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Full Length Article

Evaluation of Spontaneous Species in the Implementation of a *Panicum maximum* cv. Aruana Pasture in the Semi-arid Region

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Abstract

The aim of this study was to evaluate the herbage mass of *Panicum maximum* cv. Aruana and spontaneous species in an aruana grass pasture during the establishment phase. The trial was carried out in Tacima-PB, Brazil, in a 0.25 ha area with aruana grass. A randomised-block design with four blocks and four experimental periods was adopted, in which the treatments consisted of four harvest times (rainy, rainy/dry, dry and dry/rainy periods). Forty-seven spontaneous species were identified, belonging 36 genera and 21 families. The families with the largest number of species found were Fabaceae (9), Poaceae (5), Malvaceae (4). The herbage mass of aruana grass was lower in the rainy period of 2015 (199.61 kg/ha). The herbage mass of the spontaneous species was larger in the rainy/dry transition (2,512.66 kg/ha), followed by the rainy (1,505.47 kg/ha) and dry/rainy (1,051.32 kg/ha) periods, but decreased in the dry season (235.62 kg/ha). The family Fabaceae had high representativeness of individuals in the area, together with the families Poaceae and Malvaceae, in a *P. maximum* cv. Aruana pasture. *Herissantia crispa* and *P. maximum* cv. Aruana were the species with over 15% of presence in the area, which demonstrates their dominance therein.

Keywords: Floristic diversity; Botanic identification; Invaders; Herbage mass

Introduction

Among the herbaceous species occurring in the caatinga (Brazilian semi-arid biome), invasive species are responsible for the broad biodiversity of this group of plants in this vegetation (Albuquerque *et al.*, 2012). Their variety and floristic richness can vary according to both environment (climate and substrate) and spatial proximity (Santos *et al*., 2012).

This vegetation is rich in diversity, with the herbaceous layer producing around 500 kg/ha of plant matter without being grazed. However, this available mass, which is mostly composed of dicotyledons, is considered low. The caatinga is often classified by physiographic zones, e.g., caatinga of the Seridó, of the Curimataú, of the Sertão, of the Cariri, Agreste, etc., with each featuring one particularity, but they still need to be investigated and known to a deeper level (Leal *et al.*, 2014).

Although botanical species in the caatinga are part of the diet of small ruminants, mainly, such use is more significant during the rainy period, since the vegetation is dramatically reduced in the dry season (Melo *et al.*, 2014). In spite the considerable amount of herbage mass produced in this biome, the little knowledge of these plants still limits their manipulation (Souza *et al*., 2013; Pereira *et al*., 2014). Therefore, a forage crop must be implemented to elevate the herbage availability.

Cultivated pastures represent an alternative for livestock rearing in the semi-arid region, given that little herbage is produced in the caatinga, which results in reduced stocking rates (Animut *et al*., 2005; Formiga *et al*., 2012).

Of the cultivated species, those of the genus *Panicum*, such as aruana grass, withstand a high animal carrying capacity, constituting an option for sheep farming in intensive systems (Souza *et al*., 2014; Pezzopane *et al*., 2017). In addition to being of medium size, this species adequately fills cultivated areas; has good tillering ability (Zanine *et al*., 2016); is rapidly formed with tussocks that prevent uncovered soil (Araujo *et al*., 2013); has a dry matter (DM) yield of approximately 18 to 21 t ha^{-1} yr^{-1} under irrigation, with around 40% obtained in the winter, a period considered dry in some species; and, most importantly, is well-taken by sheep (Duarte, 2011).

