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Seed yield variables of five wild Poaceae species in La Siberia, Chapingo, México

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ABSTRACT

The objective of the study was to evaluate the seed yield variables *in situ* in *Bouteloua gracilis*, *Bouteloua hirsuta*, *Bouteloua curtipendula*, *Mulhenbergia rigida* and *Schizachyrium scoparium* in La Siberia, Chapingo, Mexico. The study was carried out on wild plants in which the following were recorded: total stems plant^{-1}, number of branches plant^{-1}, number and quantity of seed^{-1}, stem^{-1} and plant^{-1} to later evaluate the percentage of filling and viability. The data were analyzed with GLM of SAS in Completely Random Blocks design and Tukey's test (α=0.05). There was no grass species that exceeded 25 flower stems per plant ($P<0.001$). *B. gracilis* showed a lower number of inflorescences per plant compared to *B. hirsuta* ($P<0.001$), however, with a higher number of branches ($P<0.001$). Seed production per plant (mg) was higher in *M. rigida* ($P<0.001$; 12902), followed by *B. curtipendula* (2246) and *S. scoparium* (1465). In physical quality of *B. curtipendula* seed, it presented a higher percentage of filling ($P<0.001$; 17%) and *S. scoparium* greater viability ($P<0.001$; 78%) and weight of 1000 seeds ($P<0.001$; 1.52 mg). In La Siberia, *B. curtipendula* and *S. scoparium* were identified as potential grasses to collect seed and then be used for reclamation or rehabilitation.

Keywords: native grasses, seed quality, reclamation lands.

INTRODUCTION

Mexico is the center of origin of many plant species, among them grasses. Dávila *et al.* (2006) report 204 genera and 1182 species, and of these 278 are endemic and 159 are introduced and/or cultivated. In Mexico, the low or null production of seed has

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reduced the reclamation of agricultural soils to their original vocation (Jurado *et al*., 2021). Because of this, in semi-arid Mexico, the genus *Bouteloua* has nearly 60 species with broad intraspecific genetic variability (Peterson *et al*., 2015). The genus *Muhlenbergia* has 145 native species from southern United States and northern Mexico (Rosales *et al*., 2013). On the other hand, *Schizachyrium scoparium*, of common name little bluestem is a native grass from northern Mexico and southern United States that is very useful in reclamation from agricultural to livestock production (Fu *et al*., 2004), although studies about this prominent grass species have not been conducted in Mexico.

Knowledge of seed yield variables such as number of flower stems, number of branches per flower stem, number of florets per branch, and therefore percentage of filling, weight of 1000 seeds, and viability (%), allow offering pure viable seed (Rodríguez-Ortega *et al*., 2021); this is useful for reclamation or rehabilitation. The study of genetic diversity within Mexican grass species, in banderita, has been studied by Morales-Nieto *et al*. (2009), Moreno-Gómez *et al*. (2012), and in navajita by Morales-Nieto *et al*. (2007); however, the in situ study of the yield components to obtain wild seed in banderita, navajita, *Muhlenbergia rigida* and little bluestem have not been reported. Therefore, the study object was to evaluate in situ in navajita [*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths], navajita velluda (*Bouteloua hirsuta* Lag), banderita [*Bouteloua curtipendula* (Michx). Torr.], *Muhlenbergia rigida* (Kunth) Kunth, and little bluestem [*Schizachyrium scoparium* (Michx.) Nash] the following components of the seed yield: number of flower stems, number of branches per stem, amount of seed per plant, percentage of filling, percentage of viability; and in this way, to report fodder species for reclamation or rehabilitation.

