

1 Original Research Article
2 **Biometric Characterization and Phys-**
3 **iological Quality of Seeds**
4 **of *Hymenaea courbaril* L.**

5
6 **ABSTRACT**
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Aims: The objective of this work was to verify the influence of seed size on germination and vigor of seeds and seedlings of *Hymenaea courbaril* L.

Study design: The experimental design was completely randomized

Place and Duration of Study: The present work was carried out in the Laboratory of seeds of the State University of the West the Paraná, **Brazil**, between the period of January of 2018 to July of 2018.

Methodology: The seeds were obtained in the region Marialva, Paraná, classified according to the biometric characteristics, in accordance with the range of values of seed length, in small, medium and large to later be mechanically scarified and immersed in water for 48 hours. We evaluated the biometric characteristics, moisture content, germination, seed vigor and seedling development.

Results: In the present study, the size of the seeds reflected effects on physiological quality of the seeds, mainly in the parameters related to the performance of seedlings.

Conclusion: The seedlings evaluated of medium and large seeds showed better performance in the majority of parameters, in addition, it is recommended that, the use of large seeds, because they have a higher percentage of seedling emergence and the highest quality.

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9 **Keywords:** Forest Species, ***Hymenaea courbaril* L.**, Jatobá, Morphology of seeds, Physiological potential..
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12 **1. INTRODUCTION**
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14 The jatobá (*Hymenaea courbaril* L.), belonging to the family Fabaceae, is a species with
15 great forestry and environmental importance, due to its multiple uses, such as the restoration
16 of forest reserves, feeding of wildlife, medicinal and potential as a fixative and storage plant
17 of atmospheric carbon, both in its constituent assembly on the ground, which may be a sus-
18 tainable alternative within integrated systems of agricultural production and forestry compo-
19 nent [1, 2].
20

21 **The jatobá tree offers several relevant products, the bark, sap, resin and fruit** have medicinal
22 properties, the latter being edible, its wood is dense with high durability and workability and
23 can be used in civil construction and fine furniture due to its value added. The species is
24 considered rare, with irregular distribution, this due to the extraction of its wood [3, 2].
25

26 The performance of the seedlings of any plant species is influenced by the physiological
27 quality of their seeds, and this constituted the viability and vigor of the same, another factor
28 that is being evaluated for various species is the size of the seeds as a component of the
29 quality [4]. Within their species, there are individual variations among the trees due to envi-
30 ronmental influences during the development of the seed and the genetic variability [5].

Information on the biometric characteristics of the seed can provide subsidies for the selection of seeds, and genetic variables within populations of the same species, and the relationships between this variability and environmental factors, as well as breeding programs genetic [6].

According to Carvalho and Nakagawa [7], the largest and most dense seeds have a greater quantity of substances of reservation, which results in better embryos formed, resulting in more vigorous seedlings accordingly. According to Oliveira et al. [8], the seeds are considered small can manifest less performance than the seeds medium and large, within one and the same seed lot, and according to Silva et al. [9], to obtain seedlings of similar size and with a uniform emergence, a recommended tactic would be the classification of seed per size and mass.

Therefore, this study is based on the hypothesis that jatobá, as a species with several uses and great potential to explore the size of its seeds, can have a positive influence on the propagation and development of seedlings by the best initial growth until the best germination and force. Thus, the objective of this work was to verify the influence of seed size on the germination and vigor of seeds and seedlings of jatobá (*Hymenaea courbaril* L.).

2. MATERIAL AND METHODS

The fruits of jatobá (*Hymenaea courbaril* L.) were obtained from headquarters located in Marialva, Paraná, Brazil, with minimum distance between themselves, 100 meters away. The same were prepared in the Laboratory of Seed Technology, belonging to the State University of Western Parana, (UNIOESTE), Campus Marechal Cândido Rondon, PR.

