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BIOMETRIA DE ÁRVORES E SEMENTES DE FAVELEIRA

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RESUMO: O presente trabalho objetivou mensurar atributos dendrométricos e biométricos de sementes da espécie *Cnidoscolus quercifolius* POHL, mais conhecida por favela ou faveleira. As variáveis dendrométricas avaliadas foram: altura total, diâmetro médio de copa, índice de abrangência e área de projeção da copa. Para a biometria das sementes foram realizadas avaliações das variáveis: massa, comprimento, largura e espessura. Os dados foram analisados por estatística descritiva e correlação de Pearson (5%). Os resultados revelaram variação entre 3,5 a 7,5 m de altura total e diâmetro de copa entre 5,5 a 9,75 m, havendo baixa correlação entre estes atributos (62%). Para as sementes, foi encontrada correlação de Pearson forte entre todas as variáveis (>90%), encontrando-se variações de 11,32 a 16,61 mm de comprimento; 5,09 a 10,39 mm de largura; 4,04 a 8,45 mm de espessura; e 0,10 a 0,50 g de massa. A variável massa foi a que apresentou maiores variações. Conclui-se que existe variação significativa dentro dos parâmetros morfométricos de árvores e sementes de faveleira, podendo estes nortearem atividades de restauração ecológica, tratos silviculturais de ambientes naturais e programas de melhoramento vegetal.

Palavras-chaves: *Cnidoscolus quercifolius*, dendrometria, caatinga, silvicultura.

BIOMETRY OF FAVELEIRA TREES AND SEEDS

ABSTRACT: The present work aimed to measure the dendrometric and biometric properties of the seeds of the species *Cnidoscolus quercifolius* POHL, commonly known as 'favela' or ' faveleira'. The dendrometric variables evaluated were total height, average crown diameter, coverage index and crown projection area. For the biometrics of the seeds, the following variables were evaluated: mass, length, width and thickness. The data were analyzed using descriptive statistics and Pearson correlation (5%). The results revealed variation between 3.5 and 7.5 m in total height and crown diameter between 5.5 and 9.75 m, with a low correlation between these attributes (62%). For seeds, a strong Pearson correlation was found between all variables (>90%), with variations from 11.32 to 16.61 mm in length, 5.09 to 10.39 mm in width, 4.04 to 8.45 mm thick, and 0.10 to 0.50 g in mass. The variable mass showed the greatest variations. There is significant variation in the morphometric parameters of faveleira trees and seeds, which may guide ecological restoration activities, silvicultural activities and plant improvement programs.

Keywords: *Cnidoscolus quercifolius*, Dendrometry, Caatinga, Forestry.

1. INTRODUCTION

The species *Cnidoscolus quercifolius* Pohl, known as “favela” or “faveleira”, belongs to the Euphorbiaceae family, is a xerophilic plant, has a shrub or arboreal size and is endemic to the Caatinga biome (Medeiros; Aloufa, 2015).

The faveleira has a branched trunk from the base and thin bark, needle-like stinging trichomes (0.2-12 mm) covering branches, petioles, leaf blades, perianths and fruits. It flowers at the end of the dry season, and in the

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rainy season, its flowers are small and white, gathered in inflorescences shaped like small clusters. They bear fruit in the rainy season with fruits similar to capsules, which open when ripe, releasing the seeds, and generally with the presence of three seeds per fruit (Melo; Sales, 2008).

In the lives of populations in semiarid regions, faveleira is a species that is recognized for its economic potential and ecological importance. There are several uses, in addition to the environmental context, including food, medicine, forage, and energy (Aloufa; Medeiros, 2016; Oliveira; Fernandes; Costa Júnior, 2011; Medeiros; Aloufa, 2015; Torres *et al.*, 2018). The latter is considered a sustainable alternative for the production of biodiesel, which is produced from the oil extracted from its seeds. According to previous studies, biodiesel from faveleira oil has good results because of its use as fuel (Beltrão; Oliveira, 2007). Cavalcanti *et al.* (2011) observed lipid levels in shellless faveleira seeds of approximately 40.3 and 42.5% for varieties with thorns and without thorns, respectively. The authors highlighted that these levels are lower than those of the forest species Brazil nut (68%) but higher than those of the cultivated species soybean and cotton, which contain approximately 20% lipids.

