Article

Forage and seed production of eight grasses at the establishment in Tulancingo, Hidalgo

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Abstract

The objective of the study was to evaluate, in the first year of establishment, the number of plants established, forage production, morphological composition, seed yield, physical and physiological quality of seed in seven native Mexican grasses and buffel, in Tulancingo, Hidalgo. The experiment was established in April 2020 under irrigation in a completely randomized block design. To analyze the data, GLM of SAS and Tukey (α= 0.05) were used. In the establishment, the highest number of established plants (14 plants m^{-2}; p< 0.05) was observed in gigante. The highest production of forage in dry matter was observed in buffel and gigante (5 814 and 5 094 kg ha^{-1}; p> 0.05) respectively, followed by engordador grass (3 619 kg ha^{-1}; p< 0.001). The highest weight per plant was observed in buffel (62 g plant^{-1}; p< 0.001), while the highest leaf:stem ratio (p< 0.001) was observed in navajita (2.7) and banderita Herguz (2.59). In seed production, gigante grass produced the largest amount with 685 kg ha^{-1} (p< 0.01), filling, viability and therefore, the largest amount of viable pure seed per hectare (p< 0.001). Gigante, buffel and engordador are grasses that can be potential species of grass for reconversion in the Tulancingo Valley.

Keywords: Bouteloua, native American grasses, reconversion.

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Introduction

In Mexico, extensive livestock farming predominates in areas of low rainfall where overgrazing is the main cause of grassland deterioration (Quero *et al*., 2017a). Therefore, it is necessary to evaluate Mexican semiarid grasses to be established in soils where traditional crops such as corn and barley are damaged by early frosts or prolonged summer droughts (Velázquez *et al*., 2015). For this, there are several genera of native Mexican grasses such as Bouteloua, Aristida, Lycurus, Setaria, Sporobolus, Pappophorum, Hilaria, Digitaria, Panicum, Tripsacum, among others. Buffel grass (*Pennisetum ciliare*) was introduced from Africa to Mexico and has adapted to the Mexican semiarid, with good nutritional value, resistance to drought and grazing (García *et al*., 2003; Joaquín-Cancino, 2018).

The establishment of native grasses, according to Quero-Carrillo *et al*. (2014), for semiarid areas, has low success due to the poor control of factors such as: seed quality assessment, soil preparation, seed compaction with soil matrix and also consider high competition with weeds. On the other hand, constant temperature is important for homogeneous germination in grasses, where Hernández-Guzmán *et al*. (2015), at 22° constant in large caryopses of banderita, navajita, buffel and rhodes grasses, reported 95% of germination, attributing greater size of botanical seed to obtain a higher percentage of gemination.

In semiarid Mexico, the lack of production of grass seeds is the cause of the high price in the domestic market; however, there is a great diversity of grasses native to semiarid areas (Morales *et al*. 2009a; Quero-Carrillo *et al*. 2014; Garduño *et al*., 2015a), which are in each semiarid microclimate of Mexico with specific forage characteristics. Therefore, the objective of the study was to evaluate in the first year of establishment of the meadows: emergence, plant height, forage yield and seed production, as well as to characterize dispersal units of eight forage grasses physically and physiologically in Tulancingo, Hidalgo, Mexico, under irrigation conditions.

Materials and methods

The study was carried out in the municipality of Tulancingo de Bravo, Hidalgo, located at 2 120 masl at the coordinates 20° 05’ 06.07” north latitude and 98° 24’ 24.6” west longitude. The place has a temperate climate with 16 °C of average annual temperature and 550 mm of annual rainfall, cataloged as warm semidry temperate, in addition, the place has vertisol-type soil of clay texture (INEGI, 2017). The length of the study was from April to December 2020. The seeds of the various grass genotypes were collected manually from September to October 2019 (Table 1).

The grasses were sown on April 4, 2020, under conditions of drip irrigation and plastic cover (mulch) with complete dispersal units. The temperature and precipitation data were taken from the meteorological station of the National Meteorological Service, located in Huapalcalco, Tulancingo, Hidalgo at 2 km from the study site.

