Australian Journal of Crop Science AJCS

AJCS 13(04):622-627 (2019) ISSN:1835-2707
doi: 10.21475/ajcs.19.13.04.p1651

Biometric characteristics of fruits, seeds and plants of *Hancornia speciosa* Gomes. (Apocynaceae)

Alan Mario Zuffo[1*], Aécio Busch[2], Fábio Steiner[2], Charline Zaratin Alves[1], Francisco de Alcântara Neto[3], Mariely de Abreu dos Santos[1], Graziely Alves Nogueira[1], Wéverson Lima Fonseca[4], Augusto Matias de Oliveira[5], Tiago de Oliveira Sousa[6], Adaniel Sousa dos Santos[5]

[1]Federal University of Mato Grosso do Sul, 79560-000, Chapadão do Sul, Mato Grosso do Sul, Brazil
[2]State University of Mato Grosso do Sul, 79540-000, Cassilândia, Mato Grosso do Sul, Brazil
[3]Federal University of Piauí, 64049-550, Teresina, Piauí, Brazil
[4]Federal University of Ceará, 60020-181, Fortaleza, Ceará, Brazil
[5]Federal University of Piauí, 64900-000, Bom Jesus, Piauí, Brazil
[6]Federal University of Vales de Jequitinhonha and Mucuri, 39100-000, Diamantina, Minas Gerais, Brazil

***Corresponding author: alan_zuffo@hotmail.com**

Abstract

The economic and scientific interest in *Hancornia speciosa* Gomes (mangabeira) has increased in recent years, especially due to the commercialization of its fruits and the extraction of natural compounds with high pharmacological potential. This paper aims to determine and correlate the main physical and biometric characteristics of fruits and seeds of mangaba tree, as well as identifying the most appropriate substrate for the seedling emergence test. The following physical and biometric traits were measured in 100 fruits and 100 seeds: longitudinal diameter, transverse diameter, thickness, fresh mass, pulp fresh mass, volume, number of seeds. To identify the best substrate, a completely randomized design with two treatments (substrates) and ten replications of 20 seeds was used. The evaluated substrates were: sand and commercial substrate (Plantmax HT®). The shoot height, root length, stem diameter, total dry mass, and the relation between shoot height and stem diameter were evaluated at 50 days after sowing. Mangaba fruits and seeds showed great variations in their biometric traits, in addition to significant and positive correlation predominant in most characteristics. High fruit pulp yield can be optimized with the selection of plants with fruits show greater fresh mass due to the high degree of association between this characteristic and pulp yield. The use of the commercial substrate resulted in higher shoot height, greater number of leaves, and higher shoot height/stem diameter ratio.

Keywords: Cerrado, Spearman's correlation, mangabeira, mangaba trees.
Abbreviations: CV_coefficient of variation, SD_Standard Deviation, FLD_fruit longitudinal diameter, FTD_fruit transverse diameter, FFM_fruit fresh mass, FV_fruit volume, PFM_pulp fresh mass, NSF_number of seeds per fruit, SLL_seed longitudinal length, SW_seed width, ST_seed thickness, SFM_seed fresh mass, SH_shoot height, RL_root length, SD_stem diameter, NL_number of leaves, TDM_total dry mass, SH/SD_relation between shoot height and stem diameter.

Introduction

Hancornia speciosa Gomes, popularly known as 'mangaba tree' or 'mangabeira', is a tropical fruit tree native to Brazil and belonging to the family Apocynaceae. It occurs in the tableland and coastal plains of the Northeast, in the Cerrado of the Central-West, in the North and Southeast regions of Brazil (Nascimento et al., 2014; Silva et al., 2017c). In the Cerrado region of Brazil, mangaba tree bloom from July to September and fruit maturation occurs from September and December (Silva-Júnior, 2006). Mangaba fruits may be consumed fresh or used to produce pulps, juices, sweets and ice creams (Silva-Júnior, 2006; Moura et al., 2011). In addition, studies have reported that the leaf extract has anti-hypertensive and vessel dilator effects (Pereira et al., 2012), whereas the latex has anti-inflammatory properties (Marinho et al., 2011). Due to the high economic and medicinal potential this species has been widely used in the reforestation programs of the Cerrado region (Santos et al., 2015; Almeida et al., 2016).