The biometric characteristics of trees (dendrometry) and seeds provide information for the conservation and exploitation of species, contributing to their effective and sustainable use (Lucena *et al.*, 2017). Dendrometric variables are effective in transmitting interdimensional relationships, reconstructing the space used by each tree and presupposing the degree of competition in the stand. Such metrics are important for determining silvicultural interventions in viable natural sites for sustained forestry production, allowing measurements of the stability, vitality and productivity of each individual (Durlo; Sutili; Denardi, 2004). Seed biometrics are characteristics used to differentiate physical and physiological quality, providing technological support for the viability of the propagative material of interest, whether commercial (products) or environmental.

Studies of this nature constitute important tools for detecting genetic variability within populations of the same species and their relationships with the environment and are used as a database in genetic improvement programs (Carvalho; Nazaré; Oliveira, 2003). In this sense, the objective of the present work was to analyze the biometric variability of trees and seeds of *C. quercifolius*, which originates from natural vegetation remaining in the Caatinga and thus contributes to the preservation of plant species native to the semiarid region of northeastern Brazil.

2 MATERIALS AND METHODS

2.1 Place and period of execution

Dendrometric measurements and collections of faveleiras fruits (thorn variety) were carried out between March 25th and April 10th, 2021, in a rural area in the municipality of Juazeiro-BA. The climate of the region under study, according to the Köppen classification, is semiarid, coded BSh, with the rainy season lasting from January to April (Alvares *et al.*, 2013; Teixeira *et al.*, 2002). The average annual rainfall is 571.5 mm, and the average annual temperature is 26.4°C, with an average minimum temperature of 20.6°C and an average maximum temperature of 31.7°C (Mouco; Ono; Rodrigues, 2011).

The site is an area of approximately 76 ha, with flat relief and natural vegetation reminiscent of the Caatinga biome. It presents sparse vegetation, typically savannah, with partially uncovered soil and sparse, low-density tree individuals, showing signs of degradation.

