Scientific Paper

Attributes of the inflorescence and diaspores of *Chascolytrum subaristatum* (Lam.) Desv.

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Abstract

Objective: To characterize morphological and reproductive aspects of *Chascolytrum subaristatum* (Lam.) Desv., in the Entre Ríos province, Argentina.

Materials and Methods: A comparative analysis was carried out of two observation periods, in which the inflorescences and seeds of *Ch. Subaristatum* were attended. In March, 2016, caryopses collected the previous year were planted. At the beginning of spring, 10 plants were evaluated during 2016 and 2017. he beginning of flowering, maturity and harvest moment, number of inflorescences, nodes and paracladia, and number of spikelets, were recorded. In addition, the weight, moisture and germination of anthecia with caryopses, were determined. The results between harvests, relative to the number of nodes and anthecia, were compared through the mean difference test for independent samples. The chi square test was applied for the homogeneity of proportions.

Results: The structural morphology of the inflorescence in both years showed low variability. The percentage of inflorescences increased 37 % in the second year with regards to the first. The results of weight, moisture and germination of the caryopses showed significant differences between the harvest years ($p \leq 0,05$). Non-deep physiological dormancy was observed, which was overcome after dry storage.

Conclusions: Regarding the relation of the inflorescence with the productive aspects, harvest and seed quality, to manage the grassland appropriately, and to avoid grazing at the moment of development of the reproductive tillers, is suggested. In the Entre Ríos region, seed production is possible, and varies according to the conformation of the inflorescence, plant age and harvest year.

Keywords: maturity, yield, seed, longevity

Introduction

Chascolytrum subaristatum (Lam.) Desv. (= *Briza subaristata* Lam.) is a species of the family *Poaceae*, subfamily *Pooideae*, tribe *Poeae*, subtribe *Calotthecinae*, of the genus *Chascolytrum* (Anton and Zuloaga, 2020), of which three species introduced in Argentina are cited (Zuloaga *et al.,* 1999).

In the Entre Ríos province, Argentina, it can be found in natural areas. Twenty three botanists along with their collaborators collected this species, at least 53 times since 1903, in eleven departments of the province. In the Soil Chart of Entre Ríos it is reported in 13 departments. According to these collections and records, it was found in the 17 departments of this province, in areas of xerophilous to hydrophilous vegetation, grasslands and prairies.

The botanical excursions made to these departments (Galussi *et al*., 2015; 2016) allowed to locate *Ch. subaristatum* in reduced natural areas, generally low and humid. It was found in two sites in Paraná and in four sites in Villaguay, along with 37 species, mostly herbaceous grasses. The relative frequency in which it was found was between 14 and 35 % and the cover, between 1,8 and 5,8 %.

It is a perennial, cespitose species, which is from 10 to 80 cm high. It shows long linear 2-mm leaves, a little rough, membranous, broken and glabrous ligule. According to the leaf anatomy studies conducted by Moya *et al*. (2019), *Ch. subaritatum* has an anatomic pattern of C_3 grasses, with colorless parenchyma cells in the mesophyll. The external periclinal walls of the epidermal cells of the adaxial and abaxial faces are impregnated with lignin. The stems show circular section. It has a unistratified epidermis, without hairs and with thick cuticle, and a subepidermal sclerenchymatous ring. The closed collateral vascular bundles are arranged in 3 or 4 concentric rings, with parenchymatous pith or hollow pith.

Ch. subaristatum is a good forage plant of flower-high fields, since late July until March (Burkart, 1969). The digestibility of the leaf blade is of moderate

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nutritional value, with relatively low dry matter content, good protein content and metabolic energy. Due to its growth in autumn-winter-spring, it is considerably important in natural areas because it contributes feed in the productive silvopastoral system.

For inflorescence it shows a contracted, erect panicle, a little mutant in maturity, with brief lateral branches, medium-sized and multi-flowering spikelets, 4,5 to 8 mm long (Burkart, 1969). In the flowering season, in October, its flowers are casmogamous, and cleismogamous in November and December. The plants are highly variable, in the size of their panicle as well as in the size of their spikelets and anthecia (Rosengurtt *et al*., 1968). According to the description done by Pohl (1994) and Calderón-de-Rzedowski and Rzedowski (2001), the inflorescence is a 5-15 cm long panicle, contracted, with 5-15 mm long pedicels. Its spikelets are more or less ovoid, a little compressed, 3,5 to 8 mm by 2,5 to 6 mm wide, pendulous in maturity.