Biometric characterization consists in evaluating morphological traits of different parts of the plant, such as fruits and seeds, or of the plant as a whole (Silva et al., 2017a). According to Gusmão et al. (2006), biometric studies can contribute to the determination of plant patterns in genetic breeding programs, as well as to provide knowledge for direct and indirect selection in these traits.

The use of seeds is the most widely used method for the propagation of mangaba plants. However, as this species produces recalcitrant seeds, the sexual propagation is hampered (Santos et al., 2015). Therefore, the success of seed utilization depends on a rapid and uniform emergence of seedlings in the nursery or field (Barros et al., 2010; Vieira et al., 2015). The delay in emergence of seedlings leaving the

seeds more vulnerable to attack from predators (pests and pathogens) and unfavorable environmental conditions (temperature, substrate moisture, among others) and, therefore, compromise the establishment of a uniform stand (Silva et al., 2017b; Ribeiro et al., 2017).
The cultivation of a native species depends on the technical knowledge, spread and growing environment of this species. Thus, among other important factors for the production of seedlings, are the type of substrate used (Silva et al., 2011; Gordin et al., 2016). The substrate has the function of sustaining the plants during rooting, in addition to providing the essential mineral nutrients. Therefore, the substrate may influence both emergence and initial seedling growth due to their physical, chemical and biological properties (Silva et al., 2011; Ajalla et al., 2012). Thus, studies aiming to establish the best substrate for the emergence of mangaba seedlings are necessary to ensure the propagation of the species in reforestation areas
In this context, this paper aims to determine and correlate the main biometric characteristics of fruits and seeds of mangaba tree, as well as identify the most appropriate substrate for the seedling emergence test.