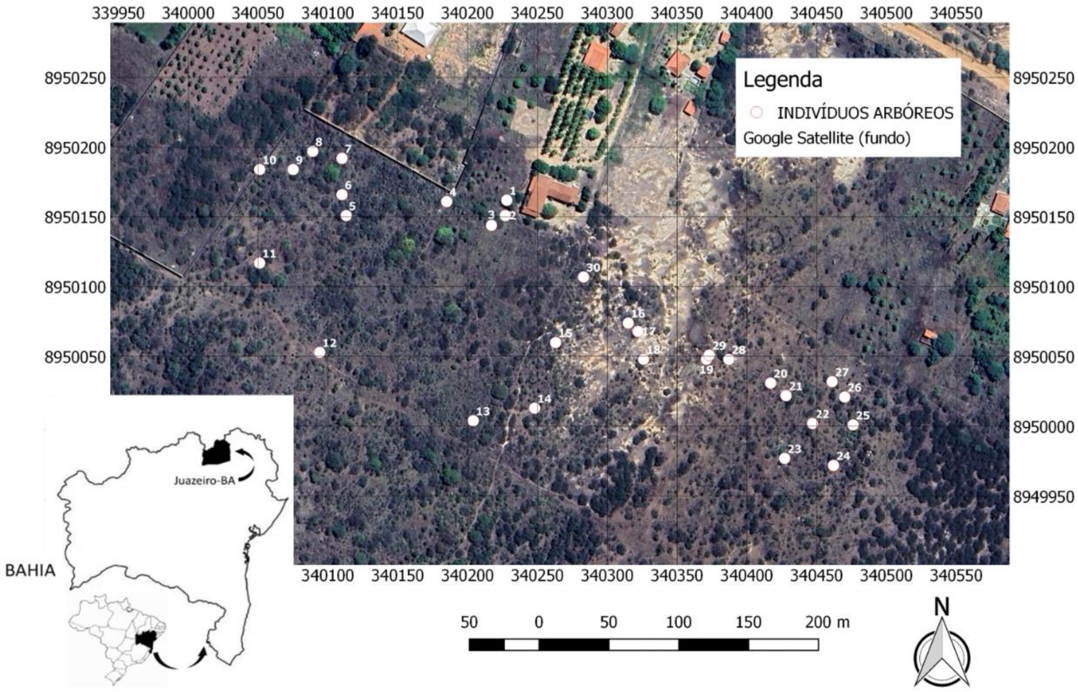
2.2 Dendrometric measurements

Dendrometric data were obtained from measurements of 30 adult tree individuals, evaluating trees with viability of approximation in all their axes. The geographic coordinates of the UTM of each tree were collected (Figure 1), and the following variables were measured: 1) total height of the tree (HT), in meters, measured from the base of the bole close to the ground to the apex of the branches, with aid of a graduated PVC rod; and 2) average crown diameter (DC), in meters, obtained by averaging the diameters (D1 and D2) in the north/south and east/west directions (Figure 2). With the data collected, 3) the coverage index (AI) was also calculated, expressed by equation 1, and 4) the canopy projection area (APC), in m^2, was expressed by equation 2.

$$[IA = DC/HT] \quad (1)$$

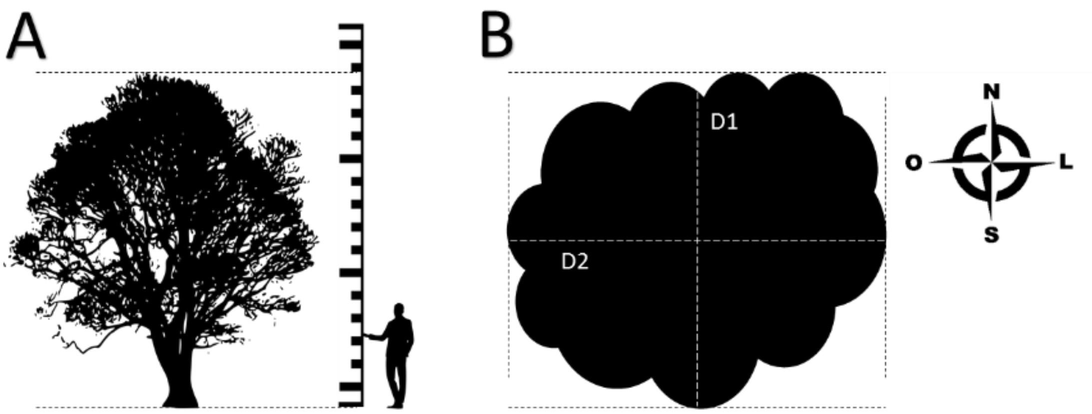
$$[APC = (\pi/4) \times (DC^2)] \quad (2)$$

Figure 1. Location of faveleira tree individuals subjected to dendrometric evaluations. Rural area, Juazeiro-BA.



QGIS 2.16 software (QGIS Development Team, 2015) was used.
Source: First author (2023).

Figure 2. Diagrams of measurements of height and crown diameter of faveleira tree individuals in a Caatinga remnant in Juazeiro, BA.



Projection of the vertical structure from the base of the trunk to the apex of the highest branch (A) and projection of the horizontal structure of the crown with the measuring diameters oriented in the north/south/east/west direction (B).
Source: First author (2023).

2.3 Harvesting, processing and biometric characterization of seeds

Manual harvesting of ripe fruits was carried out directly from individuals, avoiding damaged fruits and those on the ground. Fruits were collected from 50 matrices in the presence of a dry pericarp and in the dispersion stage (Figure 3, images A and B). The number of matrices was due to the need for a significant number of viable fruits for analysis, in addition to the possibility of collecting these fruits. Soon after collection, the fruits were sent to the Seeds and Flora Management Laboratory (LASMAF) located on the Agricultural Sciences Campus of the Federal University of Vale do São Francisco (UNIVASF) in Petrolina-PE.