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Table 1: Analysis of the soil of the aruana grass experimental area

Sample	Mean
pH	5.2
P (mg/dm^3)	11.94
K^+ (mg/dm^3)	62.4
Na^+ ($cmolc/dm^3$)	0.1
$H^+ + Al^{+3}$ ($cmolc/dm^3$)	2.26
Al^{+3} ($cmolc/dm^3$)	0.11
Ca^{+2} ($cmolc/dm^3$)	2.9
Mg^{+2} ($cmolc/dm^3$)	1.8
BS (%)	66.86
CEC	23.55
OM (g/kg)	6.9

P, K, Na: Mehlich 1 extractant; BS%: base saturation; H + Al: 0.5 *M* calcium acetate extractant, pH 7.0; CEC: cation-exchange capacity; Al, Ca, Mg: 1 *M* KCl extractant; OM: organic matter (Walkley-Black)

Although cultivated pastures are an option to increase herbage production (Lara *et al.*, 2012), they are introduced as a substitute to the native vegetation - mainly the arboreal vegetation, which implies loss of soil quality, reduction of organic matter and exchangeable minerals (cations, bases, etc.), and development and appearance of smaller species. The pasture will undergo competition with spontaneous species from seeding and new seedlings of the same species or different species. However, the major obstacle in this system is maintaining only desired botanical species in the pasture, since species already adapted to the local conditions will reduce the production of cultivated pasture (Ferro *et al*., 2015).

Regarding the above-mentioned context, to date, there are no research data on the implementation of aruana grass in dryland farming and the occurrence of spontaneous species in the pasture area in the semi-arid region of Paraíba State. The present study was thus proposed to evaluate the herbage mass of aruana grass and spontaneous species in a *Panicum maximum* cv. Aruana pasture during its establishment phase, characterizing the species via botanical identification.

Materials and Methods

Site and Treatments

The experiment was undertaken in a 0.24-ha pasture area cultivated with aruana grass (6º29'18" S, 35º38'14'' W), belonging to the Agricultural Company of Paraíba State (Empresa Estadual Agropecuária da Paraíba - EMEPA), in Tacima - PB, Brazil. The municipality of Tacima is in the *Agreste* mesoregion, Curimataú Eastern microregion, where the climate is a BSwh' (hot semiarid) type, according to the Köppen classification (Alvares *et al.*, 2014). The location is part of the Brazilian semi-arid region, where the predominating vegetation is the hyperxerophilic Caatinga, with deciduous species and mica schist soil with granite outcrops that predominate in the region of Curimataú (Loiola *et al.*, 2012). Its rainy period is from February through May, although April is the month with the highest rainfall, with an annual mean of 300 to 500 mm (Francisco *et al.*, 2015). The studied area is occupied by *P. maximum*, cv. Aruana, which was planted in June 2014 by broadcasting.

Precipitation data recorded during the experimental period are depicted in Fig. 1.

Based on the soil chemical analysis (Table 1), we chose not to adopt fertilization or correction procedures. Although the pH was not near neutrality, base saturation was high and the levels of calcium, phosphorus, magnesium, and potassium were adequate for aruana grass.

Spontaneous plants were collected between April and August 2015, which is the period when these plants are more developed, according to the herborisation procedures recommended by Bridson and Forman (1988). For the identification of the species, specialised literature, and material photographs were consulted, and a comparison was made with previously identified material (Lorenzi, 2002; Sá *et al.*, 2009; Pinheiro *et al.*, 2010). The species were organised by alphabetical order and listed in a Table.

A randomised complete block design was adopted with four blocks (20 m × 30 m, totalling 0.25 ha) that were defined according to the heterogeneity of the area and four experimental treatments that corresponded to four collection times (rainy period, when the abundance allowed for an agronomic evaluation; rainy/dry transition; dry period; and dry/rainy transition, to determine the most persistent species over the four periods). Collections took place from April 2015 to February 2016, on the following dates: 1 (rainy period) - 04/14/2015; 2 (rainy/dry period) - 08/08/2015; 3 (dry period) - 10/17/2015; and 4 (dry/rainy period) - 02/27/2016.

Evaluation of the Mass Herbage and Frequency of Botanical Species

To quantify the herbage mass, two X-shaped transects were established in each block and four frames were thrown per transect, totalling eight collection points per block. Following the direct method, the entire plant material present in a 1-m^2 frame was harvested, weighed, and separated into aruana grass and weeds. This material was dried in a forced-air oven until reaching a constant weight, at 55ºC, for 72 h, to obtain the dried herbage mass. The herbage mass per hectare was calculated by multiplying the herbage mass collected within the frame by 10,000 m^2.