Results and discussion

Biometry of the fruits and seeds

The descriptive analysis of the biometric traits of mangaba fruits and seeds is shown in Table 1. The coefficients of variation (CV) ranged from 21.28% to 121.62% for the fruits and from 30.84% to 92.29% for the seeds. These results show that the CV values varied from high (20 to 30%) to very high (> 30%), being higher than 30% for most variables, thus pointing to a great variation in the biometric traits of mangaba fruits and seeds. The CV values obtained in the present study are higher than those observed by Gonçalves et al. (2013) for biometric traits of mangaba and by Zuffo et al. (2018) for Cerrado cashew (*Anacardium humile* A. St. Hil.). However, in both studies, the authors collected the fruits from a Cerrado native area.
Regarding the biometric traits of mangaba fruits, 45% of the fruits had longitudinal diameter (FLD) in the range between 23.3 and 28.5 mm (Figure 2a), with an average value of 26.57 mm (Table 1). The mean fruit transverse diameter (FTD) was 24.15 mm (Table 1), with 76% of the fruits having values in two transversal diameter classes between 17.6 to 23.1 mm and from 23.2 to 28.7 mm (Figure 2b). For the fruit fresh mass (FFM), 78% of the fruits having values between 3.6 and 15.8 g (Figure 2c), with an average value of 13.37 g (Table 1). Fruit volume (FV) ranging from 4.0 to 41.0 cm^3, with 64% of the fruits presenting values between 4.0 and 10.2 cm^3 (Figure 1d), with average value of 12.59 cm^3 (Table 1). For pulp fresh mass (PFM), 77% of the fruits having values in the range between 2.7 and 14. 9 g (Figure 1e), with average PFM value of 12.67 g (Table 1). Regarding the number of seeds per fruit (NSF), 70% of the fruits presented 0-3 seeds (Figure 2f), and it was the characteristic with the greatest variation for fruits. These results presented here are below those showed by Gonçalves et al. (2013), which verified that the values of fruit longitudinal diameter (FLD), fruit fresh mass (FFM), fruit volume (FV), pulp fresh mass (PFM), number of seeds (NSF) in the mangaba fruits were 44.57 mm, 41.81 mm, 46.49 g, 4.77 cm^3, 40.15 g and 22 units, respectively. However, Nascimento et al. (2014) showed an average value of 17.17 g for fresh mass of mangabeira fruits, while Ganga et al. (2010) reported that the mangaba fruits have average value of fresh mass of 27.88 g. These variations in fresh mass and other biometric traits may be related to genetic variability and environmental conditions resulting from geographical locations (Santos et al., 2009).
Regarding the biometric traits of mangaba seeds, 59% of the seeds presented a longitudinal length (SLL) between 9.2 and 11.0 mm (Figure 3a), with an average value of 9.87 mm (Table 1). For the seed width (SW), 32% of the seeds having values in the range between 8.3 and 8.9 mm (Figure 3b), and it was the biometric traits with the smallest variation for seeds. For the seed thickness (ST), 66% of the seeds presented values between 3.3 and 4.9 mm (Figure 3c), with an average value of 4.93 mm (Table 1). For the seed fresh mass (SFM), 64% of the seeds having values in the range between 0.1 and 0.4 g (Figure 3d), with an average value of 0.70 g (Table 1). These results were higher than those reported by Gonçalves et al. (2013) for seed longitudinal length (SLL), seed width (SW), seed thickness (ST) and seed fresh mass (SFM), with mean values of 9.43 mm, 7.35 mm, 3.42 mm and 0.27 g, respectively. Therefore, as can be seen, smaller fruits led to a reduced number of seeds per fruit, consequently producing seeds with larger dimensions and fresh mass.
After evaluating the intrinsic traits of fruits and seeds, it is also necessary to analyze the association between these characteristics (Zuffo et al., 2016a). The authors also state that the association between biometric traits is important because it allows assessing the degree of interference of a characteristic over another from an economic perspective, as well as indirect selection.
The values of Spearman's correlation coefficients (r_s) for the biometric traits of mangaba fruits and seeds (Table 2) indicated that there was a positive and significant correlation between fruit longitudinal diameter (FLD) and fruit transverse diameter (FTD). Fruit fresh mass (FFM) was significantly correlated with fruit volume (FV), pulp fresh mass (PFM), number of seeds per fruit (NSF) and seed fresh mass (SFM). Fruit volume (FV) also correlated significantly with pulp fresh mass (PFM), number of seeds per fruit (NSF) and fresh weight of seeds (FWS). Fruit fresh mass (FFM) was significantly correlated with the number of seed per fruit (NSF) and seed fresh mass (SFM). The number of seeds per fruit (NSF) presented a positive and significant correlation with seed fresh mass (SFM), while seed width (SW) correlated significantly with seed thickness (ST).
The highest correlation coefficient values were observed between fruit fresh mass (FFM) and pulp fresh mass (PFM) (r_s = 0.994; p = 0.01). These results were expected for the association between FFM and PFM owing to the contribution of the pulp mass to the total mass of the fruit. High correlation coefficient values were also observed between fruit fresh mass (FFM) and number of seeds per fruit (NSF) (r_s = 0.729; p = 0.01). Therefore, the total fruit mass is directly related to pulp yield and number of seeds.
Accordingly, the selection of plants bearing fruits with greater fresh mass favors the improvement of the species, considering that the selection of plants with heavier fruits

Table 1. Biometric characterization of fruits and seeds of mangaba (*Hancornia speciosa* Gomes). N = 100 fruits and N = 100 seeds.

Parameter	Mean	Skewness	Kurtosis	S.D.	CV (%)
Fruit					
Longitudinal diameter (mm)	26.57 (0.56)[†]	-0.30	1.56	5.65	21.28
Transverse diameter (mm)	24.15 (0.56)	0.63	1.54	5.64	23.38
Fresh mass (g)	13.37 (0.99)	1.55	1.16	9.96	74.49
Volume (cm^3)	12.59 (0.95)	1.92	2.58	9.59	76.20
Pulp fresh mass (g)	12.67 (0.96)	1.56	1.30	9.60	75.76
Number of seeds	4.14(0.50)	1.60	1.25	0.50	121.62
Seed					
Length (mm)	9.87 (0.44)	1.75	5.44	4.43	44.88
Width (mm)	9.41 (0.29)	4.45	21.77	2.90	30.84
Thickness (mm)	4.93 (0.21)	1.25	-0.06	2.12	43.14
Fresh mass (g)	0.70 (0.06)	2.33	5.00	0.64	92.29

[†]Values in parentheses represent the standard error of the mean; S.D.: Standard Deviation; CV: Coefficient of Variation.