Figure 3. Manual harvesting of faveleira fruits (A); Fruits with the presence of the epicarp before processing (B); Benefited seeds (C).

Source: First author (2022).

In the laboratory, the fruits were subjected to manual processing to extract the seeds from the epicarp (Figure 3 C). Then, they were selected to exclude chochas and physically damaged chochas.

In total, 673 seeds were obtained, with a small sample divided into two subsamples of 4 g and subjected to water content determination using the oven method at 105 ±3°C (Brazil, 2009). For characterization purposes, the seeds had a water content of 7.3%.

From the lots obtained, 300 (three hundred) seeds were randomly separated for individual biometric evaluation. The length, width and thickness were determined with the aid of a digital caliper (0.01 mm), and the mass was obtained by weighing on an analytical balance (0.001 g).

2.4 Data analysis

Dendrometric variables and seed biometrics were subjected to descriptive statistics, and frequency distribution graphs were created with the determination of classes using the square root rule (√n). In addition, a correlation study was carried out between the variables using the Person method at 5% probability. For the dendrometric data, multivariate grouping analysis (cluster analysis) was also carried out using the hierarchical method with the construction of a dendrogram. The analyses were carried out using the programs SISVAR version 5.6 beta (Ferreira, 2011), Microsoft Excel® version Office 2016 and Action Stat® version 3.4 (Estatcamp, 2019).

RESULTS AND DISCUSSION

3.1 Dendrometric analyses

The faveleira trees had a minimum height of 3.5 and a maximum of 7.5 m and a minimum crown diameter of 5.5 and a maximum of 9.75 m, leading to an APC between 23.7 and 74.6 ^{m2}. According to Durlo and Denardi (1998), the study of the range of variation (minimum and maximum) of the data is essential for characterizing the species, being even more important than the average value. The coefficients of variation were 18, 16.4, 15.6, and 34.3% for total height, crown diameter, coverage index and crown projection area, respectively (Table 1).

Table 1. Descriptive study of the dendrometric data of faveleira (*Cnidoscolus quercifolius* Pohl).

Variables	Minimum	Maximum	Average	DP	CV (%)
HT (m)	3.50	7.50	5.56	1.01	18.03
DC (m)	5.50	9.75	6.97	1.14	16.37
AI	0.86	1.68	1.27	0.19	15.62
APC (^{m2})	23.70	74.60	39.1	13.4	34.33

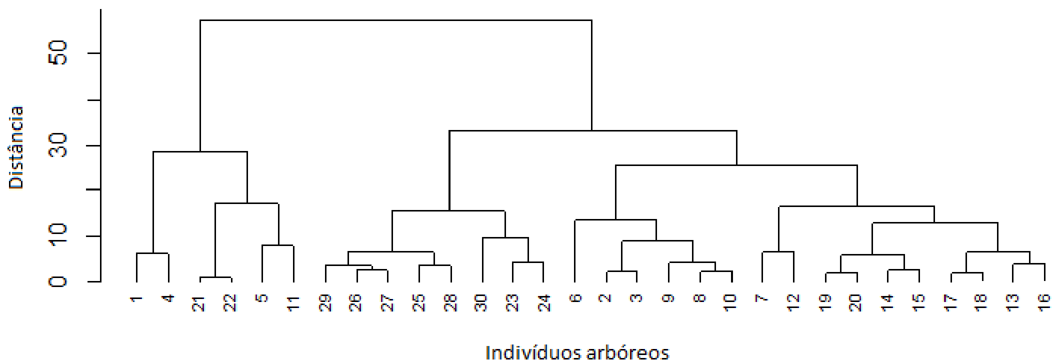
HT: total height; DC: crown diameter; IA: coverage index; APC: canopy projection area; SD: standard deviation; CV: coefficient of variation.
Source: Authors (2023).