Table 1. Place of collection of forage plant materials (*Poaceae*) in 2019.

Num.	Grass name	Locality	Coordinates	Municipality	Federative State
1	Banderita HHL (*Bouteloua curtipenula*)	Huitexcalco	20° 15 20.37 N 99° 15 09.52 W	Chilcuautla	Hidalgo
2	Banderita Herguz (*Bouteloua curtipenula*)	San Juan	20° 23 05.78 N 100° 00 26.12 W	San Juan del Río	Querétaro
3	Navajita (*Bouteloua gracilis*)	Teotihuacán	19° 41 56.1 N 98° 50 54.2 W	San Juan Teotihuacán	State of México
4	Buffel (*Pennisetum ciliare*)	La Palma	22° 14 0.3 N 100° 56 07.1 W	Soledad de Graciano Sánchez	San Luis Potosí
5	Gigante (*Leptochloa dubia*)	Dos Cerros	20° 14 49.6 N 99° 09 18.9 W	Mixquiahuala	Hidalgo
6	Pappophorum (*Pappophorum vaginatum*)	La Palma	22° 13 38.4 N 100° 50 55.0 W	Soledad de Graciano Sánchez	San Luis Potosí
7	Tempranero (*Setaria machostachya*)	Dos Cerros	20° 16 39.9 N 99° 08 27.1 W	Mixquiahuala	Hidalgo
8	Engordador (*Bouteloua repens*)	Chapantongo	20° 19 43.4 N 99° 22 59.0 W	Chapantongo	Hidalgo

Land preparation and sowing

The land was prepared with fallow and three passes of harrow, later, furrows were traced 1.2 m apart and 6 000-gauge tapes with dripping of 1.2 L h^{-1} and 20 cm apart were placed, which was measured when turning on a Truper Expert BOAP-1 electric pump of 1 hp (®Mexico) for 1 h and was measured with a beaker. Subsequently, it was mulched and irrigated in three periods of 50 min with intervals of 2 h, which accumulated 3 L per dripper and equivalent to 20 L m^{-2} and with the above, field capacity was achieved.

It is worth mentioning that each experimental plot consisted of two furrows 5 m long with a distance of 1.2 m between furrows, which allowed the presence of 100 drippers, that is, two tapes per plateau with 25 drippers per tape. The sowing was carried out at a depth between 1 and 2 cm at a density of five viable pure seeds per hole and 15 plants m^{-2}. Each plot consisted of 12 m^2 with a capacity for 180 plants.

The determination of the viability of seeds with tetrazolium was in accordance with the methodology of Hernández-Guzmán *et al*. (2021) and at 21 days, five viable seeds per hole were resown in holes with diaspores.

Plot management

After sowing and resowing (May 4), it was irrigated with 1.2 L per dripper to ensure imbibition. Subsequently, it was irrigated on May 18, June 1 and 15 with 1.2 L and finally, July 16 and August 8 with 1.2 L. It is worth mentioning that each irrigation was applied gradually over 10 days. No pests or diseases that slowed plant growth or affected forage and seed production were observed. No fertilization or herbicide application was performed during the study period. The variables evaluated in the study period were the following.

1) emergence and second emergence (%). They were evaluated 14 days after sowing (das) and it was effective when the first leaf was visible, according to Hernández-Guzmán *et al*. (2015); Quero-Carrillo *et al*. (2017).

2) morphological composition based on dry matter (kg ha^{-1}). Four plants were cut 10 cm above ground and separated into leaf blades, stems, inflorescences and dead material. Then the morphological components were placed in previously labeled paper bags and introduced into a forced-air oven (Ciderta® brand, Huelva, Spain) for 48 h at 55 °C and after the time, it was weighed on a Entris® Sartorius balance (0.0001 g; Beijing, China).

3) leaf:stem ratio. It was calculated by dividing the dry weight of leaves (g) by the dry weight of stems (g).

4) forage production (DM, kg ha^{-1}) was the sum of the morphological components. For this, the average weight of the four plants was multiplied by the number of plants emerged in the experimental plot of 12 m^2.