MATERIALS AND METHODS

The study was conducted in the experimental area "La Siberia", which contains a surface of 32 ha, in geographical coordinates 19° 28' 18.30" and 19° 27' 41.00" N and 98° 50' 45.92" and 98° 51' 28.17" W, municipality of Texcoco, Estado de México, Mexico. The place is located at 2323 masl with haplic phaeozem and lithosol soil of medium texture and precipitation of 700 mm (INEGI, 2018). The study period covered from the month of June to October 2018. The 60 areas (1 m^2) in La Siberia were limited in three sections within the 32 ha of the total surface, and fixed squares were marked for this according to the species (when inflorescences exerted and could be identified) and a sketch was made so that they could be identified easily later. The variables of the yield components were:

1. Plant height. This consisted in measuring from the base on the ground to the tallest leaf or inflorescence. 2. Number of flower stems per plant (N_FS). The stems with visible inflorescence were counted in the field at the time of harvest. 3. Number of branches per plant (NB). The number of branches was counted in all the stems of navajita and navajita velluda. 4. N_FB. In pectinated grasses the number of florets per branch were counted. 5. Number of branches per flower stem (N_BFS). In non-pectinated grasses, they were counted for three flower stems and multiplied by the total number of stems. Branches were collected along the rachis in the five species and deposited in paper bags that were previously labeled; then, they were placed in a greenhouse with air flow during three

weeks and weighed when the moisture was 12% (Hernández-Guzmán *et al.*, 2021). 6. Seed production per plant (SPP). For this, the weights of the dispersion units of the complete plant were added (mg). 7. Number of plants per m^2 and ha^{-1}. Plants were counted per species in each limited area until each species had exerted inflorescences. 8. Filling (%). Four repetitions were taken of 100 dispersion units of a work sample of 3 g and with the help of clamps and stereoscopic microscope they were dissected, in order to separate plant seeds. 9. Viability (%). The viability was measured with tetrazolium at 0.1%, and for this, 50 cariospsides in good state were obtained from a working sample of 6 g, according to the methodology described by Hernández-Guzmán *et al.* (2021). 10. Pure viable seed ha^{-1} (PVS ha^{-1}). It was determined when multiplying amount of seed per plant × number of plants per ha × percentage of filling × percentage of viability; the result is the amount of effective seed to be considered viable (kg). 11. Weight of 1000 seeds (mg). Eight repetitions were counted from 100 dispersion units and the mean was multiplied by 10 (Hernández-Guzmán *et al.*, 2021).

To consider the moment of harvest for each species, visits were made every seven days, and it was conducted when the inflorescences turned beige color. The dates of harvest were October 21, 2018, for navajita; October 24, 2018, for *M. rigida* and banderita; for navajita velluda, October 26, 2018; and for little bluestem, November 7, 2018. Once the number of branches per flower stem and number of florets per branch had been counted, all the dispersion units of the 60 samples were obtained; they were homogenized and then a sending sample of 30 g was obtained (ISTA, 2012). The data were set up in a completely randomized block design and analyzed with GLM from SAS (2009), and Tukey's test (α=0.05) was used to separate the means. The temperature and precipitation of the place were taken from the meteorological booths of Universidad Autónoma Chapingo, 2 km from the place.

RESULTS AND DISCUSSION

The precipitation and the temperature in the Chapingo region were adequate for growth of the Poaceae plants studied (Figure 1), since they are C_4 plants with summer growth (Gould and Shaw (1992).

Seed yield components

The greatest height in the grass species evaluated was observed in little bluestem (138 cm) and they were all different between one another ($P<0.001$; Table 1), which indicates variability in height and morphology (Alvarez-Lopeztello *et al.*, 2016). In the number of flower stems (N_FS) no difference was found between banderita, *M. rigida* and little bluestem grasses ($P>0.05$), while navajita grass was lower ($P<0.001$; 9.4 stems); however, it is within the range reported by Morales *et al.* (2009), that is, 3 to 186. On the other hand, in our study it averaged 24 in little bluestem and was similar to results by Butler and Briske (1988) in genotypes collected in Texas. Therefore, there is similarity in the same species of North American grass, since they are product of the repopulation of genotypes of Mexican grasses which were lodged by the "eternal" frosts (Quero *et al.*, 2007). In the species of pectinated

