Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.14, n.2, e5645, 2019
Recife, PE, UFRPE. www.agraria.pro.br
DOI:10.5039/agraria.v14i2a5645
Protocolo 5645 - 02/05/2018 • Aprovado em 24/01/2019

Morphological and physicochemical descriptors for characterization of mangaba tree germplasm

Ana Veruska Cruz da Silva Muniz[1], Marina Ferreira da Vitória[2], Ana Letícia Sirqueira Nascimento[3], Ana da Silva Ledo[1], Lúcio Flávio Mota Macedo[2], Evandro Neves Muniz[1], Josué Francisco Silva Júnior[1]

[1] Embrapa Tabuleiros Costeiros, Aracaju, SE, Brasil. E-mail: ana.veruska@embrapa.br (ORCID: 0000-0002-4177-9335); ana.ledo@embrapa.br (ORCID: 0000-0002-4353-4788); evandro.muniz@embrapa.br (ORCID: 0000-0003-2806-229X); josue.francisco@embrapa.br (ORCID: 0000-0002-4427-7488)
[2] Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Ciências Agrárias e Veterinárias de Jaboticabal, Jaboticabal, Brasil. E-mail: marina_fv@hotmail.com (ORCID: 0000-0003-3616-0703); flaviommota.zoo@gmail.com (ORCID: 0000-0001-9983-1784)
[3] Universidade Federal de Sergipe, Campus São Cristóvão, São Cristóvão, SE, Brasil. E-mail: analeticia_16@hotmail.com (ORCID: 0000-0002-3011-5322)

ABSTRACT: The objective of this study was to evaluate and select morphological and physicochemical descriptors for the characterization of mangaba tree germplasm. We used 30 descriptors in 54 plants from 10 accesses in the fruiting stage (CA, AB, PT, PR, TC, PA, LG, BI, IP and AD) from the Active Germplasm Bank of Embrapa Coastal Tablelands located in the Experimental Field of Itaporanga d'Ajuda, Sergipe, Brazil, faithful trustee of the species. The diversity was verified between and within the accesses, however, without direct relation with its origins. The mean vitamin C content was considered high (394.45 mg/100g) and there was no difference between the accesses. There was a significant difference for most descriptors related to the growth of the plants and the physicochemical characteristics of the fruits. The results are important for the conservation actions of the species and individuals selection for future improvement programs.

Key words: *Hancornia speciosa* Gomes; morphology; postharvest; variability

Descritores morfológicos e físico-químicos para caracterização de germoplasma de mangabeira

RESUMO: O objetivo deste trabalho foi avaliar e selecionar descritores morfológicos e físico-químicos para caracterização de germoplasma de mangabeira. Foram utilizados 30 descritores em 54 plantas oriundas de 10 acessos em fase de frutificação (CA, AB, PT, PR, TC, PA, LG, BI, IP e AD) do Banco Ativo de Germoplasma da Embrapa Tabuleiros Costeiros, localizado no Campo Experimental de Itaporanga d'Ajuda, Sergipe, Brasil, fiel depositário da espécie. A diversidade foi verificada dentro e entre acessos, entretanto, sem relação direta com suas origens. O teor médio de vitamina C foi considerado alto (394.45 mg/100g) e não houve diferença entre os acessos. Houve diferença significativa para a maioria dos descritores relacionados ao crescimento das plantas e características físico-químicas dos frutos. Os resultados são importantes para as ações de conservação da espécie e seleção de indivíduos para futuros programas de melhoramento genético.

Palavras-chave: *Hancornia speciosa* Gomes; morfologia; pós-colheita; variabilidade

Introduction

The mangaba tree (*Hancornia speciosa* Gomes - Apocynaceae), a native fruit from Brazil, is naturally found from the Coastal Tablelands and Coastal Lowlands of the Northeast to the Cerrados of the Central-West, North and Southeast regions (Soares et al., 2006). The species has been suffering a reduction in areas of natural occurrence, with conservation strategies being now essential for its preservation. Mangaba fruits can be consumed *in natura*, but most of the yield is processed and used in the production of frozen pulp, juices, sweets, jellies, ice cream and liqueurs. Research has revealed the potential nutritional value, with a higher protein content than that of most fruit species that are used commercially (Nascimento et al., 2014), as well as being a source of vitamins (A, B1, B2 and C), iron, phosphorus and calcium (Soares et al., 2007).