In the period of 12/02/2015 to 01/15/2016, considered the end of the dry season, the area was grazed by 24 mixed-breed sheep with an average live weight of 25 kg in an attempt to stimulate regrowth in the subsequent rainy period.

The frequency of botanical species was determined based on the observation of their presence within a 1 m^2 frame, which was performed in each evaluation period.

Statistical Analysis

For the spontaneous plants, only one descriptive analysis of the species was carried out, with botanical identification.

The biomass variable was analysed using the statistical package SAS (Statistical Analysis System, version 9.2, 2008). Results were subjected to analysis of variance and Tukey's test was applied for the significant variables at the 5% significance level. For frequency, the chi-square test was applied; the basic principle of this method is to compare proportions, i.e. possible divergences between the observed and expected frequencies for a given event.

Results

Spontaneous Species and Mass Herbage

Forty-seven spontaneous species belonging to 36 genera and 21 families (Table 2) were identified. Fabaceae (9); Poaceae (5); Malvaceae (4); Boraginaceae, Portulacaceae, and Rubiaceae (3); and Amaranthaceae, Euphorbiaceae, Cleomaceae, Convulvulaceae, and Asteraceae (2) were the only families with more than one species. The others (Gratiolaceae, Turneraceae, Passifloraceae, Amaryllidaceae, Solanaceae, Oxalidaceae, Polygalaceae, Verbenaceae, Rhaminaceae, and Cactaceae) were represented by only one species (Table 2).

The herbage mass of aruana grass was lower in the rainy period of 2015 (199.61 kg/ha), a time during which the grass underwent the first rainy period after being implemented. This low herbage mass was probably because the grass was under establishment in the area, and the portions of uncovered soil allowed spontaneous species to emerge and compete for space. The rainy/dry (1,299.73 kg/ha), dry (1,519.49 kg/ha), and dry/rainy (1,183.12 kg/ha) periods did not differ from each other for herbage production. Although the aruana grass was grazed by sheep in the dry period, it exhibited good reestablishment of leaf area and appearance of new plants where its herbage mass remained at the same level as in the other collections (Table 3).

The highest herbage mass values for the spontaneous species was obtained in the rainy/dry transition (2,512.66 kg/ha), followed by the rainy (1,505.47 kg/ha) and dry/rainy (1,051.32 kg/ha) periods. The dry period did not allow for the appearance or development of most species that have an annual life cycle with rapid growth and seed production, which complete their cycle and die, culminating in low herbage mass in this period (235.62 kg/ha) (Table 3). This herbaceous component had greater contribution from the species *Herissantia crispa*, which exhibited resistance to drought.

Total biomass had the best results obtained in the rainy/dry period (3,812.39 kg/ha), and no difference was detected for the other periods. Spontaneous species represented 85.44% of the total in the rainy period, followed