5) date of anthesis and date of harvest. The anthesis was considered when the plants showed exserted anthers visible from 50% and the harvest date was made when the coloration of the complete dispersal units changed, that is, when they turned from green, dark brown or crimson red to beige. In *P. vaginatum*, the harvest was when 50% of the inflorescences turned white.

6) seed production (kg ha^{-1}). The inflorescences of each plant by species and experimental unit were placed on previously labeled 1x1 m kraft paper in a greenhouse environment with air flow for 14 days. Subsequently, the dispersal units were separated manually from the inflorescences and 12 days later, the determination of seed moisture began with a digital moisture tester (LDS-1G with LCD screen. Beijing, China), until the seeds reached 12% of moisture.

7) physical purity of seeds (%). To obtain caryopses from diaspores, batches were homogenized manually in three repetitions. The weight of the sample for physical analysis was 3 g in banderita, 6 g in navajita and buffel and was in accordance with the rule for the classification of forage grass seeds described by SNICS-SADER (2021), while in *Pappophorum*, engordador, tempranero and gigante, it was 6 g (they are not described in the rule). Then, by friction and with the help of a corrugated rubber mat and pad, caryopses were obtained that were then placed in Petri dishes. Damaged caryopses were removed with the help of a stereoscopic microscope, and it was weighed as was done by Hernández-Guzmán *et al*. (2015); Quero-Carrillo *et al*. (2016); Quero-Carrillo *et al*. (2017).

8) weight of one thousand caryopses (mg). Eight repetitions of 100 complete botanical seeds were counted and the average multiplied x 10 (Hernández-Guzmán *et al*. 2015).

9) viability (%). The viability was determined with the help of tetrazolium, it was determined according to the methodology used by Hernández-Guzmán *et al*. (2021).

10) viable pure seed (kg ha^{-1}). It resulted from the multiplication of the weight of caryopses obtained in physical purity by the percentage of viability.

The treatments were the grass species: a) banderita [*Bouteloua curtipendula* (Michx). Torr.] HHL genotype; b) banderita [*B. curtipendula* (Michx). Torr.] Herguz genotype; c) navajita [*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths]; d) buffel [*Pennsitem ciliare* (L.) Link.]; e) gigante [*Leptochloa dubia* (Kunth) Nees]; f) *Pappophorum vaginatum* Buckley; g) tempranero (*Setaria macrostachya* Kunth); and f) engordador [*Bouteloua repens* (Kunth) Scribn. and Merr]. The statistical design in the field was in completely randomized blocks with three repetitions and in the laboratory in a completely randomized design and the GLM procedure of SAS (2009) was used to evaluate the treatments and the means were compared with the Tukey test (α= 0.05).

Results and discussion

The temperature in Tulancingo, Hidalgo was fluctuating (Table 2), which did not allow a homogeneous emergence, as reported by Hernández-Guzmán *et al*. (2015); Quero-Carrillo *et al*. (2016); Quero-Carrillo *et al*. (2017). The total rainfall during 2020 accumulated 534.5 mm and irrigation 10.2 L.

Table 2. Meteorological variables and amount of water applied in Tulancingo in 2020.

Concept	Jan	Feb	Sep	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average temperature (°C)	12.9	14.2	16.1	17.7	18.2	17.3	16.4	16.3	16	14.9	14.1	13.4	15.6
Average minimum temperature (°C)	6	7	9	11	12	12	11	11	11	10	8	6	9.5
Extreme minimum temperature (°C)	-10.6	-7.4	-6.8	-4	-4	-2	-2.2	0	-1.2	-5	-7	-8	-4.8
							Accumulated						
Precipitation (mm)	9.7	5.2	11.9	32.4	49.4	94.8	67.4	65.8	115	54.3	21.6	7	534.5
Irrigation (L m^{-2})				20	16	16	8	8					68
Daylight hours	11.1	11.5	12.1	12.6	13.1	13.2	13.3	12.8	12.2	11.7	11.2	10.9	145.7
Sunshine hours	7.2	7.8	7.3	7.1	7.3	6.4	5.9	6.5	5	6	6.7	6.4	79.6