In order to minimize the genetic erosion of native species, several research centers are dedicated to develop strategies for germplasm conservation (Nabout et al., 2016). The implementation of Germplasm Banks (BAGs) is a widely used *ex situ* conservation strategy based on the conservation of the species in the field, outside its place of origin (Costa et al., 2011). In these sites, the genetic variability of the species is conserved, as well as it can be increased, with the constant introduction of new accesses and/or cultivars from areas of occurrence or improvement programs (Brondani et al., 2006).

Embrapa has an Active Germplasm Bank of Mangaba (BAGMangaba), established in 2006 in the municipality of Itaporanga d'Ajuda/SE, consisting of 22 accesses, propagated by open pollinated seeds, from the states of Bahia, Paraíba, Sergipe, Pernambuco, Alagoas, Ceará, Pará and Minas Gerais.

In order to know the germplasm variability, it is fundamental to characterize the available accesses, which can be through lists of published botanical, morphological and agronomic descriptors (Gotor et al., 2011). In perennial plants, such as the mangaba tree, the morphoagronomic characterization performs a preponderant function for eliminating duplicates, reducing maintenance costs and identifying desirable accesses to improvement (Burle & Oliveira, 2010). The BAGMangaba characterization has been executed since its implementation, and the data contained in this study collaborated for the recent publication of the new list of species descriptors by FAO/Bioversity (Silva Júnior et al., 2018).

This study was developed with the objective of evaluating 30 morphological and physicochemical descriptors in 54 plants from 10 accesses from the Active Germplasm Bank of the Embrapa Coastal Tablelands (BAGMangaba).

Materials and Methods

The study was held at BAGMangaba, located in the Experimental Field of Itaporanga d'Ajuda, SE (11°06'40"S and 37°11'15"W). In 2016, from January to April, 54 plants from 10 accesses in the fruiting phase were evaluated. (Table 1).

The accesses were characterized using quantitative morphological (Table 2), qualitative morphological (Table 3) and physicochemical (Table 4) descriptors. The selected descriptors were based on descriptors lists from taxonomically close species that are part of the same genus and family, as recommended by Burle & Oliveira (2010).

In order to perform the physicochemical characterization, we evaluated: a) Soluble solids content (SS), using a digital refractometer, PAL-1 model (Atago Co, Tokyo, Japan), according to AOAC (1992) standards, expressed as °Brix; b) Total titratable acidity (TTA): determined by titration with 0.1N NaOH solution and 1% phenolphthalein as the initiator, with values expressed as percentage of citric acid; c) Potential of ionic hydrogen (pH) of the pulp: with readings done by an electronic potentiometer, in the solution containing 5 g of diluted pulp in 50 ml of distilled water; d) SS/TTA ratio: obtained by dividing the two parameters; e) Vitamin C: determined by titration with DCBIB (Diclorofenolendofenol) and the values expressed in mg.100^{-1} g of fresh matter. The sample was composed of 12 adult leaves, 12 mature fruit and 12 seeds per fruit of each individual. The fruit were harvested when ripe, still on the plant, with yellow bark and red pigmentation in almost the whole area. The experimental design was completely randomized, with 10 treatments (accesses) and replicates ranging from 4 to 6 plants, as a function of the individuals number per access (Table 1).

The quantitative morphological characterization was analyzed by the Scott-Knott test (Scott & Knott, 1974) at 5% probability using the SISVAR statistical program (Ferreira, 2011). The qualitative data analysis was submitted to the Kruskal-Wallis non-parametric test (Pohlert, 2016), employing

Table 1. Origin and number of mangaba tree germplasm accesses from Embrapa Coastal Tablelands, Itaporanga d'Ajuda, SE.