In terms of the total height of trees, studies on the remaining fragments of Caatinga show a variation in amplitude, which is expected, as each stand has specific environmental characteristics, especially regarding the availability of growth resources, such as nutrients and water, mainly in the context of the Caatinga, a biome with different surface dynamics. Medeiros (2018) cites different sources to address the height of individuals, some indicating that they do not exceed 5 m, while others cite a variation of 4 to 8 m. The latter is similar to the results of the present work.

The multivariate analysis for the cluster shows that the distribution of individuals throughout the area appears to be a determining factor for this range of metric variation found, as seen by contrasting Figures 1 (location) and 4 (cluster analysis). Figure 4 shows the formation of four distinct groups: Group A (1, 4, 21, 22, 5, and 11); Group B (29, 26, 27, 25, 28, 30, 23, 24); Group C (6, 2, 3, 9, 8, 10) and Group D (7, 12, 19, 20, 14, 15, 17, 18, 13, and 16). Therefore, four slum settlements are dendrometrically heterogeneous within the studied area. The identification of these groups is important for delimiting the zones of superior individuals for collecting products or propagules. For the latter, for example, it is possible to achieve homogeneity in batches of seeds with superior characteristics.

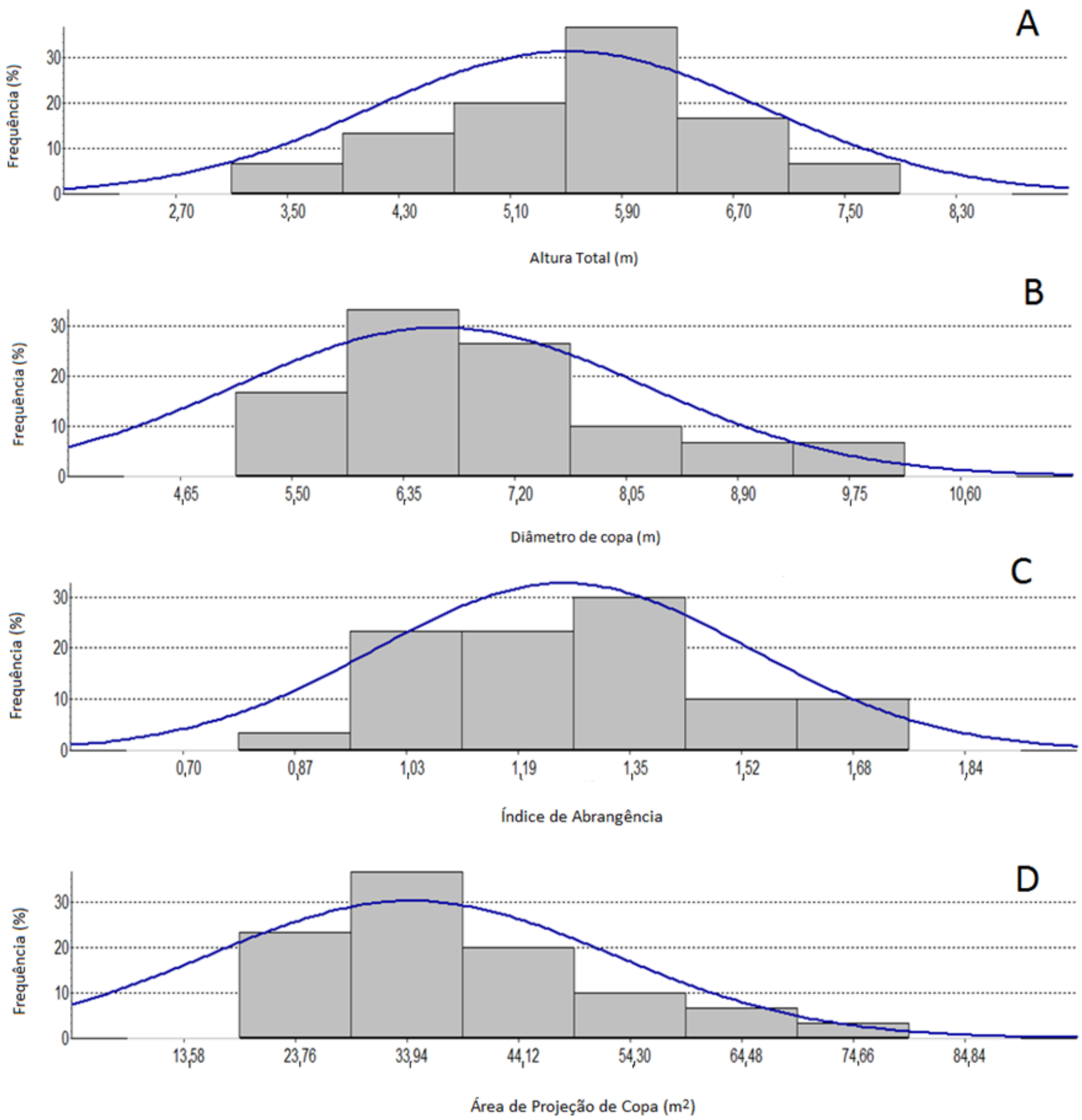
Regarding the data distribution analysis, 6 frequency classes were obtained, showing a predominance of individuals within the range of 5.5 to 6.3 m in total height, representing 36.6% of individuals (Figure 5A).