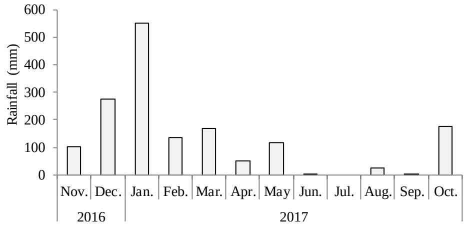

Fig 1. Mean monthly rainfall during the development of mangaba tree fruits in the years 2016 and 2017. Source: INMET Experimental Station in Cassilândia, MS, Brazil.

Table 2. Spearman's rank correlation coefficient (rs) between the different biometric characteristics of fruits and seeds of mangaba (*Hancornia speciosa* Gomes).

	FLD	FTD	FFM	FV	PFM	NSF	SLL	SW	ST
FTD	0.693**								
FFM	-0.116^{ns}	0.006^{ns}							
FV	-0.043^{ns}	-0.023^{ns}	0.636**						
PFM	-0.094^{ns}	0.026^{ns}	0.994**	0.619**					
NSF	0.006^{ns}	0.020^{ns}	0.740**	0.469**	0.729**				
SLL	0.072^{ns}	0.082^{ns}	-0.140^{ns}	-0.109^{ns}	-0.149^{ns}	-0.098^{ns}			
SW	-0.107^{ns}	-0.150^{ns}	-0.046^{ns}	-0.106^{ns}	-0.037^{ns}	0.095^{ns}	-0.101^{ns}		
ST	-0.151^{ns}	-0.034^{ns}	0.044^{ns}	0.052^{ns}	0.053^{ns}	-0.062^{ns}	-0.335^{ns}	0.463**	
SFM	-0.232^{ns}	-0.144^{ns}	0.393**	0.399**	0.338**	0.489**	-0.026^{ns}	-0.001^{ns}	0.044^{ns}

** and * significant at 0.01 and 0.05 significance level, respectively, by the T test; ns: non-significant. FLD - fruit longitudinal diameter, FTD – fruit transverse diameter, FFM - fruit fresh mass, FV - fruit volume, PFM - pulp fresh mass, NSF - number of seeds per fruit, SLL - seed longitudinal length, SW - seed width, ST - seed thickness, SFM - seed fresh mass.

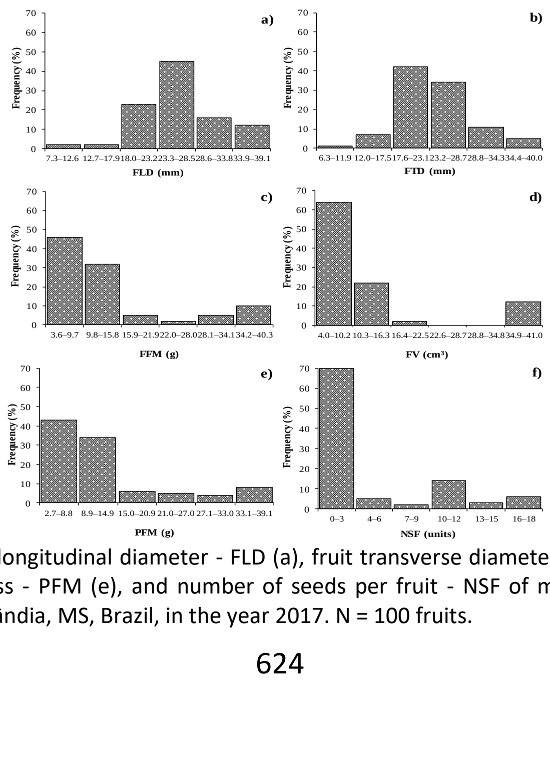

Fig 2. Frequency distribution of fruit longitudinal diameter - FLD (a), fruit transverse diameter - FTD (b), fruit fresh mass - FFM (c), fruit volume - FV (d), pulp fresh mass - PFM (e), and number of seeds per fruit - NSF of mangaba (*Hancornia speciosa* Gomes) collected in the municipality of Cassilândia, MS, Brazil, in the year 2017. N = 100 fruits.

Table 3. Shoot height (SH), root length (RL), stem diameter (SD), number of leaves (NL), total dry mass (TDM) and shoot height and stem diameter ratio (SH/SD) of mangaba (*Hancornia speciosa* Gomes) seedlings growing on two substrates. Cassilândia, MS, Brazil, 2017.