Precedence	Code/Access	No. of plants	Latitude	Longitude
Jandaíra, BA	Costa Azul - CA	5	11°33'43" S	37°40'52" W
Conde, BA	Barra de Itariri – BI	6	11°48'34" S	37°40'52" W
Mata de São João, BA	Lagoa Grande – LG	6	12°31'52" S	38°18'04" W
Indiaroba, SE	Terra Caída – TC	6	11°31'10" S	37°30'47" W
Indiaroba, SE	Preguiça – PR	6	11°30'43" S	37°27'11" W
Indiaroba, SE	Pontal – PT	6	11°28'24" S	37°24'16" W
Salvaterra, PA	Água Boa – AB	6	0°45'22" S	48°30'55" W
Conde, PB	Ipiranguinha – IP	5	7°45'22" S	34°54'43" W
Alhandra, PB	Mata Redonda– AD	4	7°20'38" S	34°56'07" W
João Pessoa, PB	Paratibe – PA	4	7°12'25" S	34°49'06" W

Table 2. Quantitative morphological descriptors for evaluation of 54 plants in mangaba tree germplasm.

Descriptor	Abbrev.	Evaluation form/unit	Evaluation method
Plant height	H	Height from ground to highest leaf (m)	Digital clinometer
Crown insertion	IC	Height from the ground to the start of the crown (m)	Measuring tape
Crown length	L	Mean of the North-South and East-West crown lengths (m)	Tape measure
Crown diameter	CD	Crow length/2 (m)	Tape measure
Stalk diameter	SKD	Measured diameter below crown insert (cm)	Measuring tape
Leaf blade length	LBL	Length from base to the leaf apex (cm)	Graduated ruler
Leaf blade width	LBW	Measurement, in cm	Graduated ruler
Petiole length	PEL	Measurement, in cm	Graduated ruler
Fruit diameter	FD	Measurement, in cm	Digital calipers
Fruit length	FL	Measurement in cm	Precision scale
Fruit mass	FM	Weight, in g	Precision scale
Total number of seeds	NS	Counting, Unit	Manual counting
Seed mass	SM	Weight, in g	Precision scale
Total seeds mass	TSM	Weight in g	Precision scale
Seed length	SL	Measurement, in mm	Digital calipers
Seed diameter	SD	Measurement, in mm	Digital calipers

Table 3. Qualitative morphological descriptors for the evaluation of 54 plants in mangaba tree germplasm.

Descriptor	Abbrev.	Classification
Crown shape	CS	0. Conical 1. Round 2. Flattened 3. Flattened Round 4. Elongated Round
Trunk surface	TS	0. Smooth 1. Rough 2. Very Rough
Ramification pattern	RP	0. Less Ramified 1. Intermediate 2. Very Ramified
Leaf shape	LS	0. Lanceolate 1. Elliptical 2. Oblong 3. Oblong Lanceolate 4. Oval
Leaf edge	LE	0. Straight 1. Slight wavy 2. Wavy
Inflorescence position	INP	0. Terminal 1. Subterminal 2. Axillary 3. Terminal and Subterminal 4. Terminal and Axillary
Fructification habit	FH	0. Lone Fruits 1. Fruits in bunches 2. Lone/Bunches
Fruit shape	FS	0. Oblong 1. Rounded
Fruit size uniformity	FSU	0. Low 1. Intermediate 2. High

the chi-squared test with standardized adjusted residuals for the multiple comparisons, using Yates correction or Fisher exact test, when necessary, with the aid of the R software (R Development Core Team, 2015).

The cluster analysis was performed using the hclust (R Development Core Team, 2015) and factoextra (Kassambara & Mundt, 2005) packages. It was used as a dissimilarity measure the standardized Euclidean distance (D):

$$D = \left\{ \sum_{K=1}^{p} (X_{ik} - X_{jk})^2 \right\}^{\frac{1}{2}}$$

where X_{ik} represents the i individual characteristic, for the k variable; X_{jk} represents the characteristic of j individual, for the k variable and p represents the number of variables. In order to visualize the relations between the quantitative descriptors, the Pearson correlation coefficient matrix was estimated and calculated based on the Euclidean standardized distance by the UPGMA (Unweighted Pair-Group Method using Arithmetic Averages) method, with the aid of the R software (R Development Core Team, 2015).

