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Biometriy of Seeds of *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. ex. S. Moore and Seedling Growth After Different Periods of Water Immersion

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HIGHLIGHTS

- There was variability in the dimensions of seeds with lateral wings and embryo.
- The frequency distribution of *T. aurea* seeds provided important data for size classification.
- Immersion of the seeds for 48 hours produced more vigorous seedlings.

Abstract: This study aimed to determine the biometric characteristics of seeds of *Tabebuia aurea* and evaluate the effect of different periods of water immersion on the initial growth of seedlings. For this, the following dimensions were analyzed: length, width, and thickness of seeds with lateral wings and embryo. The moisture content, weight of a thousand seeds, and the number of seeds per kilogram were determined. The seeds were subjected to 11 treatments, as follow: control (no immersion in water; 0 hours) and periods of water immersion for 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60 hours, with four replications of 25 seeds in each treatment. The aerial part and seedling root lengths were analyzed 30 days after sowing. The water content was 9.81% and the weight of a thousand seeds was 130.260 g, corresponding to about 7,677 seeds/kg. The seeds with lateral wings had mean length, width, and thickness of 5.252, 1.226, and 0.147 cm, respectively. For the embryo, these dimensions corresponded to 1.355, 0.805, and 0.103 cm. Regarding the aerial part and root length of *T. aurea* seedlings, immersion for 48 hours is recommended because this treatment had the best results.

Keywords: forest seeds; Bignoniaceae; Caatinga; craibeira.

INTRODUCTION

Tabebuia aurea (Silva Manso) Benth. & Hook. f. ex. S. Moore, popularly known as “craibeira”, “ipê-amarelo”, among others, belongs to the family Bignoniaceae Juss. This species has an arboreal structure, reaching between 5–20 m height and 60–100 cm diameter [1]. It is native to Brazil and can be found in all regions of the country, being part of the flora of the Pantanal, Atlantic Forest, Cerrado, Amazon, and Caatinga biomes [2].

T. aurea is an extremely ornamental plant and stands out in the Brazilian semi-arid region due to its beauty and comfort provided by the shade of its large canopy [3]. This species has yellow flowers that stand out in areas of Caatinga [4]. It has been used for urban and rural reforestation, afforestation, civil construction, paper production, and carpentry, as it produces wood with high mechanical resistance [5], with high durability and resistance to decay [6]. It is widely cited in the literature for its use (leaf, bark, and roots) as antianemic, antipyretic, diuretic, vermifuge, and purgative, in the treatment of flu and inflammatory processes [7, 8, 9].

Currently, identifying and distinguishing some Bignoniaceae species is a challenge [10] because fruits and seeds of native species commonly have higher variability in their characteristics than cultivated species [11]. Seeds with greater length, thickness, and width are characterized as the most vigorous, influenced by the highest concentration of reserves, which make them more viable for seedling production [12].

Studies on plant production contribute to the development of innovative sustainable techniques and the maximization of resources through the propagation of forest species seeds [13]. Moreover, seed morphology, together with the observation of seedlings, make possible the correct identification of plant structures and provides information on physiological quality [14].

The use of quality seeds is important for seedling production [15]. However, the reproduction of native species is often restricted by seed dormancy, delaying their germination [16]. Dormancy is when there is a lack of germination in a seed/tuber, even though the necessary conditions of temperature, humidity, oxygen, and light are provided [17].

In this context, several studies on native species seeds have been conducted to improve the initial establishment of seedlings. The adequate water supply to seeds is essential for processes such as mobilization of reserves, energy release, and enzymatic and hormonal activities in plants. Based on this, immersion of seeds in water may influence the vigorous growth of seedlings produced [18].

Considering the need for information on native species, which hinders the productivity of seedlings and their use in ecological restoration programs, this study aimed to determine the biometric characteristics of *T. aurea* seeds and evaluate the effect of different periods of water immersion on the initial growth of seedlings.

MATERIAL AND METHODS

Study area

This research was conducted in the municipality of Sumé, located in the western Cariri micro-region of Paraíba, northeastern Brazil. The climate in the region is characterized by rainfalls concentrated in 3 or 4 months, irregularly distributed in time and space, with mean annual temperatures relatively high (25– 27ºC), mean insolation of 2,800 hours/year, relative humidity about 50%, and mean evaporation rates around 2,000 mm/year [19].

The region is predominantly covered by hyperxerophilous caatinga vegetation and well-developed Chromic Luvisols on gently undulating relief [20].