Substrate	SH	RL	SD	NL	TDM	SH/SD
	- - - - - - (cm) - - - - - -		(mm)	(unit)	(mg)	-
Sand	5.34±0.45b	5.51±0.71a	1.42±0.15a	4.13±0.32b	139.50±16.25a	3.93±0.54b
Commercial	6.85±0.49a	5.98±0.17a	1.33±0.17a	5.13±0.50a	141.75±18.81a	5.40±0.63a
CV (%)	9.09	22.15	10.76	11.82	16.51	17.25

Means followed by the same letter do not differ by the Fisher-Snedecor F test. CV: Coefficient of Variation.

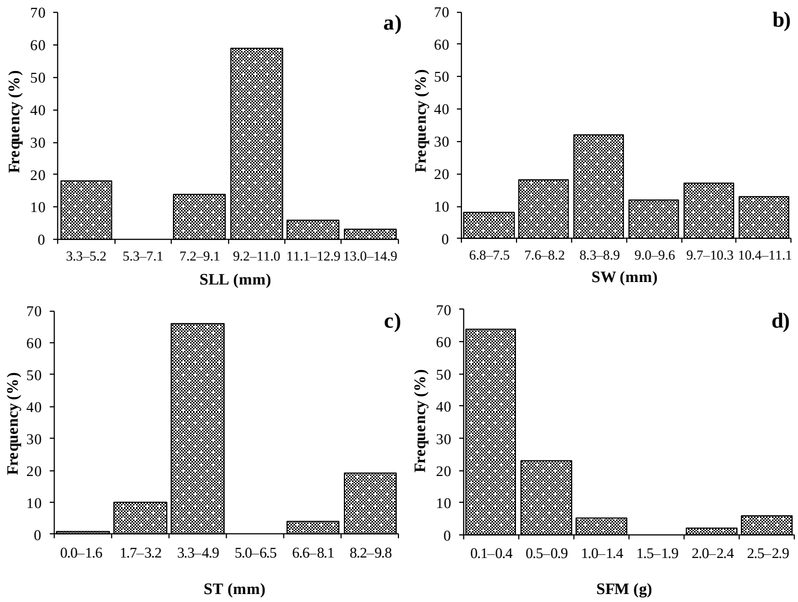

Fig 3. Frequency distribution of seed longitudinal length - SLL (a), seed width - SW (b), seed thickness - ST, (c) and seed fresh mass - SFM (d) of mangaba (*Hancornia speciosa* Gomes) collected in the municipality of Cassilândia, Mato Grosso do Sul, Brazil, in the year 2017. N = 100 seeds.

Table 4. Pearson's correlation (r) for the biometric variables of mangaba (*Hancornia speciosa* Gomes) seedlings.

	SH	RL	SD	NL	TDM	SH/SD
SH	1					
RL	0.283^{ns}	1				
SD	-0.218^{ns}	0.006^{ns}	1			
NL	0.678**	0.281^{ns}	-0.031^{ns}	1		
TDM	0.438*	0.372^{ns}	-0.218^{ns}	0.257^{ns}	1	
SH/SD	0.828**	0.168^{ns}	-0.689**	0.534**	0.411^{ns}	1

** and * significant at 0.01 and 0.05 significance level, respectively, by the T test; ns: non-significant. SH - shoot height, RL - root length, SD - stem diameter, NL - number of leaves, TDM - total dry mass, and SH/SD - shoot height and stem diameter ratio.

will result in an increase of pulp yield. These findings were also observed by Gonçalves et al. (2013) and Nascimento et al. (2014).

Effect of the substrate on emergence and seedling growth

The substrates used do not significantly affect (p >0.05) the root length (RL), stem diameter (SD) and total dry mass (TDM) of mangaba seedlings (Table 3). The non-effect of substrates on root length and stem diameter of mangaba plants were also reported by Silva et al. (2011). However, the commercial substrate (Plantmax HT®) provided seedlings with higher shoot height (SH), greater number of leaves (NL) and a higher shoot height and stem diameter ratio (SH/SD). Therefore, this commercial substrate should be used for adequate initial growth of the mangaba seedlings.