The extraction of the seeds was performed manually, consisting in the breaking of the fruit with the aid of a hammer and the endocarp chalky (pulp) removed with the help of a spatula. Subsequently the tegument of seeds were scarified mechanically with the help of sandpaper iron, on the opposite end of the micropyle, without reaching the cotyledons, then immersed in water for 48 hours [10].

2.1 Biometrics Seeds

The seeds of jatobá were characterized biometrically, where they were assessed randomly. Subsequently, in accordance with the range of values of seed length (SL) were classified in small ($SL \leq 24.49$ mm), medium ($SL > 24.49$ mm ≤ 26.49 mm) and large ($SL \geq 26.50$ mm). The following morphometric parameters were determined: length (mm) and diameter (mm) seeds, measured with the aid of a digital caliper, and the length measured from the base to the apex and the width measured on the midline of the seed, weight of a thousand seeds, in accordance with the Rules for Seed Analysis (RSA), mass of dry matter and water content, obtained by the oven method $105 \pm 3^{\circ}\text{C}$ [11], for these last 4 repetitions was used with 7 seeds.

For each variable, mean values were calculated, maximum, minimum, standard deviation and coefficient of variation. The data of the length and width of seed were grouped into classes to better presentation in the histogram of frequency. The data analysis was performed with the aid of Excel spreadsheet.

2.2 Germination test

The seeds were placed in trays, arranged between layers of vermiculite fine texture and kept in chambers of germination type BOD, with a photoperiod of 12 hours of light and constant temperature of 25°C . The germinated seeds were counted daily for 35 days, until the stabilization of germination.

With the data computed the germination test were calculated germination percentage, germination speed index (GSI), the mean germination time (MGT), average speed of germination (ASG) and first count of germination test (FCG). The calculations of the percentage of germination, ASG and MGT were performed according to Labouriau [12]:

$$G (\%) = (N/A) \times 100$$

On what: G - this is the percentage of germination; N is the number of germinated seeds; and A - this is the total number of seeds germinated.

$$MGT = \frac{\sum nt \cdot ti}{\sum n_{total}} \text{ (days)} \quad ASG = \frac{1}{MGT} \text{ (seeds/day)}$$

On What: MGT - refers to the average time of germination in days; nt - is the number of germinated seeds in a time interval; ti - is the time interval; ntotal is the total number of germinated seeds; ASG - is the average speed of germination.

The GSI calculations were performed by Maguire [13]:

$$GSI = \frac{G1}{N1} + \frac{G2}{N2} + \dots + \frac{Gn}{Nn}$$

In that: GSI= germination speed index; G= number of germinated seeds; N= number of days from sowing.

2.3 Evaluation of Seedlings

Subsequently the germination test, the ratings of seedlings as the length of the main root and aerial part (cm), diameter of the base of the hypocotyl (mm), mass of dry matter of the root system (g) and aerial part (g). The length of the aerial part and root were measured with the aid of graduated ruler. The hypocotyl diameter was performed with the aid of a digital caliper, whereas the neck of the aerial part. For the evaluations of mass of dry matter, the seedlings were separated in the aerial part and root system. Then, were arranged in Kraft paper bags and taken to the greenhouse air circulation at 65°C for 72 h. Subsequently, the samples were weighed on an analytical balance with a precision of 0.001 g, the results were expressed in grams.

2.4 Emergency Test

This was conducted in a greenhouse, the seeds were placed in plastic tubes of 120 cm³, filled with commercial substrate, and irrigated three times a day. The emerged seedlings were counted daily until 38° day, where the stabilization of the emergency. On the basis of the count of emergency, we calculated the index of emergence speed [13], the percentage of emergence, the average speed of emergence (ASE) and the mean emergency time (MET). The calculations of percentage of emergence, ASE and MET were performed according to the methodology of Labouriau [12].

2.5 Experimental Delineament

The experimental design was completely randomized, consisting of 3 seed sizes, 7 replications with 15 seeds. The results obtained were submitted to tests of normality and homogeneity, and subsequently to the analysis of variance by F test at 5% probability of error, and significant when the averages were compared by the Tukey test at 5% probability of error.