Emergence, resowing and total

The number of plants at sowing, resowing and total was different ($p< 0.001$, Table 3). At sowing, gigante grass showed the highest number of emerged plants with 8.3 m^2 ($p< 0.001$). At emergence, the banderita (HHL and Herguz) and navajita grasses (mostly distributed in the Chihuahuan Desert; PMAR, 2012) had 4.3, 4.8 and 2.2 plants m^{-2} ($p< 0.001$), respectively. The above is relevant since Quero-Carrillo *et al*. (2014), in grasses, consider 5 plants m^{-2} as a good emergence; therefore, in seed availability increase the density.

Table 3. Number of plants m^{-2} emerged at sowing, resowing and in the sum in 180 holes in 12 m^2 in seven native grasses and one exotic grass (buffel grass) sown on April 22, 2020, in Tulancingo, Hidalgo.

Common and scientific names	Sowing	Resowing	Total emerged plants
Banderita HHL (*Bouteloua curtipenula*)	4.3 bc	6.3 a	10.6 abc
Banderita Herguz (*Bouteloua curtipenula*)	4.3 bc	6 a	10.3 bc
Navajita (*Bouteloua gracilis*)	2.2 dc	2.9 bc	5.1de
Gigante (*Leptochloa dubia*)	8.3 a	5.9 a	14.2 a
Engordador (*Bouteloua repens*)	6.3 ab	5.4 ab	11.7 ab
Tempranero (*Setaria macrostachya*)	0.8 d	1.2 c	2 e
Pappophorum (*Pappophorum vaginatum*)	1.8 dc	5 ab	6.8 cd
Buffel (*Pennisetum ciliare*)	5.9 ab	3.5 abc	9.4 bc
SEM	0.65	0.61	0.83

Equal lowercase literals by column are statistically similar averages ($p > 0.05$).

At resowing, banderita HHL grass had the greatest emergence ($p < 0.001$), while tempranero grass stood out for having the lowest value ($p < 0.001$). The greatest emergence in the sum of the two sowings was observed in gigante, engordador and banderita HHL grasses with 14.3, 11.7 and 10.6 plants m^2, respectively ($p < 0.001$). In this regard, Quero-Carrillo *et al*. (2016), in rainfed conditions in Atotonilco El Grande, Hidalgo, in the navajita, banderita and buffel grasses in sowing with diaspores, recorded 10, 10 and 5 plants m^{-2}, respectively, accusing the scarce and poor distribution of rain.

Likewise, to have good emergence of tempranero grass in field, Dekker *et al*. (2003) mention that the temperature should be 10 to 15 °C constant or more. As Moreno-Gómez *et al*. (2012) refer, they reported 37.5 °C for germination and emergence of *B. gracilis* and *Eragrostis curvula*. On the other hand, Hernández-Guzmán *et al*. (2015), in banderita, navajita, buffel and rhodes at 22 °C constant in the laboratory, achieved germination in large caryopses of more than 90%, which influences to show the physical parts of the effective germination (plumule and coleorhiza).

Therefore, in rainfed conditions, the probability of rain from April to May when there are higher temperatures is scarce; however, sowings at the end of June (change of season from spring to summer) will have to be made with the greatest demand in the control of the factors for a successful sowing; as reported by Quero-Carrillo *et al*. (2014).

The scarce emergence in the species studied is also due to the natural protection of the botanical seeds (glumes, lemmas, paleas, edges), which prevent the entry of water for imbibition, in addition, these structures contain abscisic acid that prevents gibberellic acid from making an effect on the layer of aleurone that sends germination signals to the embryo (coleoptile + plumule and coleorhiza) for the visual appearance of the first leaf and roots (Hernández-Guzmán *et al*., 2015); Quero-Carrillo *et al*., 2017). Constant temperature and moisture (field capacity) are necessary for the elongation of the subcoleoptile internode, which contains the apical meristem that generates adventitious roots, to be carried out to a better extent (Moreno-Gómez *et al*., 2012).