As previously stated, not only the intrinsic characteristics of plants should be analyzed but also the association between such characteristics (Zuffo et al., 2018). According to Zuffo et al. (2016a) and Zuffo et al. (2016b), this association is important as it allows assessing the degree of interference of one characteristic over another.

The values for Pearson's linear correlation coefficients of the mangaba seedlings indicated that there was a positive and significant correlation between shoot height (SH) with number of leaves (NL), total dry mass (TDM) and the SH/SD ratio; whereas the number of leaves (NL) correlated significantly only with the SH/SD ratio (Table 4). The highest correlation coefficient value (r = 0.828, p = 0.01) was observed between shoot height (SH) and the SH/SD ratio. On the other hand, there was a negative and significant correlation between stem diameter (SD) and the SH/SD ratio

(Table 4). Therefore, the selection of mangaba seedlings with higher shoot height will result in an indirect selection of seedlings with greater number of leaves (NL), higher total dry mass (TDM) and a higher SH/SD ratio.

Materials and methods

Biometric characterization of fruits and seeds of mangaba

Mature fruits of *Hancornia speciosa* Gomes ("mangaba") were collected from the 10 years old trees established in a savannah area located at the State University of Mato Grosso do Sul (UEMS), in the municipality of Cassilândia, MS, Brazil (19º05'20'' S, 51º48'24'' W, and altitude of 520 m), during the rainy season, in November 2017. The matrices trees have been conducted without specific management for pruning, fertilization, irrigation and phytosanitary control. The climate of the region, according to the Köppen classification, is Aw with rainy summer and dry winter. Climatic data were obtained from the weather station of the National Institute of Meteorology (INMET) (Figure 1).
After collected, the fruits were placed in polyethylene bags and taken to the Crop Science Laboratory of State University of Mato Grosso do Sul. In the laboratory, the fruits were previously selected, discarding those visually impaired or deformed, and a sample of 100 fruits was taken for measurement of biometric characteristics.
Fruit longitudinal diameter (FLD) and transverse diameter (FTD) were measured using a digital caliper (Clarke-150 mm) with 0.01 mm accuracy, considering the largest diameter. Fruit fresh mass (FFM) and pulp fresh mass (PFM) were individually weighed, in grams, using a digital precision balance with 210 g capacity and 0.0001 g accuracy. Fruit volume (FV), in cm^3, was determined by water displacement using a calibrated cylinder. The number of seeds per fruit (NSF) were also measured.
After the biometric characterization of the fruits, the seeds were manually extracted and then the measurements of seed longitudinal length (SLL), seed width (SW), seed thickness (ST) and seed fresh mass (SFM) were carried out using a digital caliper and a digital precision balance.
The biometric data of the fruits and seeds were analyzed using the adjustment of statistical distributions and descriptive statistics, who understood the measurements of position (average, minimum and maximum values) and dispersion (coefficient of variation, skewness, kurtosis and standard deviation). The Spearman's nonparametric correlation coefficient (r_s) and the respective significance level (P value) between the biometric characteristics of fruits and seeds were estimated using the t-test (Zar, 1996). All statistical analyses were performed using BIOESTAT version 5.0 software for Windows (Ayres et al., 2007).

Testing the effect of the substrate on sedling growth

The experiment was carried out under greenhouse conditions, at the State University of Mato Grosso do Sul (UEMS), in Cassilândia, MS, Brazil (19°06'48" S; 51°44'03" W and average altitude of 510 m) from November to December 2017. During the trial, the mean air temperature was 26.8 ºC during the day and was 23.4 ºC during the night, and mean relative humidity was 75% (± 5%).
The experimental design was completely randomized, with two treatments (substrates) and ten replications of 20 seeds. The substrates tested were: sand and commercial substrate (Plantmax HT®). The Plantmax HT® presented the following chemical characteristics: pH in $CaCl_2$ of 5.9; 5.8 g kg^{-1} of C, 680 mg kg^{-1} of P; 0.40 $cmol_c$ kg^{-1} of Al^{+3} + H; 2.90 $cmol_c$ kg^{-1} of K; 7.80 $cmol_c$ kg^{-1} of Ca; 7.50 $cmol_c$ kg^{-1} of Mg; 18.60 $cmol_c$ kg^{-1} of CEC. The substrates were placed in plastic trays (46 × 29 × 6.5 cm) and then the seeds were sown at a depth of ± 1.0 cm.
At 50 days after sowing (DAS), the following characteristics were evaluated: shoot height (in cm) – measuring from the substrate surface to the point of insertion of the highest leaf; root length (cm) – by measuring the length of the primary root; stem diameter (cm) – by measuring the root collar area using a digital caliper (Clarke-150 mm) with ± 0.01mm accuracy; and the number of leaves (NL). Afterwards, the shoots and roots were placed in paper bags and taken to a forced circulation oven for 72 hours at 65 °C (± 1.0 °C) for determination of the total dry mass using a digital precision balance. Based on these evaluations, the ratio between shoot height and stem diameter (SH/SD) was determined.
The data were submitted to analysis of variance (ANOVA) and, when significant, the means were compared by the Fisher-Snedecor F test, at a 0.05 significance level, using the statistical software Sisvar® version 5.3 for Windows (Software de Análises Estatísticas, UFLA, Lavras, MG, BRA).