3. RESULTS AND DISCUSSION

Table 1 shows the biometric characteristics of the jatobá seeds classified into three size classes, small, medium and large. The mean values, the minimum and maximum length of

the seeds (SL) were, respectively, 22.55 mm, 24.47 mm and 18.46 mm for small seeds, 25.14 mm, 26.48 mm and 24.50 mm to 27.54 mm and medium seed, 30.48 mm and 26.50 mm for the large seeds.

Table 1. Average, Maximum and minimum standard deviation and coefficient of variation of the physical characteristics of seeds of *H. courbaril* L. The seeds were classified in small (SL $\leq$ 24.49 mm), medium (SL >24.49 mm $\leq$ 26.49 mm) and large (SL $\geq$ 26.50 mm).

SMALL SEEDS					
Determinations	Average	Maximum	Minimum	Standard deviation (σ)	CV (%)
LS (mm)	22.55	24.47	18.46	1.45	6.42
DS (mm)	16.31	28.27	12.38	1.60	9.81
WTS (g)	3940.06	4030.30	3840.80	6.97	1.77
DMS (g^{-1})	3.75	3.96	3.59	0.19	5.03
WC (%)	8.93	10.04	8.36	0.75	8.42
MEDIUM SEEDS					
Determinations	Average	Maximum	Minimum	Standard deviation (σ)	CV (%)
LS (mm)	25.48	26.48	24.50	0.58	2.29
DS (mm)	17.14	22.79	13.13	1.40	8.15
WTS (g)	4659.63	4769.00	4575.00	65.54	1.41
DMS (g^{-1})	4.67	4.81	4.53	0.14	3.05
WC (%)	7.74	8.49	7.25	0.59	7.57
LARGE SEEDS					
Determinations	Average	Maximum	Minimum	Standard deviation (σ)	CV (%)
LS (mm)	27.54	30.48	26.50	0.81	2.96
DS (mm)	17.63	20.48	14.57	1.22	6.89
WTS (g)	5295.00	5358.00	5212.00	47.23	0.89
DMS (g^{-1})	4.92	5.01	4.77	0.11	2.22
WC (%)	8.92	9.26	8.49	0.34	3.79

Note: length of the seed (LS), diameter of the seed (DS), weight of a thousand seeds (WTS), dry mass of seeds (DMS) and water content (WC).

Cunha-Silva et al. [14], studying the biometry of seeds of *Hymenaea courbaril* var. *Stilbocarpa* found mean values of length and diameter of 25.7 mm and 18.7 mm, respectively, which are values very close to those obtained in this study.

The small seeds presented mean values of diameter of the seed (DS), weight of a thousand seeds (WTS), dry mass of seeds (DMS) and water content (WC) equal to 16.31 mm, 3940.06 g, 3.75 g^{-1} and 8.93%, respectively. For the seeds classified as medium, the averages were 17.14 mm for DS, 4659.63 g for DMS, 4.67 g^{-1} for DMS and 7.74% for the water content. The averages of the physical characteristics of seeds of jatobá classified as large were, respectively, for DS, WTS, DMS and WC 17.63 mm, 5295.00 g, 4.92 g^{-1} and 8.92%.

The values measured for length and diameter of the seed of jatobá, classified as small seeds, medium-sized and large were separated into classes of distribution and checked the frequency on each one of them. The length of the small seeds (Fig. 1 A) were separated into

seven classes, ranging from 17.96 mm to 24.96 mm, approximately 80% of the relative frequency of LS these seeds are found in the last 4 classes of distribution, ranging from 20.96 to 24.96 mm, where these, 30% of small seeds have a length ranging from 22.96 to 23.96 mm.