Figure 4. Dendrogram of the multivariate cluster analysis (cluster analysis) using the hierarchical method for the dendrometric variables of *Cnidoscolus arboreal individuals quercifolius* Pohl.



Source: First author (2023).

Figure 5. Frequency distribution and normal curve for the dendrometric variables of *Cnidoscolus quercifolius* Pohl.



A) Total height (m); B) crown diameter (m); C) coverage index; D) canopy projection area (^{m2}).
Source: First author (2023).

In a study by Calixto Júnior and Drumond (2011), in a fragment of Caatinga 30 years old after clear cutting, *C. quercifolius* was among the most important species in Petrolina-PE, presenting superior dendrometric characteristics, being the species with the largest stem diameter found (30.1 cm). These results show the importance of the species for forest recovery programs in the Caatinga. The total height variation reported was 2 to 5.5 m, a smaller variation compared to the data in the present work, probably because it was an area in the process of recovery, as noted by the authors. The phytosociological importance of *C. quercifolius* was also documented by Calixto Júnior and Drumond (2014) in a comparative study of two fragments of Caatinga, also in Petrolina-PE, with different levels of conservation.

The coverage index, calculated by the relationship between the crown diameter and the total height of the tree, presented an average value of 1.27 (Table 1). Roman, Bressan and Durlo (2009) and Silveira *et al.* (2015) reported on the possibility of using the coverage index as an indicator of silvicultural intervention throughout the life of a stand, such as for carrying out thinning and informing the number of trees that belong to a hectare without suffering competition. Considering the average value obtained for the slum and accepting the premise that the coverage index does not change with height, slums 5 m high, for example, would have a canopy with a diameter of 6.35 m. Thus, determining its APC, up to 322 favelas would fit per hectare, without intraspecific competition.

In the present work, the correlation matrix between the variables revealed a positive correlation of 62% ($p<0.01$) between the parameters height and crown diameter. This reveals an average correlation between an individual's vertical growth and their lateral branching potential.

In terms of crown diameter, the highest frequency class ranged from 5.92 to 6.77 m, representing 33% of the total area. For the coverage index (AI) and canopy projection area (APC), there was a greater frequency for classes 1.27 to 1.43 and 28.85 to 39.03, respectively (Figure 5).

According to Wink *et al*. (2012), canopy shape parameters are related to an individual's size in the environment, inferring stability, vitality and productivity. In a study with Brazil nut trees, one of the native forest species with the greatest economic value in the country, Tonini, Kaminski and Costa (2008) concluded that the crown shape and its sociological position have a direct influence on seed production; well-formed and long crowns were the most productive. Therefore, it is possible to relate the dimensions of the individual's canopy to its fruit and seed production characteristics, which is highly important for studies of the faveleira due to its energy potential from its oilseeds.