The observations made by Galussi *et al*. (2017) in a growth period allowed to define, among other characteristics of *Ch. subaristatum*, the constitution of the inflorescence (trophotagma and flowering unit), which turned out to be an apparent panicle.

According to Arciniegas-Torres and Flórez-Delgado (2018), silvopastoral systems constitute a feasible solution for animal husbandry with sustainability approach, for which they represent a viable choice for conservation and adaptation to climate change, because they allow to intensify animal husbandry production through the optimization and rational use of natural resources.

Given that *Ch. subaristatum* is part of the silvopastoral systems of the Entre Ríos province, Argentina, their study is useful, in order to promote and preserve the presence of this species in the pastureland. From this perspective, the objective of the research was to characterize morphological and reproductive aspects of *Ch. subaristatum*, in the Entre Ríos province, Argentina.

Materials and Methods

Location. For the foreseen evaluations, fifteen plants were cultivated that emerged from caryopses harvested from November to December, 2015, in Oro Verde, Entre Ríos province, Argentina (Galussi *et al*., 2016). This region is located at 31º 50' 37,31" S - 60º 32' 27,92" W.

Experimental procedure. Planting was carried out on germination paper (ISTA, 2014), once the seedlings were obtained, with length of 5 cm in the aerial part. In a protected environment, they were transplanted in pots with loose soil, in which the substrate was kept moist. Afterwards, the pots with the plants were taken to the external medium, with permanent irrigation.

At the beginning of spring, during two consecutive years (2016 and 2017), 10 plants were evaluated (the same ones in the two years). From them data of flowering onset, maturity and harvest moment, number of inflorescences, nodes and paracladia, number of spikelets, anthecia with caryopses and their germination, were taken.

For both harvests, the inflorescences were cut after the central rachis changed color, from yellowish green to light brown, and were placed in open paper envelopes. Once the disarticulation of the anthecia was done, the weight, moisture and germination were determined, according to ISTA (2014; 2018), with some modifications (Galussi *et al*., 2016).

The anthecia with caryopses were stored in the laboratory, in paper envelopes, at room temperature. Germination was evaluated in later periods, according to the harvest year, in three repetitions of 100 caryopses (with lemma and palea) at 25 ºC, on germination paper (ISTA 2014; 2018). In a third harvest of the same plants, only the number of inflorescences was recorded, and in anthecia with caryopses, the moisture content, weight and germination were determined.

Statistical analysis. The statistics average, standard deviation and variation coefficient were calculated. The data, relative to the number of nodes and anthecia, were compared by the mean difference test for independent samples. The chi square test was applied for the homogeneity of proportions (Di Rienzo *et al*, 2016).

Results and Discussion

For the two evaluated years, the inflorescence, from the node of the flag leaf to its apex, reached from 40 to 47 cm of total length, with little variability according to the plants and years, characteristic referred by Burkart (1969). The main axis of the inflorescence (trophotagma plus the flowering unit) which bears the paracladia had approximately from 100 to 160 mm of length. From six to nine nodes, proximal internodes from 30 to 35 mm and distal internodes of 5 mm, were observed. The paracladia that integrate the inflorescence were of first, second and third order, in number from 11 the 17 the first order ones for both harvests. The paracladia, mostly of prophylar origin, may be long (40 mm), intermediate (25 mm) or short (15 mm). Those of second and third order were less (1 to 4) and showed lower length.

It was observed that the appearance of trophotagma paracladia, of first, second and third order, is acropetal, the anthesis and maturation of the caryopses in the spikelets being equal. The change of color of the spikelets, from light green to brownish yellow, is expression of the maturity degree of the diaspore. The pikelets were compressed, with multiple anthecia, from 8 to 10 as average, distichally arranged and fertile.

The observations showed that upon maturation, the anthecia are disarticulated from the spikelets. This type of disarticulation is basipetal, which can be due to the lower size of the top caryopses, leading to much faster drying.

Figure 1 shows the characteristics of the anthecia and caryopses, which coincide with those referred by Calderón-de-Rzedowski and Rzedowski (2001), and allow to describe the lemma. It is a structure from 1,8 to 3,5 mm long by 2,5 to 6,0 mm wide, subtrilobate, swelled on the back, with dilated membrane margin. It has an acute or acuminate, mucronate or briefly aristate, oval to sub-orbicular palea, from 1 to 2 mm long and light yellowish. It is tear- or heart-shaped, dorsiventrally compressed. The seed fruits are caryopses, from 1,0 to 1,5 mm long, dorsiventrally compressed, with a pointed embryo covered by glumellas.