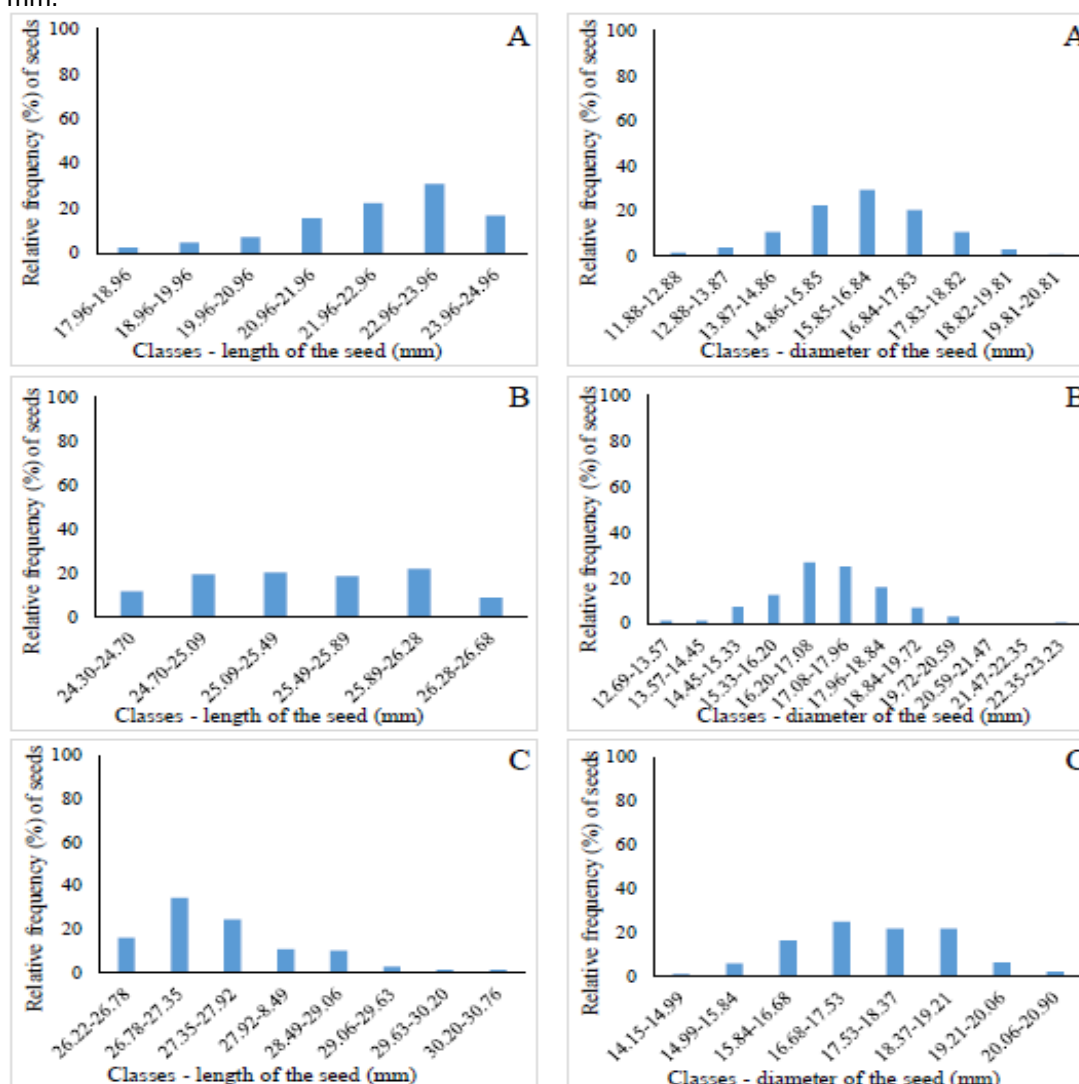


Fig 1. Relative frequency of seeds of *H. courbaril* in different classes of length and diameter. The seeds were classified in small seeds (A= LS ≤ 24.49 mm), medium (B= LS > 24.49 mm ≤ 26.49 mm) and large (C= LS ≥ 26.50 mm).