Table 2: Species found in an aruana grass pasture area

Taxon	Herbarium No.
Amaranthaceae	
Amaranthus viridis L.	22.680
Froelichia humboldtiana (Roem. Et Schult.) Seub	22.681
Amaryllidaceae	
Griffinia gardineriana (Herb.) Ravenna	22.680
Asteraceae	
Blainvillea acmella (L.) Philipson	23.099
Centratherum punctatum Cass.	23.103
Boraginaceae	
Euploca polyphylla (Lehm.) J.I.M. Melo & Semir	22.690
Heliotropium indicum L.	22.687
Heliotropium procumbens Mill.	22.693
Cactaceae	
Pilosocereus pachycladus subsp. *Pernambucoensis* (Ritter) Zappi	23.112
Cleomaceae	
Cleome guianensis Aubl.	22.691
Cleome rotundifolia (Mart. & Zucc) Lltis	22.673
Convolvulaceae	
Evolvulus ovatus (L.)	23.118
Jacquemontia bahiensis o'Donell	22.682
Euphorbiaceae	
Cronton glandulosus L.	22.678
Cronton hirtus L'Hér.	22.679
Fabaceae	
Centrosema pascuorum Mart.	23.111
Centrosema pubescens Benth.	23.114
Chamaecrista nictitans Subspp. *Patellaria* (DC. Ex Collad) H.S. Irwin D. Barneby	23.100
Chamaecrista rotundifolia (Pers.) Greene var. *rotundifolia*	23.110
Mimosa sensitiva var. *malitiosa* (Mart.) Barbeby	23.116
Stylosanthes scabra Vogel.	22.675
Zornia cearensis Huber	23.115
Zornia curvata Mohlembs.	23.102
Zornia leptophylla (Benth.) Pittier	23.101
Gratiolaceae	
Scoparia dulsis L.	22.671
Malvaceae	
Herissantia crispa (L.) Brizicky	22.685
Sida cordifolia L.	22.684
Sida rhombifolia L.	23.105
Waltheria indica L.	23.107
Oxalidaceae	
Oxalis spp.	22.683
Passifloraceae	
Passiflora foetida L.	22.692
Poaceae	
Brachiaria decumbens Stapf	23.113
Brachiaria mutica (Forsk.) Stapf	23.119
Cenchrus ciliares L.	22.694
Dactyloctenium aegyptium (L.) Willd	23.117
Panicum maximum cv. Aruana Jacq	22.688
Polygalaceae	
Polygala martiana (A.W. Benn) J.F.B. Pastore & .J.R Abbott	23.104
Portulacaceae	
Portulaca halimoides L.	22.689
Portulaca hirsutissima Camb.	22.676
Portulaca oleraceae L.	22.670
Rhamnaceae	
Crumenaria decumbens Mart.	23.108
Rubiaceae	
Borreria capitata (Ruiz D Pav.) DC. Var. capitata	23.109
Diodella apiculata (Willd. ex Roem. & Schult.) Delprete	23.120
Richardia grandiflora (Cham. & Schltdl.) Steud.	22.677
Solanaceae	
Solanum agrarium Sendtn.	22.674
Turneraceae	
Turnera subulata L.	22.686
Verbenaceae	
Stachytarpheta angustifolia (Mill.) Vahl	23.106

Table 3: Herbage mass of Aruana grass and spontaneous species

	Herbage mass (kg dry matter ha^{-1})			
Collection period	Aruana	Spontaneous	Total biomass	% Spontaneous
Rainy	199.61b	1505.47b	1705.08b	85.44a
Rainy/dry	1299.73a	2512.66a	3812.39a	64.96b
Dry	1519.49a	235.62c	1772.62b	16.05d
Dry/rainy	1183.12a	1051.32bc	2234.44b	47.10c
SEM[1]	181.36	217.24	246.66	4.03

[1]SEM = standard error of the mean; Different lowercase letters differ in the column, according to Tukey's test at the 5% significance level