3.2 Biometric analysis of seeds

Faveleira seeds had an average length of 14.16 mm, varying between 11.32 and 16.61 mm; width ranged from 5.09 mm to 10.39 mm, with an average of 7.99 mm; and thickness averaged 5.47 mm, varying with minimum values of 4.04 mm and maximum values of 8.45 mm (Table 2). According to Cavalcanti *et al.* (2011), with work carried out in the municipality of Santa Luzia, state of Paraíba, the average values for length, width and thickness were 14.5, 8.3 and 5.6 mm, respectively. These values are very close to those observed in the present work, with an insignificant variation in decimal order. For amplitude, the results showed a slightly greater variation compared to that reported by Melo and Sales (2008), who reported in their work dimensions on the order of 11.4-13.5 × 5.5-8 mm.

Table 2. Biometric characterization of faveleira seeds (*Cnidoscolus quercifolius* Pohl).

Variables	**Minimum**	**Maximum**	**Average**	**DP**	**CV (%)**
C (mm)	11.32	16.61	14.16	1.01	7.10
L (mm)	5.09	10.39	7.99	0.63	7.96
E (mm)	4.04	8.45	5.47	0.41	7.63
M (g)	0.10	0.50	0.30	0.07	21.81

C: length; L: width; E: thickness; M: mass; SD: standard deviation; CV: coefficient of variation.
Source: Authors (2023).

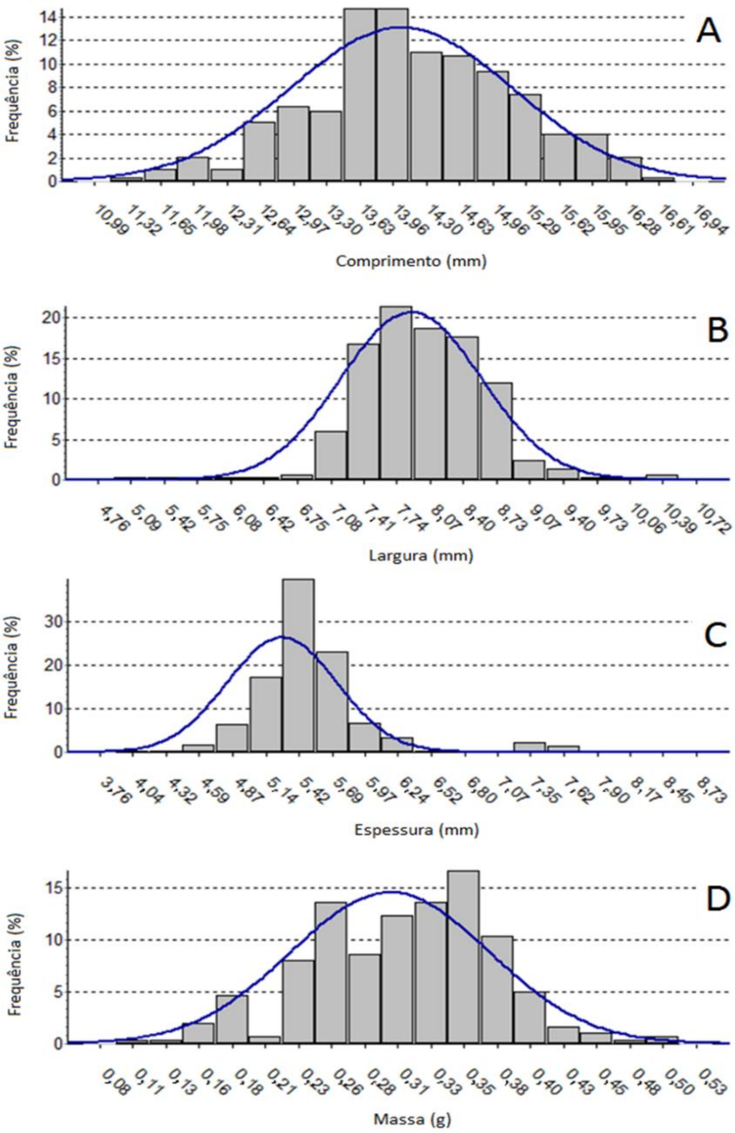
The mass presented an average value of 0.30 g, a minimum value of 0.10 g and a maximum value of 0.50 g. These values are lower than those reported by Cavalcanti *et al*. (2011), with 0.36 g. Beltrão and Oliveira (2007) reported that the average seed mass is approximately 0.35 g. The weight that the seed reaches at the end of its maturation is an extremely important characteristic, as it reflects its quality, being directly related to the deposition of nutritional reserves. This characteristic makes this attribute essential for physical analyses of typical oilseed species, such as faveleira, both due to the potential for lipid accumulation and the physiological quality of the seeds, for propagation. This relationship between woody species from the Caatinga was studied and confirmed. *Enterolobium contortisiliquum* (monkfish), *Cenostigma pyramidale* (Catingueira) and