In the 10 observed plants, which were from seven to nine months old (2016 harvest), the number of inflorescences in the first flowering (early September) was 112, and in the second flowering (mid-October), of 59, for 65 and 35 %, respectively, with regards to the total inflorescences per plant (17 inflorescences as average). Meanwhile, for the 2017 harvest, in the same plants, with age from 19 to 21 months, from a total of 180 inflorescences, the first flowering (early September) represented 7 %, and the second, 55 days later, meant 23 %, for a total of 18 inflorescences per plant as average. In the third harvest (2018), in the same plants and quantity, but from 21 to 33 months of age, 268 inflorescences were counted, for 26 inflorescences per plant as average.

In the first flowering of both harvests, from the 10 inflorescences recorded per harvest, the number of spikelets varied between 24 and 58, according to the inflorescence and according to the number of nodes and paracladia. The average of anthecia with caryopses was 314 and 290, and the recorded relative variability, 20,3 and 16,4 for the 2016 and 2017 harvests, respectively. The lowest and highest number of anthecia with caryopses was 207 and 391, and 208 and 365, for the 2016 and 2017 harvests, respectively. In total 3 139 and 3 246 anthecia were harvested, with caryopses in the first and second harvest, respectively, which depends on the environmental conditions, plant size, number of inflorescences and spikelets with fertile anthecia.

The number of nodes and fertile anthecia in the inflorescence, according to each harvest (2016 and

Figure 1. Morphological characteristics of the plant.
a - Inflorescence with spikelets, b - anthecia, c - anthecium with caryopses (diaspores), d - anthecium with scutellar view (lemma) and e - anthecium with hilum view (palea).

2017), is shown in table 1. Regarding the number of nodes, in the first harvest (2016), the mean value (6,8) was comparatively lower than that of the second one (8,9), and it also showed lower relative variability (9,3 compared with 9,8). With respect to the number of fertile anthecia (with seeds) per inflorescence, the average value for the first harvest (313,9) was higher than that of the second harvest (290,1). Nevertheless, the relative variability was lower in the latter compared with the former (16,4 of 20,3). Significant statistical differences ($p \leq 0{,}001$) were found in the number of nodes between harvests. In the 2017 harvest, the number of nodes was significantly higher than in 2016. With regards to the fertile anthecia, no statistical differences ($p = 0{,}3574$) were found.

The inflorescences (apparent panicle) are constituted by paracladia (flowering branches) of different lengths (long, intermediate and short), characteristics referred by Galussi *et al*. (2016). The long paracladia are located near the basis of the inflorescences, then the intermediate and distally, the short ones. The results of the comparative analysis between years are shown in table 2.

The proportion of inflorescences in intermediate paracladia between years was not affected (0,15 *vs* 0,14). In the second harvest, there was increase of inflorescences in short paracladia (0,43 to 0,75) in detriment of the long ones (0,42 to 0,11).

Once maturation was finished, between 40 and 45 days, and at the moment of the disarticulation of the diaspores, the moisture content, weight and germination of the anthecia with caryopses was variable, according to harvest years (table 3). In the attributes moisture and weight, there was low variability among repetitions of the same sample, although significant differences were recorded among the averages of the samples of each year ($p \leq 0{,}05$).

The average germination between years was different at the beginning and through time, fluctuating with the dormancy mechanism, although of good longevity (table 4). The germination of the diaspores with caryopses, 25 days after the 2016 harvest, was 1 %, and showed high percentage of fresh seeds. After time, the seeds of the same sample showed increase of germination, which reached 88 % of normal seedlings at 240 days of storage. Afterwards, it decreased progressively to 67 %, at 780 days of storage.

In second-year plants, the caryopses harvested and planted 25 days after harvest (2017) had a different performance with regards to the ones from the previous year. They showed high initial germination (87 %), with variability in time. Likewise, they showed their maximum germination at 240 days, similar period to the maximum peak reached in the seeds from the first harvest. This performance proved a sporadic dormancy status in this species.

The *Ch. subaristatum* individuals, of the same age and harvest year, showed scarce variability in quantity and size of inflorescences, paracladia and quantity of fertile anthecia. The structural morphology of the inflorescence, in the second-year plants, had similar characteristics to the ones reported for the first harvest year by Galussi *et al*. (2016), with slight variations in length and quantitative characteristics.