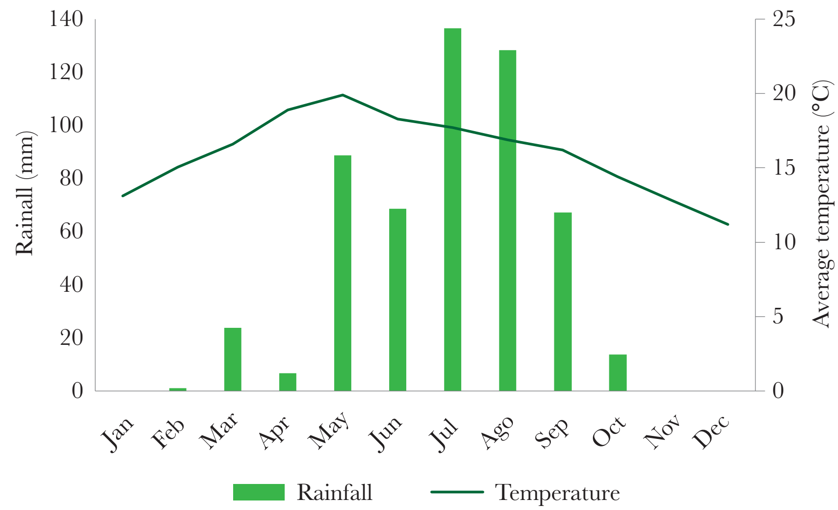

Figure 1. Monthly precipitation (mm) and mean monthly temperature (°C) in 2018 for the zone of Chapingo - Estado de México, Mexico.

Table 1. Average of yield components of 60 plants in five grass species evaluated in the Siberia Field, Texcoco, Estado de México, Mexico. Desert and can be useful in the rehabilitation of degraded soils instead of African grasses.

Species	Hight (cm)	NFS	NTW	NFB	NSS	SPP (mg)
Bouteloua gracilis	77.7 ^{c}‡	9.4 ^{b}	17.3 ^{b}	74.9 ^{a}		1 272 ^{b}
Bouteloua hirsuta	34.1 ^{e}	22.1 ^{a}	24.3 ^{a}	35.3 ^{b}		881 ^{b}
Bouteloua curtipendula	64.3 ^{d}	22.5 ^{a}			99.8 ^{b}	2 246 ^{b}
Muhlenbergia rigida	114.9 ^{b}	22.2 ^{a}			552 ^{a}	12 902 ^{a}
Schizachyrium scoparium	138.0 ^{a}	23.4 ^{a}			62.0 ^{b}	1 465 ^{b}
Average	85.8	19.9	20.8	55.1	326.1	3 753
Significancy	***	***	**	***	***	***
SEM	1.14	1.68	1.63	1.12	13.74	725.19

Equal literals per column are statistically similar averages ($P>0.05$). **$P<0.01$; ***$P<0.001$. SEM=Standard error of the mean. NFS=Number of floral stems. NTW=Number of twigs per plant. NFB= Number of florets per twigs. NSS=Number of seeds per floral stem. SPP=Seed production per plant.

grass, navajita velluda showed higher number of flower stems per plant (N_FS; 22.1) and higher number of florets per branch (24.3; $P<0.001$); however, navajita grass presented a higher number of branches per plant ($P<0.001$), which agrees with Gould and Shaw (1992) in the varietal description of each species, and therefore, higher seed production. In the non-pectinated Poaceae species, *M. rigida* stood out for producing higher number of dispersion units (spikelets) per flower stem (N_SFS), generally uniflora, and exceeded banderita and little bluestem by 5.5 and 8.9 times ($P<0.001$), respectively. The highest seed production per plant^{-1} was observed in *M. rigida* (12902 mg) and exceeded banderita by 5.7 times ($P<0.001$) and little blustem by 8.8 times, while banderita grass exceeded navajita by 1.76 times ($P>0.05$); however, these complete dispersion units sometimes do not contain plant seeds, as was mentioned by Quero-Carrillo *et al.* (2016). The species *M.*

rigida has rigid stems and of fibrous aspect (Giraldo-Cañas and Perterson, 2009), so that it is not an appealing species for livestock when it is physiologically mature, although it is a native species from the Chihuahuan.