Results and Discussion

The quantitative descriptors contributed to the accesses differentiation, since for most results there was a significant difference (Table 4). Accesses with significant variance composep two groups, and in both, they came from different states. The amplitude of the coefficient of variation (CV) was from 4.34% to 61.29% for the descriptors potential of ionic hydrogen (pH) and crown insertion (CI), respectively. The CV values can be considered average when in comparison with other similar studies using the species (Freitas et al., 2012; Souza et al., 2007).

Considering the plant height (H), the highest means were observed in the CA accesses with 5.17 m, followed by LG (4.95 m), AB (4.9 m) and BI (4.9 m) accesses. Similar results were found by Ganga et al. (2010), when evaluating the mangaba tree variability in the Cerrado, with an mean of 4.58 m.

For the crown length (L), the highest means were obtained in the CA (4.775 m), LG (4.52 m), BI (4.47 m) and AB (4.40 m) accesses. About the crown diameter, the highest mean values were 5.34 m (PT access), 5.31 m (TC access), 5.27 m (LG access), 5.09 m (CA access), and 5.05 (AB access). When analyzing the

Table 4. Plant growth descriptors used in the accesses characterization of the Germplasm Active Bank from Embrapa Coastal Tablelands.

Descriptor	AB	AD	BI	CA	IP	LG	PA	PR	PT	TC	CV (%)	Mean
Plant height	4.90 a	3.52 b	4.90 a	5.17 a	4.24 b	4.95 a	3.90 b	4.88 b	4.45 b	4.81 b	15.06	4.62
Crown insertion	0.49 a	0.54 a	0.42 a	0.40 a	0.47 a	0.42 a	0.69 a	0.62 a	0.27 a	0.68 a	61.29	0.49
Crown length	4.40 a	2.97 b	4.47 a	4.77 a	3.76 b	4.52 a	3.20 b	4.26 b	4.17 b	4.13 b	17.78	4.12
Crown diameter	5.05 a	4.11 b	4.77 a	5.09 a	3.89 b	5.27 a	3.83 b	4.61 b	5.34 a	5.31 a	18.87	4.79
Stalk diameter	5.11 a	3.58 b	4.83 a	4.99 a	3.21b	4.62 b	3.44 b	4.49 a	5.63 a	4.67 a	22.54	4.53
Leaf length	5.20 a	4.46 a	4.81 a	4.52 a	4.68 a	4.65 a	4.16 a	4.78 a	4.62 a	4.74 a	7.77	4.69
Leaf width	1.95 a	1.86 a	1.82 a	1.77 a	1.75 a	1.97 a	1.66 a	2.05 a	1.84 a	1.93 a	10.37	1.87
Petiole length	0.80 a	1.00 a	0.77 a	0.76 a	0.82 a	0.67 a	0.82 a	0.79 a	0.85 a	0.69 a	15.88	0.79

*Means followed by the same letter in the column do not differ statistically by the Scott-Knott test at 5% probability. AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

highest similarity and variance between the variables groups, the correlation coefficient between the descriptors was high and positive between plant height (H) and crown length (L) (Figure 2). Thus, there is a relation between individuals of greater height and diameter. In mangaba trees, a lower size can be desirable in order to facilitate the harvest and to reduce damage taken by ripe fruits, also called "fall fruits", in their fall, since they present high perishability.

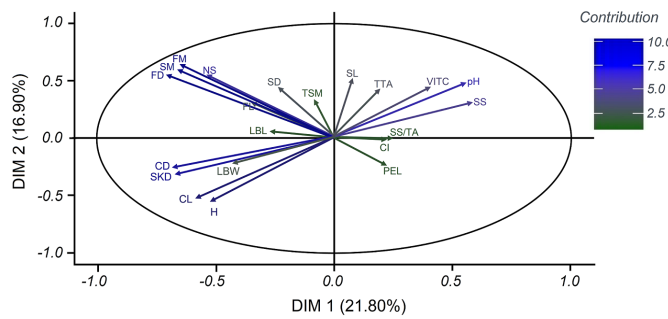
There was no variation for the crown insertion (CI), with a mean value of 0.49 m. In native populations from Tocantins, Freitas et al. (2012), obtained similar mean results, with a value of 0.41 m and crown diameter (CD) of 4.11 m. These descriptors are considered important for the construction of growth models (Zimmermann et al., 2016).