Table 1. Nodes and anthecia with seeds in *Ch. subaristatum* inflorescences in two harvests.

Harvest	Variable	Mean	Standard deviation	Variation coefficient, %	Minimum	Maximum
2016	Nodes	6,8***	0,63	9,3	6,0	8,0
2017	Nodes	8,9***	0,88	9,8	7,0	10,0
2016	Anthecia	313,9	63,83	20,3	207,0	391,0
2017	Anthecia	290,1	47,69	16,4	208,0	365,0

***$p \leq 0{,}001$

Table 2. Length of the paracladia with inflorescences in *Ch. subaristatum* (mm)

Length	Harvest 2016		Harvest 2017	
	Number	Proportion	Number	Proportion
Short	62	0,43	145	0,75
Intermediate	22	0,15	27	0,14
Long	60	0,42	22	0,11

n= 10 inflorescences from 10 plants

Table 3. Weight and moisture of the seeds per harvest.

Harvest year	Weight of 1000 seeds, g	Moisture per harvest, %
2016	0,68*	11,00*
2017	0,74*	9,60*

*p ≤ 0,05

Table 4. Germination of anthecia with *Ch. subaristatum* seeds, according to storage period (%).

Harvest year	Storage time, days						
	25	120	145	240	440	515	780
2016	1	50	76	88	74	70	67
2017	87	72	30	94	48	91	s/d

Among the plants of the first and second harvest, the percentage of inflorescences increased in 37 %, which suggests higher quantity of reproductive tillers in older plants. Although in a study of the performance in two C_3 grasses, Chicahuala *et al*. (2018) suggested that the beginning of the reproductive cycle would be controlled by external factors, little variable between years (photoperiod); while its end could be regulated, to a larger extent, by factors with higher inter-annual variability (rainfall and temperatures).

In this study, these factors were not measured, and could be the cause of the possible variability in seed production, besides the plant age. The quantity of seeds per plant reached potentially up to 7 820 diaspores. In another C_3 grass: ryegrass (*Lolium* spp.), under field conditions, in the Pampa region, productions of 1 500 to 7 500 seeds per plant have been recorded, depending on the sensitivity to glyphosate and the hydric conditions (Yanniccari *et al*., 2016). Potentially, the production per plant in such species can reach up to 12 thousand seeds (Pop *et al*., 2010).

The weight, moisture content and germination of the harvested *Ch. subaristatum* caryopses showed significant differences between harvest years. The recorded performance in germination showed certain coincidence with the report for this species (Postulka *et al*., 2002) and for other summer grasses (Bolaños *et al*., 2015). The breaking of innate dormancy without any treatment, after eight months of storage, is confirmed.

The evidence found in this study allows to state the presence of non-deep or intermediate dormancy, depending on the maturation environment. According to the report by Baskin and Baskin (1998), it can be found in grasses, and can be overcome mainly by dry storage or gibberellin application. Nevertheless, according to the observations made in this experiment, the seeds can enter dormancy again after the loss of this condition. In some years, even, after the harvest they did not show dormancy, appearing after some time of storage with the conservation of their viable embryos. For such reason, it is suggested to perform on the seeds the tetrazolium viability test (ISTA, 2018); although the pattern for viable and non-viable seeds of the species should be standardized. This performance would indicate that the evaluation of germination should not be punctual, but periodical.

Conclusions

Regarding the relation of the inflorescence with the productive aspects, harvest and seed quality, it is suggested to make an adequate management of the pastureland, and to avoid grazing at the moment of development of the reproductive tillers.

In the Entre Ríos region, seed production is possible, and varies according to the conformation of the inflorescence, plant age and harvest year. It is convenient to harvest before the disarticulation of the diaspores.

The seeds can show sporadic dormancy, since the beginning of the harvest or during the storage, which indicates that the evaluation of germination should be periodical, and it is convenient to sow after dormancy is broken in the highest quantity of seeds.

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Authors' contribution

- Alberto Aníbal-Galussi. Conception, research design, data collection and analysis and interpretation, writing and critical revision.

- María Esther-Moya. Data collection, analysis, writing and critical revision.
- Yanina Gabriela-Gillij. Data collection, analysis and interpretation and writing revision.
- Marcelo Fabián-Prand. Statistical analysis and interpretation of the results and manuscript revision.
- Fernando Gastón-Marchese. Data collection, analysis and control.
- Mariana Noemí-Hornos. Data collection and analysis.

Conflict of interests

The authors declare that there is no conflict of interests among them.

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