.9 times higher than the results reported by Rodríguez-Ortega *et al.* (2021), after 2 years of establishment; in conclusion, plant age is important for the increase in seed quantity (Quero-Carrillo *et al.*, 2014). In the 1,000-seed weight heading, eastern gamagrass caryopses were heavier than in switchgrass and alkali sacaton; these results were typical of these species, but cupule filling was poor, as reported by Rodriguez-Ortega *et al.* (2021). Contrary to eastern gamagrass and switchgrass, alkali sacaton caryopses were 2.3 times heavier than in 2020, which can only be explained by the rainfall (mm). Physical purity in alkali sacaton after 1 year of establishment was higher (43.42%) in the current study than in Rodriguez-Ortega *et al.* (2021; 22.7%); meanwhile, purity decreased in switchgrass (2.94%)), probably due to the low and poorly distributed rainfall (Rodriguez-Ortega *et al.*, 2021; 8.26%).

Caryopsis dimensions were different (P<0.001; Table 2): eastern gamagrass caryopses were longer, wider, and thicker than in alkali sacaton and switchgrass. Likewise, switchgrass caryopses was 1.5, 1.3, and 1.2 times longer, wider, and thicker than in alkali sacaton. Different dimensions are typical of each species; however, measurements should be taken into account for seed sorting or for their consideration for seed drills. Botanical seed size is important, since the vigor of a seedling depends on its intraspecies size (Quero-Carrillo *et al.*, 2017).

Yield components

Panicum virgatum. On average, it recorded 250 total stems, 193 floral stems, 38 inflorescence branches, 5.2 basal branch twigs, and 2.4 spikelets from the first pedicel of the basal branch.

Sporobolus airoides. This forage plant registered 355 total stems, 150 floral stems, 57 branches per inflorescence, 11.2 twigs, 6.5 secondary twigs, 2.7 spikelets on the tertiary twig, and 1.3 spikelets on the tertiary twig.

Tripsacum dactyloides. This grass recorded 280 total stems and 87 floral stems —out of which 75%, 22%, and 3% were single, double, and triple, respectively. In addition, an average of 6.4 cupules per gynoecium and 30.4 androecium sections were counted.

Table 2. Botanical seed dimensions of four grass species grown under rainfed conditions in Tulancingo, Hidalgo, Mexico.

Especie	Length (cm)	Width (cm)	Thickness (cm)
Panicum virgatum	2.20 b[†‡]	0.89 b	0.69 b
Sporobolus airoides	1.39 c	0.66 c	0.57 c
Tripsacum dactyloides	3.83 a	2.48 a	1.99 a
Significancia	***	***	***

[†] Different lowercase letters per column indicate different averages (P<0.05). ***P<0.001.

CONCLUSIONS

Switchgrass had the highest dry matter yield, followed by alkali sacaton and eastern gamagrass. Seed production was higher and had a higher physical purity in alkali sacaton. The largest caryopses were reported on eastern gamagrass, followed by switchgrass and finally alkali sacaton.

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