Dry matter yield and morphological composition

Significant differences (p< 0.001, Table 4) were observed in the production of dry matter. Buffel and gigante grasses stood out for showing the highest dry matter yield (p> 0.05), the above, in gigante due to a greater number of established plants, while in buffel due to a greater weight per plant. The yield of forage in navajita, banderita, gigante and buffel in the first year of establishment in Tulancingo was lower compared to that reported by Sáenz-Flores *et al*. (2015) at INIFAP La Campana, Chihuahua, under irrigation, who obtained dry matter yields of 2 052, 2 111, 5 872 and 9 917 kg ha^{-1}, that is, 4.5, 1.3, 1.15 and 1.7 times less, respectively.

Table 4. Morphological composition (g plant^{-1}), leaf:stem ratio and dry matter production (kg ha^{-1}) of seven native grasses and one exotic (bufflel grass) at 82 days of establishment under irrigation conditions, in Tulancingo, Hidalgo.

Common and scientific names	Leaf	Stem	Inflorescences	Dead material	Total	Leaf:stem	DM (kg ha^{-1})
Banderita HHL (*Bouteloua curtipendula*)	6.2 cd	4.2 cd	1.6 bc	0.9 b	12.9 c	2 abc	1 363 dc
Banderita Herguz (*Bouteloua curtipendula*)	8.2 c	4.1 cd	2.5 bc	0.3 b	15.1 c	2.5 ab	1 585 c
Navajita (*Bouteloua gracilis*)	5.5 cd	2.6 d	0.97 c	0.2 b	9.3 c	2.7 a	457 e
Gigante (*Leptochloa dubia*)	13.6 b	14.9 b	5.7 a	1.4 ab	35.6 b	0.93 c	5 094 a
Engordador (*Bouteloua repens*)	14.5 b	12.5 b	3 b	0.7 b	30.7 b	1.3 bc	3 619 b
Tempranero (*Setaria macrostachya*)	5.2 cd	6.2 c	3 b	0.6 b	15.1 c	0.89 c	288 e
Pappophorum (*Pappophorum vaginatum*)	4.3 d	3.1cd	1.3bc	0.6b	9.3c	1.9abc	630de
Buffel (*Pennisetum ciliare*)	26 a	27.8 a	5.4 a	2.9 a	62 a	0.93 c	5 814 a
Average	10.4	9.4	2.9	1.0	23.7	1.7	2 356
Significance	***	***	***	**	***	***	***
SEM	0.69	0.79	0.43	0.4	1.47	0.27	201.9

Equal lowercase literals by column are statistically similar averages (p> 0.05). SEM= error standard of the mean; **= p< 0.01; ***= p< 0.001.

In a study conducted by Garduño *et al*. (2015b) in buffel grass, the dry matter yield of eight genotypes in Salinas Hidalgo, San Luis Potosí, Mexico, at 2 083 masl was 3 448 kg ha^{-1}, which was lower compared to Tulancingo, that is, 1.68 times less, therefore, buffel grass in Tulancingo produces a good amount of forage. In the individual weight of a plant, navajita grass averaged 9.3 g, which was in the range mentioned by Morales *et al*. (2009b).

Likewise, the weight per plant of gigante grass (35.6 g) was in the range mentioned by Morales-Nieto *et al*. (2013). In tempranero, the weight per plant (15.1 g) was lower than that reported by Morales-Nieto *et al*. (2015); therefore, this species of grass and especially the genotype collected in the Mezquital Valley is not recommended for its multiplication, since it shows low emergence in the field and forage production, which decrease the chances of propagation and study.

In morphological composition, differences were observed by component ($p< 0.001$, Table 4). Buffel grass exceeded gigante and engordador in both plant weight and leaf proportion ($p< 0.001$). The highest leaf:stem ratio was observed in navajita grass as well as in banderita Herguz ($p< 0.001$), so they are good quality grasses and potential forage genotypes, since, according to Chapman and Lemaire (1993), grass species with a higher proportion of leaves have greater renewal of stems and according to Rojas *et al*. (2017), indicative of lower lignification. Therefore, the native Mexican forage materials studied are inferior in total production to buffel grass; however, in proportion of leaves, they are superior.