Anadenanthera colubrina (Angico) were the most vigorous seedlings from the heaviest seeds in the batch analyzed (Lessa *et al.*, 2015; Barroso *et al.*, 2018).

Regarding the distribution of frequencies, it was found that for length, the most frequent seeds were in the range of 13.46 to 14.13 mm, representing 29.3% of the total. For width, there was a predominance and greater concentration in the range of 6.91 to 9.23 mm, with a greater frequency in the class of 7.90 to 8.23 mm. For thickness, there was a greater concentration in the range of 5.00 to 6.10 mm, with an emphasis on the range of 5.28 to 5.55 mm, representing 36.3% of the total. For the mass parameter, the majority of seeds are concentrated between 0.21 and 0.39 mm.

The highest frequency classes showed that 29.3% of the faveleira seeds varied from 13,138 to 14,130 mm in length, 21.3% from 7.905 to 8.236 mm in width, 39.6% within the 5,280 to 5,556 mm thickness class, and 16.6% within the 0.342 to 0.367 g class (Figure 5).

Figure 5. Frequency distribution and normal curve for the dendrometric variables of *Cnidoscolus quercifolius* Pohl.



A) Length (mm), B) thickness (mm), C) width (mm) and D) mass (g).
Source: First author (2023).

Using the Pearson test (Table 3), it was possible to verify that the correlation of the biometric variables evaluated was always greater than 90%, showing that the variables analyzed were proportional to each other. Nóbrega (2001), also studying the faveleira, confirmed a positive relationship between the size, width and mass of the seeds, as in the present work. According to the author, denser seeds, in most cases, have better-formed embryos and endosperm and, as already reported, greater amounts of reserves, which explains the relationship between the dimensions and mass of the seeds. This, in turn, could imply seeds with a higher oil content in their tissue due to the classification and selection of the material, which would require investigation and confirmation in future work.

Table 3. Pearson correlation matrix for the biometric variables of faveleira seeds (*Cnidoscolus quercifolius* Pohl).

	Length	Width	Thickness	Pasta
Length	1	0.97	0.90	0.99
Width	0.97	1	0.94	0.97
Thickness	0.90	0.94	1	0.92
Pasta	0.99	0.97	0.92	1

Source: Authors (2023).

The data presented here are important and can guide ecological restoration activities, silvicultural treatments for sustainable forestry in the Caatinga and plant genetic improvement programs.

4 CONCLUSIONS

The following conclusions can be drawn about tree individuals and faveleira seeds: 1) there are variations in the morphometry for the studied parameters, both in trees and seeds, with the tree crown projection area and seed mass being the attributes with greater variations; 2) the studied area presents four dendrometrically distinct groups, indicating different management needs and the possibility of zoning for exploration; and 3) the dimensional metric attributes of the seed (length, width and thickness) and its mass are significantly related, and any of these can be used to classify seed lots.

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