Table 4: Frequency of species present in Aruana grass pasture

Species	Occurrence	%
Herissantia crispa (L.) Brizicky	111	17.99
Panicum maximum cv. Aruana Jacq	111	17.99
Centrosema pubescens Benth.	52	8.43
Richardia grandiflora (Cham. & Schltdl.) Steud.	43	6.97
52 unidentified Fabaceae	38	6.16
51 unidentified Poaceae	34	5.51
Centrosema pascuorum Mart.	25	4.05
Jacquemontia bahiensis o'Donell	22	3.57
Oxalis sp.	17	2.76
Froelichia humboldtiana (Roem. Et Schult.) Seub	16	2.59
Chamaecrista nictitans Subsp. *Patellaria* (DC. Ex Collad) H.S. Irwin D. Barneby	12	1.94
Waltheria indica L.	12	1.94
Zornia curvata Mohlembs.	11	1.78
Brachiaria mutica (Forsk.) Stapf	10	1.62
Blainvillea achmella (L.) Philipson	9	1.46
Turnera subulata L.	8	1.30
Chamaecrista rotundifolia (Pers.) Greene var. *rotundifolia*	8	1.30
Brachiaria decumbens Stapf	8	1.30
Cronton hirtus L'Hér.	7	1.13
Scoparia dulsis L.	6	0.97
Crumenaria decumbens Mart.	6	0.97
Dactyloctenium aegyptium (L.) Willd	6	0.97
Zornia leptophylla (Benth.) Pittier	5	0.81
Sida cordifolia L.	4	0.65
Sida rhombifolia L.	4	0.65
Evolvulus ovatus (L.)	4	0.65
Cleome guianensis Aubl.	3	0.49
Diodella apiculata (Willd. ex Roem. & Schult.) Delprete	3	0.49
Centratherum punctatum Cass.	3	0.49
Stachytarpheta angustifolia (Mill.) Vahl	3	0.49
Zornia cearensis Huber	3	0.49
Mimosa sensitiva var. *malitiosa* (Mart.) Barbeby	3	0.49
Cronton glandulosus L.	2	0.32
Passiflora foetida L.	2	0.32
Amaranthus viridis L.	1	0.16
Portulaca oleraceae L.	1	0.16
Portulaca hirsutissima Camb.	1	0.16
Griffinia gardineriana (Herb.) Ravenna	1	0.16
Stylosanthes scabra Vogel.	1	0.16
Borreria capitata (Ruiz D Pav.) DC. Var. capitata	1	0.16

by rainy/dry period (64.96%), dry rainy period (47.10%), and, lastly, the dry period, with 16.05%.

Frequency of Species

The frequency of species present in the area (Table 4) and the frequency of species per collection period (Table 5) show the most frequent species in the area.

The species *P. maximum* cv. Aruana and *H. crispa* were the most frequent in the area (17.99%), which is explained by the fact that aruana grass was the cultivated species; *H. crispa*, in turn, is a spontaneous species adapted to the region that develops well on pastures. *Centrosema pubescens* was the third most frequent (8.43%); this species belongs to the family Fabaceae, known for being a nitrogen fixer and appreciated by animals. *Richardia grandiflora*, of the family Rubiaceae, showed a frequency of 6.97% in the area. Unidentified Poaceae species showed 5.51% frequency; the species *C. pascourum* had a frequency of 4.05%; *Jacquemontia bahiensis*, 3.57%; *Oxalis* spp., 2.76%;

Table 5: Frequency of the main species per collection period

Species	Rainy	Rainy/dry	Dry	Dry/rainy	Total
Froelichia humboldtiana (Roem. Et Schult.) Seub	0.19%	1.75%	1.17%	0	3.11%
Herissantia crispa (L.) Brizicky	6.03%	5.84%	5.45%	4.28%	21.60%
Panicum maximum cv. Aruana Jacq	5.06%	4.47%	6.23%	5.84%	21.60%
Richardia grandiflora (Cham. & Schltdl.)Steud.	0.78%	2.53%	0.78%	4.28%	8.37%
Jacquemontia bahiensis o'Donell	0.19%	1.36%	0	2.72%	4.28%
Oxalis sp.	0.78%	0.78%	0	1.75%	3.31%
Chamaecrista nictitans Subsp. *Patellaria* (DC. Ex Collad) H.S. Irwin D. Barneby	0.19%	1.36%	0	0.78%	2.33%
Zornia curvata Mohlembs.	0	2.14%	0	0	2.14%
Waltheria indica L.	0.58%	0	0.78%	0.97%	2.33%
Centrosema pascuorum Mart.	1.95%	0.97%	0.78%	1.17%	4.86%
Centrosema pubescens Benth	3.89%	2.72%	0.39%	3.11%	10.12%
Brachiaria mutica (Forsk.) Stapf	0	1.95%	0	0	1.95%
Unidentified Poaceae	1.56%	1.75%	3.31%	0	6.61%
Unidentified Fabaceae	3.11%	1.95%	0.19%	2.14%	7.39%
Total	24.32%	29.57%	19.07%	27.04%	100.00%

Chi-square – 39 Degree of freedom – 182.88 (P<0.0001) Significant

and *Froelichia humboldtiana*, 2.59%. The remaining species had a frequency of less than 2% each, as shown in Table 4.