Date to anthesis and seed harvest

The dates to anthesis were variable between species ($p< 0.001$, Table 5) and according to Meléndez-Ramírez *et al*. (2020), this phenomenon in banderita grass is given by specific characteristics of the adaptation of genotypes in a given microclimate. Gigante grass was the earliest to show anthers, which is important because this phenomenon determines when plants begin to remove soluble carbohydrates from leaves and stems, therefore, schedule defoliation. The age to flowering of HHL and Herguz banderita grasses was 146 and 115 days, respectively, while Schellenberg *et al*. (2012) mention flowering of the same species at 76 to 86 das.

Table 5. Date of anthesis, harvest, seed yield and physical and physiological quality in the first year of establishment of seven Native American grasses and one exotic (buffel grass) established under irrigation conditions, in Tulancingo, Hidalgo.

Common and scientific names	Date to anthesis (das)	Seed harvest date (das)	Seed yield (kg ha^{-1})	Physical purity or filling (%)	Weight of one thousand botanical seeds (g)	Viability (%)	VPS (kg ha^{-1})
Banderita HHL (*Bouteloua curtipendula*)	Sept 13 (146) b	Oct 13 (176) b	242 c	15bc	0.7043 bc	80 abc	29 b
Banderita Herguz (*B. curtipendula*)	Aug 16 (115) c	Oct 13 (174) b	107 d	14c	0.843 ab	79 abc	12 c
Navajita (*Bouteloua gracilis*)	Sept 30 (161) cd	Nov 05 (197) c	110 d	3f	0.257 d	68 c	2 c
Gigante (*Leptochloa dubia*)	Jul 15 (84) c	Aug 16 (114) a	685 a	19a	0.7187 bc	90 a	118 a
Engordador (*Bouteloua repens*)	Jul 31 (100) d	Oct 10 (171) b	232 c	6e	0.8673 ab	79 abc	11 c
Tempranero (*Setaria macrostachya*)	Jul 31 (100) d	Oct 05 (166) b	99 d	17b	1.0253 a	75 bc	12 c
Pappophorum (*Pappophorum vaginatum*)	Aug 19 (120) c	Oct 13 (174) b	46 d	19 a	0.4437 cd	87 ab	8 c

Common and scientific names	Date to anthesis (das)	Seed harvest date (das)	Seed yield (kg ha^{-1})	Physical purity or filling (%)	Weight of one thousand botanical seeds (g)	Viability (%)	VPS (kg ha^{-1})
Buffel (*Pennisetum ciliare*)	Aug 30 (111) e	Sept 7 (138) d	393 b	12 d	0.892 ab	89 a	42 b
Average	117	163	239	13	0.6314	81	29
Significance	***	***	***	***	***	**	***
SEM	2.44	2.92	24.66	0.34	0.0558	2.59	2.67

Equal lowercase literals by column are statistically similar averages ($p > 0.05$). $^{**}= p < 0.01$; $^{***}= p < 0.001$; VPS= viable pure seed; SEM= error standard of the mean.

The difference in days to flowering in banderita grass is explained by the variability of genotypes, as reported by Ramírez-Meléndez *et al*. (2020), where the NdeM-La Resolana genotype showed higher inflorescence weight from 86 das compared to nine genotypes sown in two sizes of caryopsis in greenhouse. As for the seed harvest date, gigante grass was the first to show color change in the inflorescences ($p < 0.001$, Table 5) and dehiscence was observed at the time of cutting, while navajita grass had to accumulate more time to observe the change of color of inflorescences to beige and is not dehiscent in physiologically mature plants.