Data collection and analysis

T. aurea fruits in the dispersion stage were collected from adult matrices in the municipality of Sumé (07°40'18" S and 36°52'48" W; 532 m altitude) on December 5, 2017. After being collected, the fruits were packed in polyethylene bags and taken to the Ecology and Botany Laboratory (LAEB/UFCG/CDSA) for seed extraction, manually.

To obtain the biometric data, *T. aurea* seeds were manually screened, discarding those visibly damaged or with deformation; a mix was performed for selecting a sample of 100 dispersion units. Subsequently, the following dimensions were measured: length from the base to the apex, width, determined between the right and left ends, and thickness, measured between the ventral and dorsal regions of the seeds with lateral wings (Figure 1A) and embryo (Figure 1B). These measurements were made using a digital caliper (precision of 0.01 mm).

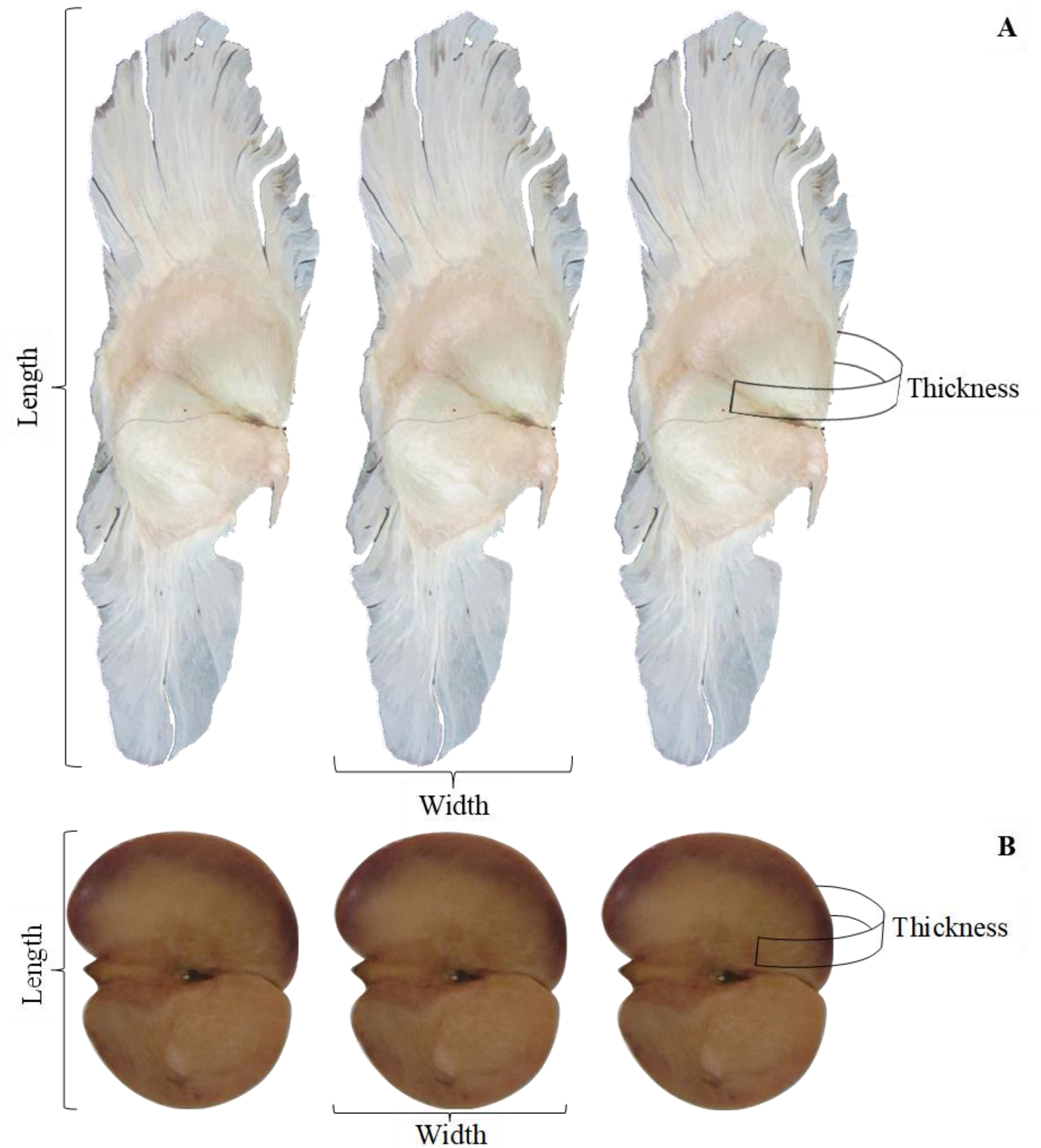

Figure 1. Illustration of the measurement of biometric characteristics of *T. aurea* seeds with lateral wings (A) and embryo (B).