Conclusion

The fruits and seeds of mangaba trees have great biometric variations, as well as a positive and significant correlation predominant in most of the biometric traits evaluated. Mangaba fruits with higher fresh mass are important indicators regarding the selection of fruits for the food industry as it guarantees higher pulp yields and, for the seed industry, it guarantees a greater number of seeds. The selection of larger fruits indirectly leads to the selection of fruits with higher pulp yields and a higher number of seeds.
The use of the commercial substrate resulted in higher shoot height, greater number of leaves, and higher shoot height/stem diameter ratio. Better quality mangaba seedlings can be obtained using the commercial substrate (Plantmax HT®), resulting in higher shoot height, greater number of leaves, and higher shoot height and stem diameter (SH/SD) ratio. Shoot height and number of leaves are the most adequate variables to indicate the ratio between shoot length and stem diameter.

Acknowledgments

The authors gratefully acknowledge financial support from the Federal University of Mato Grosso do Sul (UFMS) and the State University of Mato Grosso do Sul (UEMS).

References

Ajalla AC, Volpe E, Vieira MD, Zárate NAH (2012) Produção de mudas de baru (*Dipteryx alata* Vog.) sob três níveis de sombreamento e quatro classes texturais de solo. Rev Bras Frutic. 34(3):888-896.

Almeida LM, Nogueira CA, Borges PP, Prado ADL, Gonçalves PJ (2016) State of the Art of Scientific Literature on *Hancornia speciosa*: Trends and Gaps. Rev Bras Frutic. 38(4):1-10.

Ayres M, Ayres Júnior M, Santos AAS (2007) BioEstat 5.0: Aplicações estatísticas nas áreas das ciências biológicas e médicas. Belém: Sociedade Civil Mamirauá.

Barros DI, Bruno RLA, Nunes HV, Mendonça RMN, Pereira WE (2010) Comportamento fisiológico de sementes de mangaba submetidas à dessecação. Acta Tecnol. 5(1):31-43.

Ganga RMD, Ferreira GA, Chaves LJ, Naves RV, Nascimento JL (2010) Caracterização de frutos e árvores de populações naturais de *Hancornia speciosa* Gomes do Cerrado. Rev Bras Frutic. 32(1):101-113.

Gonçalves LGV, Andrade FR, Marimon Junior BH, Schossler TR, Lenza E, Marimon BS (2013) Biometria de frutos e sementes de mangaba (*Hancornia speciosa* Gomes) em vegetação natural na região leste de Mato Grosso, Brasil. Rev Cienc Agrar. 36(1):31–40.

Gordin CRB, Marques RF, Scalon SPQ (2016) Emergence and initial growth of *Hancornia speciosa* (Gomes) seedlings with different substrates and water availability. Rev Cienc Agrar. 59(4):352-361.

Gusmão E, Vieira FA, Fonseca Júnior ÉM (2006) Biometria de frutos e endocarpos de murici (*Byrsonima verbascifolia* Rich. ex A. Juss.). Cerne, 12(1):84–91.

Marinho DG, Alviano DS, Matheus ME, Alviano CS, Fernandes PD (2011) The latex obtained from *Hancornia speciosa* Gomes possesses anti-inflamatory activity. J Ethnopharmacol. 135(2):530-537.