The species *F. humboldtiana* was most prevalent/ present in the rainy/dry period, with a frequency of 1.75%, but absent in the dry/rainy period; *H. crispa*, in the rainy period (6.03%); *P. maximum* cv. Aruana, in the dry period (6.23%); *Richardia grandiflora*, in the dry/rainy period (4.28%); *J. bahiensis*, in the dry/rainy period (2.72%) and absent in the dry period; *Oxalis* sp., in the dry/rainy period (1.75%) and absent in the dry period; *Chamaecrista nictitans* Subspp. *Patellaria*, in the rainy/dry period (1.36%) and absent in the dry period; *Zornia curvata*, in the rainy/dry period (2.14%) and absent in all other periods; *Waltheria indica*, in the dry/rainy period (0.97%) and absent in the rainy/dry period; *C. pascuorum*, in the rainy period (1.95%); *C. pubescens*, in the rainy period (3.89%); *Brachiaria mutica*, in the rainy/dry period (1.95%) and absent in all other periods; unidentified Poaceae, in the dry period (3.31%) and absent in the dry/rainy period; and unidentified Fabaceae, in the rainy period (3.11%) (Table 5). The species *H. crispa*, *P. maximum* cv. Aruana, *R. grandiflora*, and *C. pubescens* and unidentified Fabaceae showed frequencies above the expected.

In the dry period, the cultivated species *P. maximum* cv. Aruana showed its highest frequency (6.23%), and the spontaneous species that exhibited greatest relevance and persistence in the area was *H. crispa*, with a frequency of 5.45% (Table 5).

Discussion

Fabaceae is for being the third largest plant family, surpassed only by the families Asteraceae and Orchidaceae (Lewis *et al.*, 2005). In Brazil, however, and within the phytogeographic limit of the caatingas, legumes are the family of plants with greatest richness of species (Costa *et al.*, 2007). They are a highly versatile group and the second in economic importance for their use in food production, as

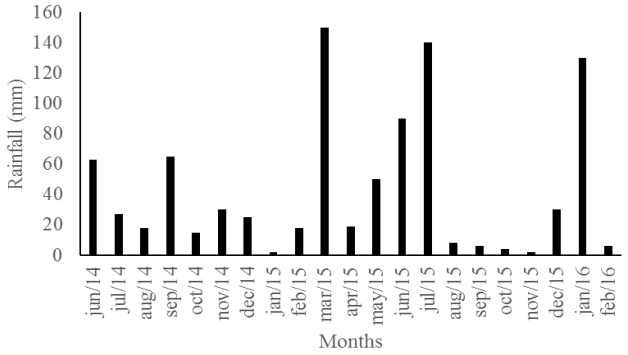

Fig. 1: Precipitation data collected from 2014 to 2016

pasture, in ornamentation, in medicine, and also in green fertilization because of their atmospheric nitrogen fixing ability (Lpwg, 2013). However, some genera are persistent in crops, where they compete for nutrients and possibly become undesirable spontaneous plants (Kozlowski, 2002).

Among the forage species, *Stylosanthes scabra* Vogel stands out for its high use potential as forage, with excellent nutritional quality (Mpanza and Hassen, 2015). This plant has a herbaceous to subshrub by habit, bearing yellow flowers, 3-foliolate leaves, and loment-type fruits. It is morphologically similar to *S. capitata*, *S. gracilis*, *S. humilis*, and *S. guianensis* because of its globose inflorescences, although the presence of pubescent basal articles differentiates *S. scabra* from the other species of the genus (Medeiros and Flores, 2014).

C. nictitans Subspp. *Patellaria* and *C. rotundifolia* (Pers.) Greene var. *rotundifolia* are considered good nitrogen fixers due to the presence of nodules with nitrifying bacteria (Camargo and Miotto, 2004). Conversely, *Z. leptophylla*, *Z. cearensis*, and *Z. curvata*, also nitrogen fixers, produce a volatile essential oil with moderate antibacterial action against gram-negative bacteria (Sciamarelli and Tozzi, 1996). Other legumes, e.g., *C. pascuorum* and *C. pubescens*, have an elevated protein content, which renders them potentially useful in animal

feeding, especially when intercropped with grasses (Abdu *et al.*, 2015). Additionally, *C. pubescens* can be used in honey production (Moreira and Bragança, 2011).