For the biometric data analysis, univariate statistics were used, which corresponded to measures of position (mean, quartiles, and minimum and maximum values) and measures of dispersion (standard deviation and coefficients of variation). Boxplots were used to graphically represent the five-point summary: minimum value, first quartile (Q1), second quartile/median (Q2), third quartile (Q3), and maximum value. Histograms were constructed to analyze the frequency distribution pattern of biometric characteristics.

For the physical characterization of *T. aurea* seeds, the tests described below were performed based on the Rules of Seed Analysis – RSA [21].

Weight of a thousand seeds

Eight replications of 100 seeds were weighed, using a 0.001-g precision scale, and the variance (S^2), standard deviation (S), and coefficient of variation (*CV*%) of the obtained values were calculated. The weight of a thousand seeds was determined by multiplying by 10 the average weight obtained from the replications of 100 seeds, as indicated in the equation:

$$\text{Weight of a thousand seeds (g)} = \bar{X} \times 10 \quad (1)$$

Where:
$\bar{X}$ = average weight of 100 seeds.

Number of seeds per kilogram

The number of seeds per kg was calculated by the rule of three based on the result found from the weighting of a thousand seeds.

1000 seeds ------ x grams
x seeds ------ 1000 grams

Moisture content

Seed moisture content was determined using four replications of 25 seeds, which were initially weighed under humid conditions and taken to a drying oven at 105 ± 3°C for 24 hours. The following equation was used:

$$\text{Moisture content (\%)} = \frac{100\,(P - p)}{P - t} \quad (2)$$

Where:
P = initial weight (container and its lid weight plus the wet seed weight); p = final weight (container and its lid weight plus the dry seed weight); t = tare (weight of the container with its lid).

A completely randomized experimental design was used. A uniform mix was performed with four replications, each one composed of 25 seeds. These dispersion units were processed and subjected to 11 treatments, as follows: control (no immersion in water; 0 hours) and periods of water immersion for 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60 hours.

Plant production occurred in the Native Seedling Production Nursery (50% shading) of the LAEB/UFCG/CDSA. Direct sowing was performed (12/31/2017) in 11 polyethylene trays with 46 cm length, 31 cm width, and 7 cm depth. Each tray was divided into four quadrants with PVC material, perforated at the base so that excess water could be released during irrigation.

The substrate consisted of sand, which was initially sieved and then washed. A hundred seeds (four replications of 25 seeds) were sown in each tray, at a depth of 1.5 cm. Irrigation was performed daily and in a controlled manner, using a graduated container with 250 ml per replication. At 30 days after sowing, the aerial part and root lengths of *T. aurea* seedlings were determined, using a graduated ruler. The obtained results were expressed in cm.

The data were subjected to analysis of variance and the means were compared by the Scott-Knott Test (p<0.05). All analyses were performed using the Microsoft Excel software (version 2019), R (version 4.0. 5), and SISVAR [22].

RESULTS AND DISCUSSION

T. aurea seeds with lateral wings had 9.81% water content. The weight of a thousand seeds was 130.260 g, with a variance of 0.226, a standard deviation of 0.475, and a coefficient of variation of 3.650%, corresponding to approximately 7,677 seeds/kg (Table 1).

Table 1. Physical characterization of *T. aurea* seeds from different matrices in the municipality of Sumé, Paraíba, Brazil.

Mean	S^2	S	*CV* (%)	PMS (g)	Nº of seeds/kg	WC (%)
13.026	0.226	0.475	3.650	130.260	7,677	9.81

Where, S^2: Variance, S: Standard Deviation, *CV*: Coefficient of variation, PMS: Weight of a thousand seeds and WC: Water content.

The expressed moisture content was lower than 10%, corroborating the values found by Carvalho and coauthors [23] for seed storage, both orthodox and intermediate. The weight of a thousand seeds had a coefficient of variation below 4%, being in line with the RAS recommendations [21] and the number of seeds per kilogram was within the expected for the species, which is between 4300 and 7800 [24].