For classified as medium (Fig. 1 B), the lengths of the seeds were distributed into 6 classes with a variation of 24.30 mm to 26.68mm. The highest relative frequencies of LS were verified in 4 intervals of classes average, the intervals of classes of extremities showed lower relative frequencies.

For the large seeds (Fig.1 C), the lengths of the jatobá seeds were separated into 8 classes with a variation of 26.22 to 30.72 mm. The greater relative frequency of LS, approximately 90%, were observed in the intervals of classes ranging from 26.22 mm to 29.06 mm, among

these 90%, approximately 55% of the seeds assessed are distributed in the intervals between 26.78 mm and 27.92 mm.

The values of diameter of small seeds (DS) were divided into 9 classes of distribution (Figure 1), the greater the relative frequency of seeds were observed in class intervals ranging from 13.87 to 18.82 mm. For the seeds averages (Fig. 1 B) were verified 12 intervals of classes of diameter of the seed, where the largest relative frequency, approximately 84%, was found in the intervals between 14.45 and 19.72 mm, while the large seeds (Fig. 1 C) had the values of DS separated into 8 intervals of classes, ranging from 14.15 mm to 20.90 mm, where 83% of the seeds observed are distributed at intervals of classes of diameters between 15.84 and 19.21 mm.

In Table 2 it is possible to check that the large seeds showed a lower mean germination percentage, while small and medium-sized seeds did not differ statistically. On the GSI, MGT and ASG the treatments did not differ statistically. The medium seeds had the lowest average percentage of first germination count, and the small and large seeds had the same average.

Table 2. Germination test of seeds of *H. courbaril* L. of different sizes.

Seed Size	G (%)	GSI	MGT (days)	ASG (days ⁻¹)	FCG (%)
Small	79.05 a	0.427 a	28.23 a	0.0353 a	4.76 a
Medium	74.29 a	0.398 a	28.39 a	0.0353 a	2.85 b
Large	66.67 b	0.362 a	28.18 a	0.0354 a	4.76 a
CV (%)	6.29	12.89	4.14	5.36	14.83

Medium followed by the same letter in column did not differ statistically among themselves by Tukey test ($p \leq 0.05$).

Note: germination (G), germination speed index (GSI), mean germination time (MGT), average speed of germination (ASG), first count of germination test (FCG).

Thus, for this species it is possible to observe that the size of the seed did not influence the germination, because besides the percentage of germination for larger seeds was smaller and the first count of the test of germination of the large seeds did not differ from small the other parameters did not differ, differently than the authors Carvalho and Nakagawa [7] and Oliveira et al. [8] reported that larger seeds may present better performance and divergence, as reported by Silva et al. [9], who work with different seed sizes of *Artocarpus heterophyllus* Lam., verified that the smaller seeds had a lower percentage of germination.

Pagliarini et al. [15], working with different substrates and sizes of seeds of *Hymenaea courbaril*, found germination percentage similar to the substrate vermiculite, ranging from 77.5% to 87.5% large seed to seed storage medium, with no statistical difference between the classes of seeds.

Unlike found in this study by Pereira et al. [16], studying different sizes of seeds of *Hymenaea stigonocarpa*, found a difference for mean germination time on that small seeds, medium-sized and large presented respective values of 19.10, 21.03 and 24.92 days, with the large seeds presenting greater MGT than the other sizes, meaning then that these take longer to germinate, results similar to this study, indicating that the seed size of this kind does not influence the percentage of germination.

The results of the test are available in Table 3. As the emergence percentage and emergence velocity index, the large seeds obtained the highest average, and small and medium-sized showed no significant difference, while for the parameter MET, with averages of 30.29 days, 29.47 days and 29.46 days, and ASE, with averages of 0.033, 0.034, and 0.034 day⁻¹,

226 respectively, for the seeds of size small, medium and large, did not differ statistically among
 227 treatments.