Of the invasive species from the studied area, *Cenchrus ciliares*, a grass largely used as forage in the semi-arid region for important traits like tolerance to drought and good green-matter yield (Porto *et al.*, 2012), was one of the most frequent in the area. Another invasive grass, *Dactyloctenium aegyptium*, is an annual species with a stoloniferous growth habit, which causes it to grow near the soil and have its population increased through new tillers and to provide good ground cover. It was accidently introduced in Brazil, where it occupies fruit-farming areas (Moreira and Bragança, 2011).

The family Malvaceae includes native and exotic plants, among which some invasive genera stand out, e.g., *Corchorus* L., *Gaya* Kunth, *Herissantia* Medik., *Malachra* L., *Malvastrum* A. Gray, *Melochia* L., *Pavonia* Cav., *Sida* L., *Sidastrum* Baker, *Triumfetta* L., *Urena* L., *Waltheria* L., and *Wissadula* Medik (Moreira and Bragança, 2011). *Sida cordifolia* is a spontaneous species widespread across the tropical and subtropical countries that develop mainly on roadsides, vacant lots, and anthropised areas. Its leaves are composed of substances like ephedrine and pseudoephedrine, which can stimulate the central nervous system, possibly increasing weight loss. It is a shrub that grows up to around 1.5 m, with white or yellow flowers and cordiform leaves (Jain *et al.*, 2011).

The genus *Herissantia* is composed of six native species from tropical America, three of which are endemic to Brazil. *H. crispa* occurs largely in the United States and Argentina and is frequent in the northeast region of Brazil, mostly in the Cerrado and Caatinga biomes. It is a herbaceous-sized plant that appears in crops, pastures, and on roadsides (Costa *et al.*, 2009). This plant is used in popular medicine as an anti-inflammatory, antipyretic, emollient, and diuretic agent for containing substances such as flavonoids. It is also used as bee pasture. Leaves are simple, with an alternate pattern, and flours are isolate, of white colour. *H. crispa* can be found in a decumbent position, propagating very well through seeds (Costa *et al.*, 2009). Two other species collected in the studied area, *Sida rhombifolia* and *Waltheria indica*, also recognised as important spontaneous species, can be used as biological allies in the combat against mites, in addition to forming important bee pastures (Moreira and Bragança, 2011).

The Cactaceae *Pilosocereus pachycladus* subspp. *pernambucoensis* is an endemic plant from the semi-arid region of Northeast Brazil, commonly known as 'facheiro'. This species can grow up to 9 m and can be used as emergency pasture after the burn of its thorns (Zappi, 1994; Lucena *et al.*, 2015).

Cronton glandulosus, a member of the family Euphorbiaceae, can be found with a sub-shrubby size, all over Brazil, in anthropised areas and in crop areas (Lucena *et al.*, 2015). By contrast, it can be a viable option for feeding cattle in the semi-arid region (Soares, 2001), in addition to being a species rich in b-caryophyllene, suggesting potential use as an anticarcinogenic agent, besides its antioxidant activity (Agra *et al.*, 2007, 2008).

Portulaca halimoides, a member of the family Portulacaceae, is an annual species found all across Brazil, mainly in the Atlantic Coast, and very often in the northeast region. The plant has juicy stalk and leaves. It is inhibited by the cultivation of lemongrass and is well adapted to vegetable-crop areas. Farmers mention it as a causative agent of digestive disorders such as bloat in cattle upon consuming the plant. The species *P. elatior* Mart. ex Rohrb., of the same genus, under spontaneous and experimental intoxication, caused excess salivation, difficulty moving, lip tremors, diarrhoea, bloat, abdominal pain, moaning, etc. (Silva *et al.*, 2006; Galiza *et al.*, 2011).