The amount of plants in La Siberia in the five grass species studied are in low density, and particularly navajita velluda, little bluestem and *M. rigida* with 1 plant m^2 ($P<0.001$), since Quero-Carrillo *et al.* (2016) and Velázquez-Martínez *et al.* (2014) recommend a minimum of 5 plants m^2, which is important for soil retention and fodder production. Because of this, each micro-environment at the level of water reserve and soil nutrients, and their availability for the seedling, there is dominance of one species, known as vegetative types (Hernández-Guzmán *et al.*, 2021). When it comes to filling of the dispersion units (Table 2), differences were observed ($P<0.001$): banderita grass had higher presence of cariopside (17%) and was low in navajita (5.62%) if compared to seed evaluated by Quero-Carrillo *et al.* (2016), from imported seeds from production fields in the south of the United States. Because of this, wild grass plants did not receive the necessary nutrients. According to Zhang *et al.* (2017), in grasses the embryo is formed first and then the endosperm, while in the endosperm, according to Sabelli and Larkins (2009), the syncytium is formed after the double fertilization of the polar nuclei (series of divisions in absence of formation of cell wall and cytokinesis), and lastly the cellularization of the endosperm which includes the formation of principal type cells (transference cells, aleurone, endosperm, and cells that surround the embryo), then mitosis and endo-reduplication, accumulation of storage substances and maturation, which includes dormancy.

In amount of pure viable seed per hectare, differences were obtained in each of the species ($P<0.001$), where *M. rigida* provides more quantity (Table 2). Banderita grass provides 162 kg of VPS which allows recovering approximately 16 ha at a density of 10 kg ha^{-1}, since it is the grass species most studied for semi-arid Mexican zones and seven out of eight varieties are registered in the National Catalogue of Plant Varieties (*Catálogo Nacional de Variedades Vegetales*, CNVV) of the National Service of Seed Inspection and Certification (*Servicio Nacional de Inspección y Certificación de Semillas*, SNICS). On the other hand, in navajita grass (with 1 title of plant breeder) it produced to reconvert or establish 3.7 ha, which is low, although it is a grass resistant to trampling and accepted by livestock

Table 2. Yield variables of four wild grasses in La Siberia, Texcoco, Estado de México, Mexico.

Species	Plants m^2	Plants ha^{-1}	Pollinated (%)	Viability (%)	PVS ha^{-1} (kg)	Weight 1000 seeds (mg)
Bouteloua gracilis	4.0 a^{ł}	4000 a	5.62 d	52 b	37 c	0.2892 d
Bouteloua hirsuta	1.0 c	1000 c	11.1 b	38 d	37 c	0.6152 c
Bouteloua curtipendula	3.0 b	3000 b	17.0 a	42 c	162 b	0.8635 b
Schizachyrium scoparium	1.0 c	1000 c	5.87 d	78 a	67 bc	1.5211 a
Muhlenbergia rigida	1.0 c	1000 c	7.8 c	34 e	349 a	0.2127 e
Average	3817	2000	10	49	130	0.7003
Significancy	***	***	***	***	***	***
SEM	0.2086	2086	0.45	0.95	27.1	0.00064

Lowercase literals per column are statistically similar means ($P>0.05$). ***$P<0.001$. PVS ha=Pure viable seed ha^{-1}.

(Quero *et al.*, 2017). When it comes to little bluestem, it produces seed to sow 6.7 ha (1.8 times more compared to navajita), and it is a grass species that is appealing to livestock (Butler and Briske, 1988).

Corollary. The rehabilitation of degraded pasturelands of zones with scarce rainfall in Mexico is limited by the knowledge of the functioning of grasslands; therefore, this document contributes information that in natural grasslands there can be grass species that can serve to rehabilitate degraded areas to establish a seedbed with irrigation and as a source of genetic wealth for reclamation or rehabilitation. Because of this, according to Jurado-Guerra *et al.* (2021), in Mexico grasslands are over-grazed in 95% and in shrubs 70%, which limits the production of the cow-calf system. Thus, the application of laws on conservation of resources and sustainable use of ecosystems is urgent, where the semi-arid zones are the most fragile (Hernández-Guzmán *et al.*, 2021).

CONCLUSIONS

In the grassland ecosystem of La Siberia, Texcoco, Estado de México, in the five Poaceae species studied, banderita (*Bouteloua curtipendula*) and little bluestem (*Schizachyrium scoparium*) grasses stand out because they are the most appealing to the livestock and due to their good seed production and quality, and must be considered for reclamation and rehabilitation of pasturelands.

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