The stalk diameter (SKD) presented the highest mean values in the PT (5.63), AB (5.11 cm), CA (4.99 cm), BI (4.83 cm), TC (4.67 cm) and PR (4.49 cm) accesses. The measurement occurred below the crown insertion and not at 30 cm from the soil as in other species, because the mangaba tree is usually bifurcated and not erect. The obtained values for this variable were higher than those reported by Ganga et al. (2010) and Silva et al. (2012).

There was no difference for leaf length (LBL) and leaf width (LBW), and the mean values of 4.69 cm (LBL) and 1.87 (LBW) were similar to those reported by Fonseca & Condé (1994), when evaluated mangaba trees cultivated in nurseries, 4.36 cm long (LBL) and 2.19 cm wide (LBW). The evaluated mangaba trees did not display variation in their foliar anatomy, and the leaf length (LBL) was positively correlated ($p < 0.001$) with leaf width (LBW) in the different accesses (Figure 1). Reduction in leaf width indicated reduction in leaf length. There was no significant difference for the petiole length (PEL) among the different accesses. The petiole is an important criteria in the differentiation of botanical varieties (Monachino, 1945), but in this study all accesses belonged to the Speciosa variety.

The variability observed in BAGMangaba may be a result of the genetic diversity reported by Costa et al. (2011) and Santos et al. (2017) and also by the difference in plant age.

Regarding the fruits, the mean mass (FM) was 19.2 g. The heaviest fruits were from the BI (25.49 g) and TC (23.61 g) accesses (Table 5). The highest fruit diameters (FD) were found in the TC (34.77 mm), BI (34.14 mm) and CA (31.76 mm) accesses. For fruit length (FL) there was no significant difference, and the mean value was 35.89 mm. Nascimento



H: plant height, CI: crown insertion, L: crown length, CD: crown diameter, SKD: stalk diameter, LBL: leaf length, LBW: leaf width, PEL: petiole length, FM: fruit mass, FL: fruit length, FD: fruit diameter, NS: total number of seeds, SM: seed mass, TSM: total seed mass, SL: seed length, SD: seed diameter, TTA: total titratable acidity, VitC: vitamin C, pH: hydrogenation potential, SS: soluble solids content, SS/TTA: ratio between SS and ATT variables

Figure 1. Multiple factorial analysis of the evaluated quantitative descriptors in accesses from the Active Bank of Germplasm of Embrapa Coastal Tablelands.

et al. (2014), in studies with mangaba trees from a natural population of Bahia, found similar mean values of 32.34 mm of fruit diameter (FD) and 31.87 mm of length (FL). Souza et al. (2007) reported mean values of 38.27 and 34.66 mm for the length (FL) and fruit diameter (FD), respectively. For agribusiness and the consumers, heavier and larger fruits are attractive and influence in choice (Chitarra & Chitarra, 2005).

The fruits from TC, BI, PT, LG, CA and IP presented a higher number of seeds (NS) and mass of one seed (SM) with a mean of 8.9 and 1.01 g (Table 5). The total seed mass (TSM), length (SL) and diameter (SD) per fruit did not show significant differences among the accesses. These results are lower than those found by Silva et al (2013) for the mean number of seeds (MNS) of 11.14 and 2.42 g for the seed mass (SM). In spite of the seeds abundance favoring the propagation of the species, from a commercial perspective, aiming at the *in natura* fruit market, such as juices, sweets and ice creams, fruits with a lower quantity of seeds are sought because their pulp is the main objective of the commercialization (Gonçalves et al., 2013).