The biometric data of *T. aurea* seeds are shown in Table 2, mean values of 5.252 cm, 1.226 cm, and 0.147 cm were recorded for length (considering the lateral wings), width, and thickness, respectively. The sampling accurately reflects the population as all the evaluated seed characteristics had low standard error values. Thus, the mean of the analyzed sample is close to the mean of the population, whose value is not known. Regarding the standard deviation of the evaluated characteristics, length had the highest sample variance (0.429). Concerning the coefficient of variation, thickness stood out with the highest variation (16.088%) in comparison with the average of the other seed characteristics.

The embryo had an average length of 1.355 cm, width of 0.805 cm, and thickness of 0.103 cm. The standard error values were also low, accurately describing the population, indicating that the sample mean is close to the population mean of unknown value. In the standard deviation analysis, length had the highest sample variance (0.093), whereas, for the coefficient of variation, thickness stood out with the highest variation (22.551%).

Table 2. Biometry of *T. aurea* seeds with lateral wings and embryo.

Biometric characteristics	*n*	Mean ± standard error	Standard Deviation	*CV* (%)
		Seeds with lateral wings (cm)		
Length	100	5.252 ± 0.043	0.429	8.161
Width	100	1.226 ± 0.008	0.081	6.571
Thickness	100	0.147 ± 0.002	0.024	16.088
		Embryo (cm)		
Length	100	1.355 ± 0.009	0.093	6.868
Width	100	0.805 ± 0.006	0.061	7.631
Thickness	100	0.103 ± 0.002	0.023	22.551

Where, *n*: sample size and *CV*: Coefficient of variation.

Oliveira and coauthors [25] found mean values of 5.78, 2.06, and 0.31 cm for length, width, and thickness of *T. aurea* seeds with lateral wings, respectively, and embryo values of 1.73, 1, 33, and 0.17 cm, respectively. These results are higher than the ones found in our research. The seed mean values presented here are relatively close to or in some cases higher than those (seeds with lateral wings of 3.9 x 1.2 x 0.2 cm and embryo of 1.6 x 1.1 x 0.2 cm) found by Felix and coauthors [10] for *Handroanthus impetiginosus* (Mart. ex DC.) Mattos, which belongs to the same family of *T. aurea*. The variation in the dimensions may be related to environmental factors during development and/or expression of flowering phenophase, as well as to genetic variability [26].

In the analysis of seeds with lateral wings, length had a positively asymmetric distribution, influenced by the greater distance from the median to the maximum point (Figure 2A). On the other hand, width and thickness had a negatively asymmetric behavior, evidenced by the greater distance from the median to the minimum point (Table 3; Figure 2B and 2C). It is noteworthy that the thickness had lower data dispersion, demonstrated by the amplitude, which was equivalent to 0.090 cm (Figure 2C).

The embryo length showed a negatively asymmetric distribution, influenced by the greater distance from the median to the minimum point (Figure 2D), whereas the width and thickness had a positively asymmetric behavior, due to the greater distance from the median to the maximum point (Table 3; Figure 2E and 2F). The thickness had lower data dispersion, demonstrated by the amplitude corresponding to 0.109 cm (Figure 2F).

Regarding the five-point summary values (minimum, Q1, Q2, Q3, and maximum), about 50% of sample values of length, width, and thickness were below the median for seeds with lateral wings (5.248, 1.229, and 0.148 cm, respectively) and embryo (1.369, 0.804 and 0.104 cm, respectively) (Table 3).