Many of the above-mentioned species found in the area have important potential for use as forage, fertilizer, and bee pasture, while others are not desirable due to having possibly toxic compounds, such as the genus *Portulaca*. The family Malvaceae, highly predominant in the area, mainly the species *H. crispa*, appears to be a plant that dominates the environment with quantity, rapid development, and tolerance to the dry period. In this way, these undesirable species must be thinned so that they will not compromise the development of the cultivated grass or intoxicate animals possibly grazing in the area.

Collections during the rainy, rainy/dry, and dry/rainy periods were preceded by a higher rainfall than the dry period, as shown in Fig. 1. As a result, these collections resulted in a larger herbage mass, since plants respond well to the rains.

According to Dourado *et al.* (2015), tillering is compromised under nitrogen deficiency. Those authors reported that at the first harvest obtained at a higher nitrogen rate. Although the tiller density was not measured in the present study, biomass did not differ between the last three collection periods, demonstrating that this herbage mass did not change even after grazing and thus that new tillers appeared and the leaf area was re-established.

Luna *et al.* (2010) worked in the Sertão Cearense region of Brazil, in a thinned-caatinga area, and obtained a herbaceous yield of 844.22 kg/ha DM in February and 2,505.43 kg/ha DM in August. This finding was a consequence of the moment being the period of maturity and end of cycle, which led to a higher DM yield, as occurred in the current study, where the largest herbage mass (2,512.66 kg/ha DM) was obtained in August (rainy/dry period).

In a study on light intensity in a greenhouse at 33 days, Souza *et al.* (2013) reported that aruana grass had a higher leaf dry matter yield when subjected to the light intensity of 75.1%. The whole plant however, which is composed of stem, pseudostem, leaves, roots, and senescent material, achieved its best production at a light intensity of 100%. This suggests that aruana grass is a species that responds

well to high light-intensity conditions.

Gerdes *et al.* (2005) conducted a study at the sheep farming unit of the Institute of Animal Science in Nova Odessa - SP, Brazil, and emphasised that at the end of the cycle, aruana grass had lower participation in the pasture during the evaluation period when there was a greater presence of spontaneous species, senescent material, and ryegrass, triggering competition in the area. This report conflicts with the data obtained in the present study. Those authors also stressed that spontaneous species were more present in the overseeded pasture and highlighted the significant grazing period × pasture type interaction effect, with approximately 10.5% spontaneous species in the fourth grazing period and 12.8% in the sixth grazing period, of the total herbage mass.

The aruana grass displayed rustic characteristics in response to the conditions imposed in its cultivation in the caatinga, where it was grown in an area without previous topdressing, irrigation or any manipulation (physical or chemical) for the control of weeds. However, it showed good competitive potential against the spontaneous species, especially those of the family Malvaceae, for being present in a larger quantity in the area; having a high capacity of reestablishment of leaf area post-grazing, which resulted from the occupation of the area by sheep in an extremely dry period; and satisfactorily occupying the area with regrowth, tillering, and natural reseeding after the first rains.

Although some of these spontaneous species are undesirable in the crop, e.g., *H. crispa*, of the family Malvaceae, a high frequency of Fabaceae is noted. In the rainy/dry period, together, these account for 9.14%, possibly contributing to the nitrogen fixation in the area and increasing the protein level of the pasture.

Some species appear at a higher frequency at certain times, such as *Z. curvata* and *R. grandiflora*, because each has their own germination period and duration to complete their lifecycle. The species with 0% frequency in the dry period are possibly short-cycled and do not withstand this scarcity period. The period with the highest number of species was rainy/dry transition, when plants were at the peak of their development. This information is also confirmed by the fact that this was the same period when spontaneous species showed their largest herbage mass.

Conclusion

The family Fabaceae had high representativeness of individuals in the area, together with the families Poaceae and Malvaceae, in a *P. maximum* cv. Aruana pasture. *H. crispa* and *P. maximum* cv. Aruana were the species with over 15% of presence in the area, which demonstrates their dominance therein. Special attention should be paid to *H. crispa* in protocols for the control of invasive plants in the establishment of a pasture.

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