Regarding fruit quality attributes, the mean pH value was 3.41, with a superiority of IP (3,529), TC (3.51), AD (3.51), PA (3.48) and AB (3.48) (Table 6) accesses. When pH values are below 4.5, the fruit are classified as very acidic (Azeredo & Brito, 2004). The results were similar to 3.93 found by Nascimento et al. (2014) and to the 3.5 found by Carnelossi et al. (2004). For the solids content, CA access differed significantly, with

Table 5. Biometry descriptors used in the mangaba tree accesses characterization from Embrapa Coastal Tablelands.

Access	Fruit weight	Fruit lenght	Fruit diameter	Number of seeds	Seed weight	Total seeds weight	Seed lenght	Seed diameter
AB	16.70 b	39.69 a	28.88 b	5.50 b	0.42 b	7.83 a	6.32 a	2.69 a
AD	17.95 b	36.03 a	27.98 b	7.00 b	0.68 b	8.04 a	6.85 a	2.78 a
BI	25.49 a	35.37 a	34.14 a	11.33 a	1.60 a	8.77 a	6.67 a	3.10 a
CA	19.65 b	35.08 a	31.76 a	9.40 a	1.24 ª	8.90 a	6.77 a	2.86 a
IP	17.85 b	35.51 a	29.49 b	8.80 a	0.96 b	8.43 a	6.88 a	2.78 a
LG	19.05 b	34.22 a	31.22 b	10.00 a	1.11 a	8.26 a	6.41 a	2.68 a
PA	11.85 b	33.52 a	27.43 b	5.50 b	0.47 b	8.49 a	6.40 a	2.46 a
PR	19.53 b	36.42 a	30.95 b	7.83 b	1.10 a	8.74 a	6.51 a	2.59 a
PT	17.28 b	36.72 a	29.69 b	10.33 a	1.10 a	7.55 a	6.25 a	2.62 a
TC	23.61 a	36.36 a	34.77 a	12.00 a	1.16 a	6.55 a	6.35 a	2.76 a
CV%	26.69	8.77	9.35	40.31	51.58	15.29	7.77	13.51
Média	19.2	35.89	30.84	8.94	1.01	8.13	6.53	2.74

*Means followed by the same letter in the column do not differ statistically by the Scott-Knott test at 5% probability. AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

Table 6. Physicochemical descriptors used in the mangaba tree fruit characterization of the Germplasm Active Bank from Embrapa Coastal Tablelands.

Access	pH	Soluble solids	Total titratable acidity	SS/TTA	Vitamin C
AB	3.48 a	13.49 a	0.89 b	18.80 a	378.06 a
AD	3.51 a	12.83 a	0.9 b	14.18 a	395.8 a
BI	3.37 b	13.33 a	1.19 a	12.09 b	421.82 a
CA	3.36 b	7.58 b	1.32 a	7.89 b	409.02 a
IP	3.52 a	14.25 a	1.11 b	12.81 b	328.29 a
LG	3.3 b	12.63 a	1.36 a	9.64 b	391.34 a
PA	3.48 a	13.3 a	1.1 b	12.28 b	382.99 a
PR	3.39 b	12.05 a	1.17 a	10.79 b	400.08 a
PT	3.38 b	13.37 a	0.9 b	15.6 a	364.19 a
TC	3.51 a	12.91 a	1.19 a	12.08 b	371.15 a
CV%	4.34	20.3	26.72	41.23	13.66
Média	3.41	12.41	1.15	12.23	394.45

*Means followed by the same letter in the column do not differ statistically by the Scott-Knott test at 5% probability. AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

the lowest value (7.58°Brix) (Table 6). In the others, the values were higher than 12ºBrix. The mean value was 12.41 ° Brix, a lower result than that of Perfeito et al. (2015), in fruit from Goiás (14.57°Brix), and than that of Nascimento et al. (2014), in mangaba trees from Bahia State (17,04°Brix).

The highest values of total titratable acidity (ATT) were attained by the LG (1.36% citric acid), CA (1.32% citric acid), BI (1.19% citric acid), TC (1.19% citrus acid) and PR (1.17% citric acid) accesses (Table 6), with the fruit being classified as 'well accepted' for *in natura* consumption (Sacramento et al., 2007). These results were similar to those from Souza et al. (2007); Silva et al. (2013) and Lima et al. (2015).