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Table 3. Emergency test of seeds of *H. courbaril* L. of different sizes.

Seed Size	E (%)	ESI	MET (days)	ASE (days ⁻¹)
Small	42.86 b	0.216 b	30.29 a	0.033 a
Medium	44.76 b	0.232 b	29.47 a	0.034 a
Large	52.39 a	0.271 a	29.46 a	0.034 a
CV (%)	5.89	6.21	3.27	3.56

230 Medium followed by the same letter in column did not differ statistically among themselves by Tukey
 231 test ($p \leq 0.05$).

232 Note: emergence (E), emergence speed index (ESI), mean emergency time (MET), average speed of
 233 emergence (ASE).

234

235 Klein et al. [17], working with different seed sizes of pitanga (*Eugenia uniflora* L.) obtained
 236 similar results with these for the emergence of seedlings, in which the two largest seed sizes
 237 were higher than the smaller. In addition, we found no significant difference between the siz-
 238 es, unlike the observed in this study, where larger seeds showed higher mean emergence
 239 speed index.

240

241 The findings of the evaluation of seedlings after germination is displayed in Table 4. The
 242 seedlings from the small seeds showed an average of dry mass of the root and hypocotyl
 243 length and diameter of the inferior to other treatments. Unlike found by Pagliarini et al. [15],
 244 also working with different sizes of seeds of *Hymenaea courbaril* L., who found no difference
 245 in the diameter of the hypocotyl.

246

Table 4. Performance of seedlings of *H. courbaril* L. originated from seeds of different sizes.

Seed Size	LH (cm)	RL (cm)	HD (mm)	DMA (g)	DMR (g)
Small	24.08 b	11.07 a	4.58 b	9.08 b	1.73 b
Medium	26.09 a	11.81 a	4.94 a	11.03 a	2.05 a
Large	26.14 a	12.34 a	5.12 a	10.41 ab	2.12 a
CV (%)	5.11	8.20	5.17	9.73	14.59

249 Medium followed by the same letter in column did not differ statistically among themselves by Tukey
 250 test ($p \leq 0.05$).

251 Note: length of hypocotyl (LH), root length (RL), the hypocotyl diameter (HD), mass of dry matter of
 252 aerial part (DMA), dry mass of the root (DMR).

253

254 Silva et al. [18], met with results similar to the present study while studying different dimen-
 255 sions of seed of field bean (*Clitoria fairchildiana* R. A. Howard.), where the results of their
 256 research suggested that the germination was not affected by the size of the seed, but larger
 257 seeds showed higher mean weight of root dry matter.

258

259 Klein et al. [17], analysing seeds of pitanga (*Eugenia uniflora* L.) with different sizes, corrob-
 260 orated by the results of the length of the shoot, root and hypocotyl diameter. Whereupon the
 261 averages for shoot length and diameter of the hypocotyl were smaller for the smaller seeds,
 262 and the averages for root length did not differ.

263

264 Searching for seeds of jackfruit (*Artocarpus heterophyllus* Lam.), Silva et al.,
 265 [9], observed that for the mass of dry matter of the root system, the hypocotyl diameter and
 266 length of aerial part, the smaller seeds presented lower averages.

267

The size of the seed is a variable that demonstrates enough influence in the vigor of seed and seedling performance, especially those obtained from native species, since during the whole process of formation of the seed, the climatic components, which the mother plants are subjected exert a great deal of interference in the characteristics of the fruit and, consequently, of the seed. In the present study, the size of the seeds reflected effects on physiological quality of the seeds, mainly in the parameters related to the performance of seedlings.

4. CONCLUSION

For this species it was possible to verify that the size of seeds did not influence the germination of the same, but when evaluated in greenhouse conditions (not controlled) larger seeds showed better performance.

The seedlings evaluated of medium and large seeds showed better performance in the majority of parameters, in addition, it is recommended that, when available in sufficient quantity, the use of large seeds, because they have a higher percentage of seedling emergence and the highest quality.

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