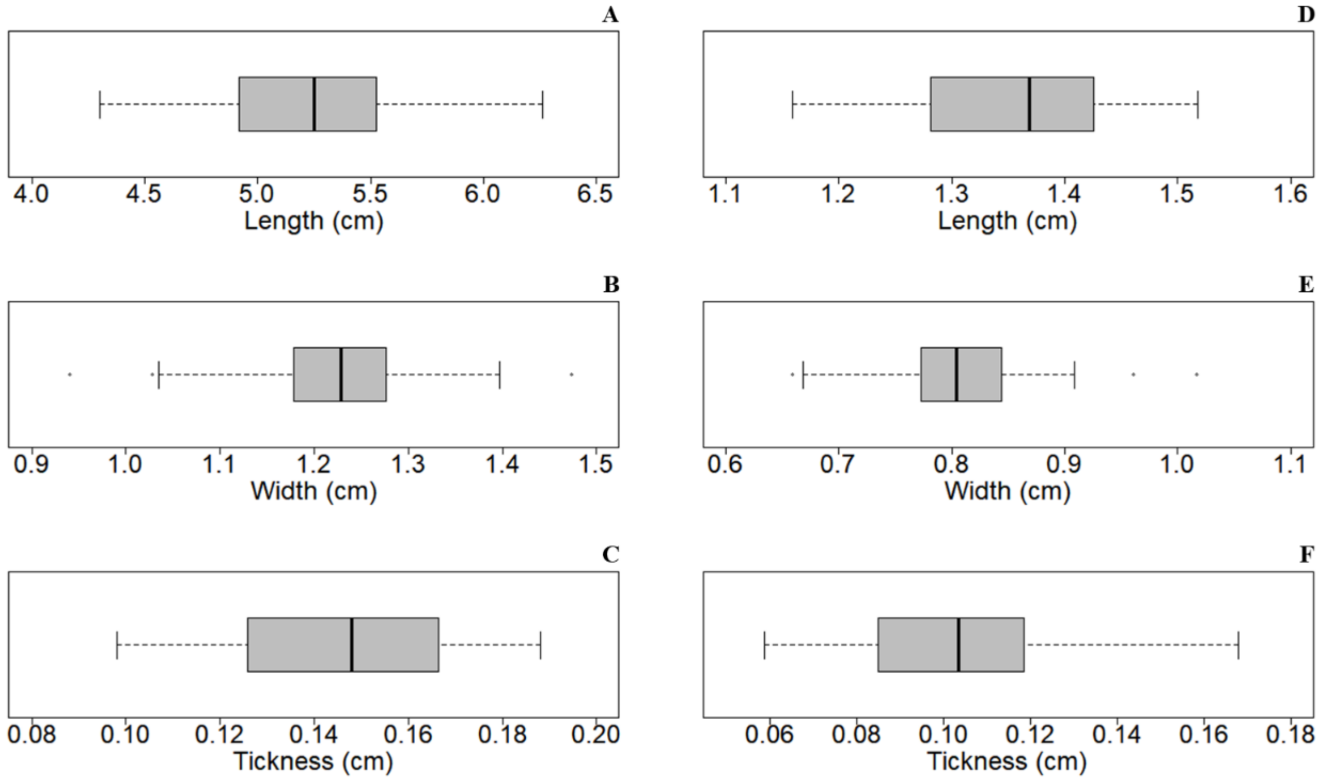

Figure 2. Boxplot of *T. aurea* seeds with lateral wings [length (A), width (B) and thickness (C)] and embryo [length (D), width (E), and thickness (F)].

Table 3. Five-point summary of the descriptive statistical analysis of the boxplot graph: minimum value, first quartile (Q1), median (Q2), third quartile (Q3), and maximum value of biometric characteristics of *T. aurea* seeds.

Biometric characteristics	Five-point summary of the boxplot				
	Minimum	Quartile 1	Quartile 2 (median)	Quartile 3	Maximum
Seeds with lateral wings (cm)					
Length	4.303	4.926	5.248	5.524	6.260
Width	0.940	1.180	1.229	1.276	1.474
Thickness	0.098	0.127	0.148	0.166	0.188
Embryo (cm)					
Length	1.159	1.282	1.369	1.425	1.518
Width	0.659	0.774	0.804	0.843	1.017
Thickness	0.059	0.085	0.104	0.118	0.168

This variation in *T. aurea* seed dimensions may be strongly associated with environmental factors. Santos and coauthors [27] explained that, in addition to the mass, the size of seeds is characteristic of each species; however, these parameters are influenced by the environment. The variability between specimens of the same species helps in their selection to improve a certain character [28]. It should be noted that the size of seeds has a positive correlation with the initial growth rate of seedlings, promoting their establishment depending on the amount of reserve and the well-formed embryo, resulting in greater plant vigor [29].

Regarding the frequency distribution analysis, *T. aurea* seeds with lateral wings had lengths concentrated between 4.846 and 5.496 cm, with an accumulated frequency of 54% seeds (Figure 3A). The width was concentrated in the range 1.147–1.323 cm, with an accumulated frequency of 75% seeds (Figure 3B). The thickness was concentrated mainly between 0.134 and 0.183 cm, with 66% seeds (Figure 3C).