The highest means of the SS/TTA ratio were displayed by AB (18.80); PT (15.61) and AD (14.18) accesses, with the mean value being 12.22 (Table 6). The SS/AT ratio is one of the best forms of flavor assessment, being more representative than the isolated measurement of sugars and acidity (Santos et al., 2010). The high values obtained can be an indicative that the pulp of these fruits are propitious for the industrialization of products like ice cream, popsicles, jams and jellies.

Vitamin C content was considered high, with a mean value of 394.45 mg/100g, and there was no significant difference between the accesses (Table 6). This is an important quality attribute to be considered in conservation and improvement programs. The obtained means were higher than those from Plácido et al. (2016) study, which was 188.33 mg $100g^{-1}$, when evaluating mangaba fruit at three maturation stages. The most significant values observed in the present study were consistent with those of Silva et al. (2012), when they characterized fruits of natural populations from the State of Sergipe. These values confirm mangaba as a rich source of vitamin C.

Among the physical characteristics of the mangaba tree fruit, the correlation between fruit mass (FM) was significantly positive ($p < 0.001$) with fruit diameter (FD), total number of seeds (NS) and seed mass (SM). Nascimento et al. (2014) detected significant correlation when estimating the coefficient of correlation between the number of seeds (NS) and the fruit diameter (FD) and also between the number of seeds (NS) and fruit mass (FM), similar to the value found in this study. Souza et al. (2007) and Capinan et al. (2007) also found a high correlation between fruit mass (MFR) and its diameters. These characteristics represent great importance for the commercial exploitation, mainly in the fruit processing. Therefore, the selection of accesses with heavy and large fruit, with a small number of seeds, is difficult (Figure 2).

The knowledge of the fruit and seeds variability is important for the improvement and composition of germplasm banks, aiming their extension or uniformity, and can be used in the development of cultivars that produce fruit with important characteristics in order to improve their commercialization (Gonçalves et al. 2013).

The multiple factorial analysis for all quantitative descriptors (Figure 2) showed that the descriptors FD, FM, SM and NS resulted in a greater contribution to the total variation (37.6%) among the accesses. However, the IC, SS/TTA and PEL descriptors were of smaller contribution to evaluate the variability among the accesses.

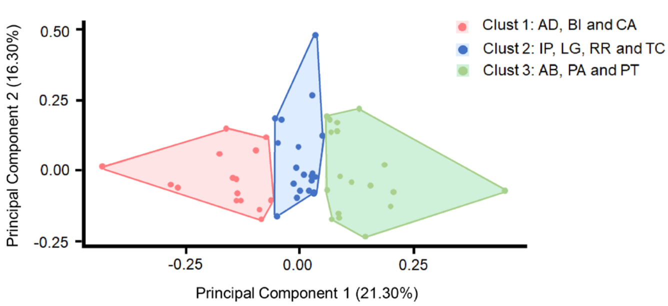
The data obtained in the evaluation of the quantitative morphological and physicochemical descriptors resulted in a principal component analysis (PCA), with a 37.6% variance among the accesses (Figure 2). Then, three distinct groups were formed: G1 (AD, BI, CA accesses); G2 (AB, PA and PT accesses) and G3 (IP, LG, PR and TC accesses), with G3 being the group with the highest similarity.

There was no significant difference ($p < 0.05$) in the crown shape (CS), inflorescence position (INP), fruit shape (FS) and fruit size uniformity (FSU) (Table 7). Perhaps because these characteristics do not occur exclusively, such as the shape of the fruit, where it was possible to observe the two formats - oblong and rounded - in the same plant. Thus, the use of these descriptors to indicate the variability in a mangaba tree germplasm can be limiting.

In contrast to the collections of species of major commercial importance such as coffee (Lara et al., 2014), cassava (Oliveira et al., 2015) and passion fruit (Machado et al., 2015), there are still no studies related to germplasm characteristics from mangaba tree.