The *P. vaginatum* grass differed from the eight species due to the most heterogeneous maturation in the same inflorescence, since, while the apical part is dehiscent, in the basal part the anthers are not yet evident; however, it was determined to harvest the entire inflorescence when it became 50% white. Banderita grass in its two genotypes and engordador grass showed homogeneous color change both by plot and inflorescence. The introduced buffel grass showed heterogeneity in maturation by plant and it was determined to cut when 60% of the inflorescences changed from brown to beige.

Seed yield and physical and physiological quality

Differences were observed in seed yield ($p < 0.001$), as well as in physical and physiological characterization in the eight grasses studied in Tulancingo during the first production cycle (Table 5). Gigante grass stood out for showing the highest seed yield ($p < 0.001$), physical purity ($p < 0.001$), caryopsis yield ($p < 0.001$), viability ($p < 0.001$); therefore, the largest amount of viable pure seed ($p < 0.001$).

The seed yield of gigante (685 kg ha^{-1}), buffel (393 kg ha^{-1}) and navajita (110 kg ha^{-1}) grasses exceeded that reported by Sáenz-Flores *et al*. (2015) by 3, 1.76 and 1.35 times, respectively, however, the HHL (242 kg ha^{-1}) and Herguz (107 kg ha^{-1}) genotypes of banderita grass were lower by 1.86 and 4.2 times. The production of buffel grass seed (393 kg ha^{-1}), established in Tulancingo, Hgo., was 7.3 times higher than that reported by Kumar *et al*. (2015) and 0.32 times lower than Beltrán *et al*. (2017), so Tulancingo is a good place to produce buffel grass seed.

As for the weight of a thousand botanical seeds, the highest value was observed in tempranero grass ($p< 0.001$); however, similar to the Herguz genotype of grass banderita and buffel ($p> 0.05$), therefore, Quero *et al*. (2014) recommend rehabilitating degraded ranges or reconversion with banderita grass since it produces more seed compared to navajita, while Quero-Carrillo *et al*. (2017) mention that banderita grass does not decrease its viability compared to navajita in laboratory conditions for 16 months in polyethylene sacks.

Buffel grass seed production exceeded (except for gigante grass; $p< 0.001$) the rest of native grasses, which should be considered because it can replace the native Mexican grasslands (Joaquín-Cancino, 2018), while the INIFAP Northeast, Velázquez *et al*. (2015) recommend sowing native grasses so as not to alter the ecosystem. On the other hand, the filling of dispersal units of gigante grass and pappophorum was higher ($p< 0.001$), followed by banderita and buffel grasses, while engordador grass stood out for the lowest percentage of filling ($p< 0.001$) despite being uniform in anthesis and maturation of inflorescences.

Physical purity and viability were lower in navajita, banderita and buffel compared to commercial seeds used by Quero-Carrillo *et al*. (2016) to establish meadows in two sites of the Chihuahuan Desert, which results in sowing more viable pure seed per hectare, so that the establishment of the meadows is successful. The nutrition of the botanical seed of grasses in early stages is important since, according to (Zhang *et al*., 2017), the embryo is the first to form and then the endosperm.

Meanwhile, in the endosperm, according to Sabelli and Larkins (2009), after the double fertilization of the polar nuclei, syncytium (series of divisions in the absence of cell wall formation and cytokinesis) is formed and finally the cellularization of the endosperm, which includes the formation of major type cells (transfer cells, aleurone, endosperm and cells that surround the embryo), subsequently, mitosis and endo reduplication, accumulation of storage substances and maturation, which includes dormancy. Therefore, for seed production, it is important that each floscule obtains nutrients for greater filling and greater proportion of larger caryopses; since the greater the weight of the botanical seed, the greater the vigor of the seedlings (Quero-Carrillo *et al*., 2017).

Conclusions

In the first year of establishment of eight forage grasses in Tulancingo, Hidalgo; gigante, buffel and engordador showed to be potential forage species. The banderita and navajita grasses showed the highest leaf:stem ratio. Gigante grass stood out for producing the largest quantity of seed and being the earliest species in coloration change of inflorescences from brown to beige; likewise, in gigante grass, the highest percentage of filling, viability and therefore, the highest content of viable pure botanical seeds ha^{-1} were observed.

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