The frequency distribution analysis of the *T. aurea* seed embryo indicated a length mainly concentrated between 1.340 and 1.459 cm, corresponding to 49% of the total sample (Figure 3D). The width was concentrated between 0.760 and 0.839 cm, resulting in the accumulation of 53% of the samples (Figure 3E). The thickness was mainly in the interval 0.078–0.125 cm, with 69% of the samples (Figure 3F).

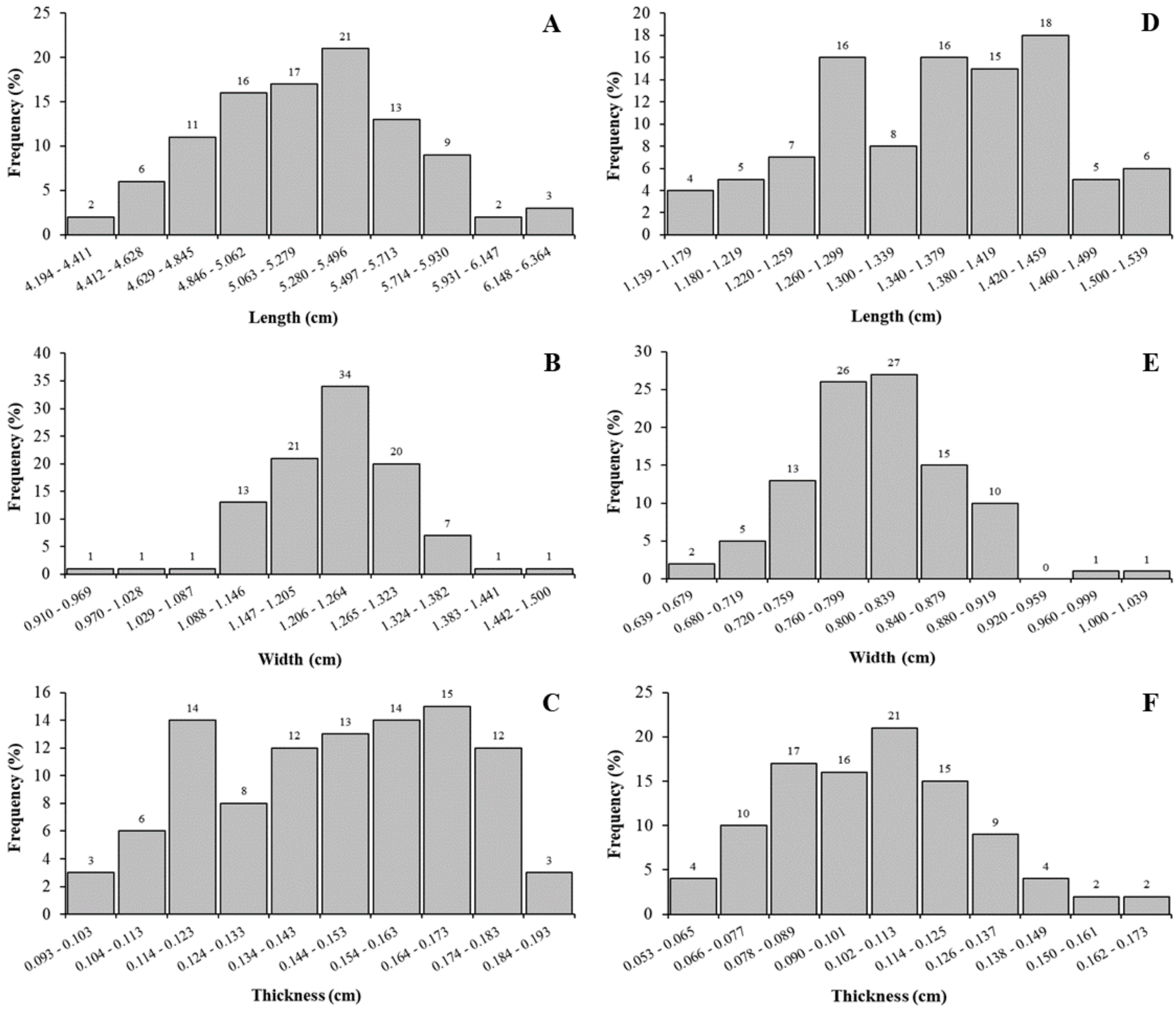

Figure 3. Percentage frequency of *T. aurea* seeds with lateral wings [length (A), width (B), and thickness (C)] and embryo [length (D), width (E), and thickness (F)].