Moura NF, Chaves LJ, Venkovsky R, Naves RV, Aguiar AV, Moura MF (2011) Genetic structure of mangaba (*Hancornia speciosa* Gomes) populations in the Cerrado region of central Brazil. Biosci J. 27(3):473-481.

Nascimento RSM, Cardoso JÁ, Cocozza FDM (2014) Caracterização física e físico-química de frutos de mangabeira (*Hancornia speciosa* Gomes) no oeste da Bahia. Rev Bras Eng Agric Amb. 18(8):856-860.

Pereira ABD, Veríssimo TM, Oliveira MA, Araújo IA, Alves RJ, Braga FC (2012) Development and validation of an HPLC-DAD method for quantification of bornesitol in extracts from *Hancornia speciosa* leaves after derivatization with p-toluenesulfonyl chloride. J Chromatogr B. 887:(1): 133-137.

Ribeiro MR, Souto AGL, Maitan MQ, Xavier BS, Rosado LDS, Santos CEM (2017). Luminosity and sowing depth in the emergence and development of passion fruit seedlings. J Seed Sci. 39(3), 311-317.

Santos FS, Paula RC, Sabonaro DZ, Valadares J (2009) Biometria e qualidade fisiológica de sementes de diferentes matrizes de *Tabebuia chrysotricha* (Mart. ex A. DC.) Standl Sci For. 37(82):163-173.

Santos PAA, Paiva R, Silva LC, Souza AC, Santana MC, Silva DPC (2015) Cryopreservation of the mangaba tree (*Hancornia speciose* Gomes): a protocol for long-term storage. Acta Sci Agro. 37(3):289-296.

Silva-Junior JF, Lédo AS (2006) A cultura da mangaba. Aracaju: Embrapa Tabuleiros Costeiros.

Silva EA, Oliveira AC, Mendonça V, Soares FM (2011) Substratos na produção de mudas de mangabeira em tubetes. Pesqui Agropecu Trop. 41(2):279-285.

Silva RM, Cardoso AD, Dutra FV, Morais OM (2017a) Aspectos biométricos de frutos e sementes de *Caesalpinia ferrea* Mart. ex Tul. provenientes do semiárido baiano. Rev Agric Neotropical, 4(3):85-91.

Silva ACD, Smiderle OJ, Oliveira JMF, Silva TJS (2017b) Tamanho da semente e substratos na produção de mudas de açaí. Adv For Sci. 4(4):151-156.

Silva EA, Oliveira AC, Mendonça V, Soares FM (2011) Substratos na produção de mudas de mangabeira em tubetes. Pesq Agropec Trop. 41(3):279-285.

Silva AVC, Amorim JAE, Vitória MF, Ledo AS, Rabbani ARC (2017c) Characterization of trees, fruits and genetic diversity in natural populations of mangaba. Ciênc Agrotec. 41(3):255-262.

Vieira MC, Naves RV, Souza ERB, Silva GD, Belo APM, Camilo YMV (2015) Emergência de plântulas de mangabeira provenientes de frutos coletados em diferentes localidades do Estado de Goiás. Com Sci. 6(1):33-40.

Zar JH (1996) Biostatistical analysis. 4. ed. New Jersey, River, Prentice-Hall/Upper Saddle.

Zuffo AM, Gesteira GS, Zuffo Júnior JM, Andrade FR, Soares IO, Zambiazzi EV, Guilherme SR, Santos AS (2016a) Caracterização biométrica de frutos e sementes de mirindiba (*Buchenavia tomentosa* Eichler) e de inajá (*Attalea maripa* [Aubl.] Mart.) na região sul do Piauí, Brasil. Rev Ciênc Agrár. 39(1):455-472.

Zuffo AM, Steiner F, Bush A, Zuffo Júnior JM (2016b) Physical characterization of fruits and seeds of *Delonix regia* (Bojer ex Hook.) raf. (Fabaceae – Caesalpinoideae). Int J Curt Res. 8(11):42072-42076.

Zuffo AM (2018) Biometria do hipocarpo, fruto e semente e desenvolvimento das plântulas de *Anacardium humile* A. St. Hil. (Anacardiaceae). Rev Ciênc Agrár. 41(2):464-474.