These intervals with the highest values in terms of frequency of length, width, and thickness were close to or even above the mean values observed in the biometric analysis, indicating a remarkable characteristic of *T. aurea* seeds in semi-arid environments. Seed biometry of native species needs to be studied as they have unique behavior, conditioned to biotic and abiotic factors of each collection region during seed development [30].

In this sense, based on species biometric frequency distribution, the appropriate sieves for separating seeds into different sizes can be selected, considering their importance in the processing because, in addition to the classification by size, they help in the removal of impurities [31].

The aerial part of *T. aurea* seedlings (Figure 4) from seeds subjected to prolonged periods of water immersion (36 to 60 hours) had the highest length mean values, differing significantly from the other treatments, with an emphasis on immersion for 36 hours, which had an average length of 6.5 cm. It is noteworthy that the control (no immersion; 0 hours) showed no significant difference compared to the initial periods of water immersion (6 to 30 hours).

Regarding the root length of *T. aurea* seedlings (Figure 5), seeds subjected to water immersion from 6 to 60 hours had higher averages than the control (no immersion; 0 hours), especially the 48-hour immersion period, which resulted in a mean length of 12.5 cm. The periods of water immersion for 6, 18, 24, 42, 48, and 54 hours did not differ between them but statistically differed from the other treatments.

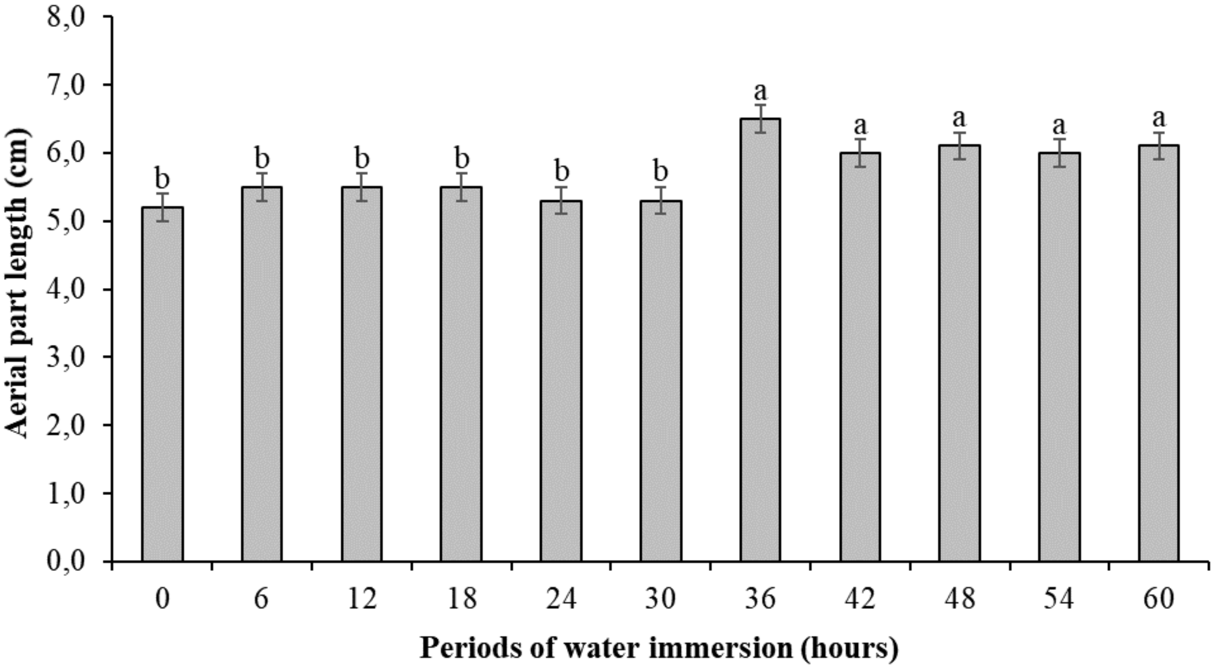

Figure 4. Aerial part length of *T. aurea* seedlings subjected to different periods of water immersion, 30 days after sowing. Where: Means followed by the same letter above the bars do not differ significantly by the Scott-Knott Test (p<0.05). The data are mean values of treatments ± standard error.

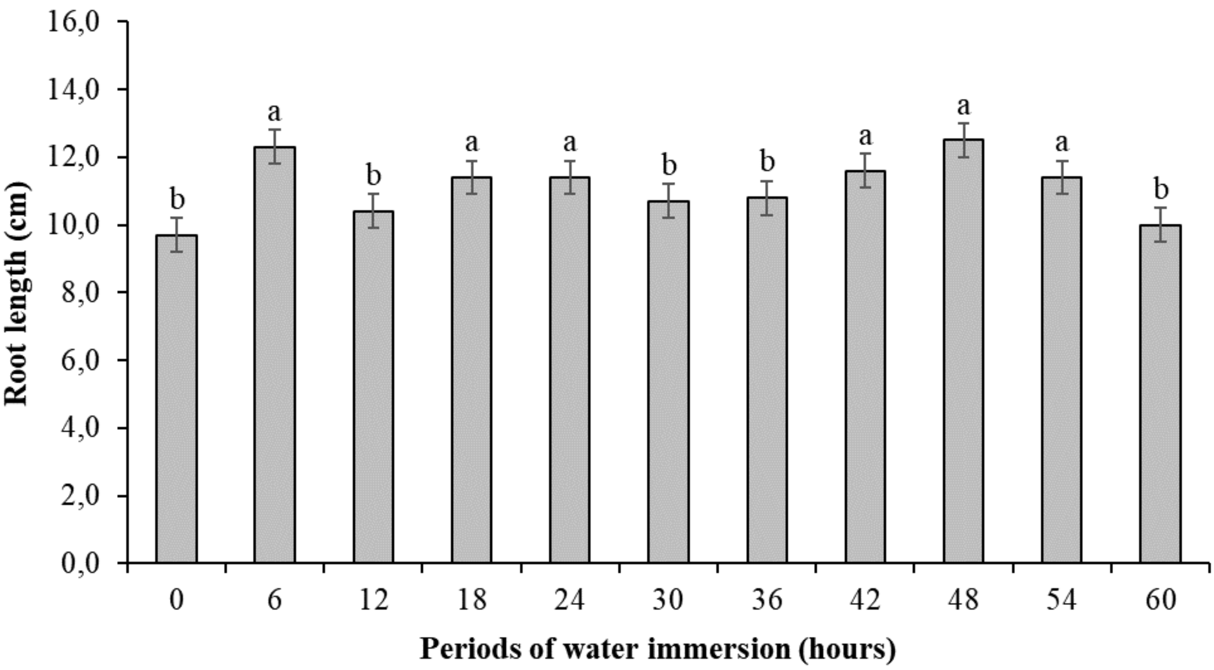

Figure 5. Root length of *T. aurea* seedlings subjected to different water immersion periods, 30 days after sowing. Where: Means followed by the same letter above the bars do not differ significantly by the Scott-Knott Test (p<0.05). The data are mean values of treatments ± standard error.

The mean length values for the aerial part and root obtained in our research were higher than those found by Pacheco and coauthors [32] in a study using Biochemical Oxygen Demand (BOD), subjecting *T. aurea* seeds to different temperatures and substrates for 14 days. These authors found mean values of 4.2 cm and 5.4 cm for the aerial part and root of seedlings, respectively, in a sand substrate at 25ºC.

These results, higher than those found in the literature, indicate that the immersion of *T. aurea* seeds in water contributed to the potentiation of growth in terms of the aerial part and root lengths of seedlings, promoting higher productivity quality.

CONCLUSION

T. aurea seeds had a moisture content of 9.81% and a thousand seeds weighed 130.260 g, corresponding to about 7,677 seeds/kg (within the expected for the species). There was variability in the dimensions of seeds with lateral wings and embryo, with averages lower than those observed in research on the same species and close to or higher than the averages found for species of the same family (*H. impetiginosus*).

However, the frequency distribution of *T. aurea* seeds with lateral wings and embryo revealed that the most representative intervals in terms of length, width, and thickness were close to or even above the mean values observed in the species biometric analysis, evidencing a remarkable characteristic of *T. aurea* in its natural environment. This finding helps in the classification of seeds by size using classification sieves.

The immersion of *T. aurea* seeds in water for different periods led to greater development of the aerial part and root lengths, showing significant differences with the highest averages recorded in the evaluation. Immersion for 48 hours is recommended, due to the expression of the best results. Thus, this treatment should be used to obtain more vigorous seedlings.

Therefore, the information contained in this study helps in the identification of specimens of *T. aurea*, as well as in the verification of genetic variability, providing relevant data of the biometric characteristics of this species in the semi-arid region of Brazil, in addition to contributing to its productive potential, favoring ecological restoration and conservation programs for this species.

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Conflicts of Interest: The authors declare no conflict of interest.

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