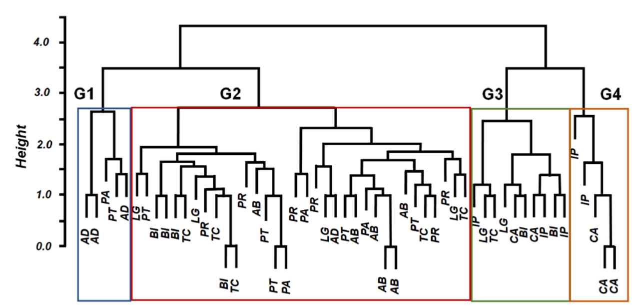
In this study, the analysis of genetic diversity from the Euclidean distance, for the qualitative descriptors, allowed to cluster the accesses into four distinct groups (Figure 3). In Group 1 (G1), individuals from AD access; in Group 2 (G2), the individuals from accesses BI, TC, PT, PA and AB; in Group 3 (G3), accesses LG, TC, CA, BI and IP; and in group 4 (G4), the individuals from the CA access. With the exception of individuals belonging to the same access, only CA and BI individuals (group G3) originate from the same State. The presence of different accesses in the groups indicates that the qualitative results obtained reveal high diversity among the accesses. The clustering methods were partially concordant, in which the accesses that showed highest similarity were ordered in the same group.

Considering that the material is in the same environmental conditions, the qualitative descriptors variation may have been influenced by the existing genetic variability (Costa et al., 2011; Santos et al., 2017), mainly because it is an allogamous



AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

Figure 2. Principal components analysis (PCA), with total variance of 37.6%, using quantitative descriptors (morphological and physicochemical) in 10 accesses of the BAGMangaba of Embrapa Coastal Tablelands.



AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

Figure 3. Obtained dendrogram based on the euclidian distance, for the clustering of accesses from BAGMangaba of Embrapa Coastal Tablelands, according to the qualitative characteristics.

Table 7. Qualitative morphological descriptors (CS: Crown shape; TS: Trunk surface; RP: Ramification pattern; FH: Fruiting habit; INP: Inflorescence position; LS: Leaf shape, LE: Leaf edge; FFR-FF: Fruit format; FSU: fruit size uniformity) evaluated in accesses from BAGMangaba of Embrapa Coastal Tablelands, using the Kruskal-Wallis test.

Descriptors	Accesses										P-value
	AB	AD	BI	CA	IP	LG	PA	PR	PT	TC	
CS	29.5	7.2	29.5	16.1	31.2	30.6	26.6	36.5	22.9	36.5	0.0500*
TS	20.0	26.7	29.0	36.2	20.0	33.5	20.0	33.5	29.0	24.5	0.2332
RP	27.7	29.9	18.8	31.2	20.6	36.5	21.0	27.7	32.1	27.7	0.4032
FH	39.0	23.2	16.5	16.5	27.3	30.0	30.0	34.5	25.5	30.0	0.0847
INP	34.2	31.5	27.5	8.0	8.0	27.5	28.0	40.3	37.2	27.7	0.0001*
LS	28.5	28.5	28.5	28.5	28.5	24.0	28.5	24.0	28.5	28.0	0.6231
LE	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	0.9999
FS	11.0	33.5	33.5	33.5	28.1	33.5	20.0	29.0	20.0	33.5	0.0005*
FSU	33.3	43.2	33.3	34.5	38.0	10.0	16.1	26.3	10.0	34.5	0.0001*

* The value of the mean point between the qualitative descriptors was used to the comparison among the mangaba tree accesses. AB – Água boa; AD – Mata Redonda; BI – Barra de Itariti; CA – Costa Azul; IP - Ipiranguinha; LG – Lagoa Grande; PA - Paratibe; PR - Preguiça; PT - Pontal; TC – Terra Caída.

species (Costa et al., 2015). Despite this, Santos et al. (2017) observed low genetic diversity among accesses of this same mangaba germplasm, which would explain a smaller genetic distance between some accesses (Figure 4). In the same study, these authors indicated BI, CA, PR and PT accesses as rich sources of vitamin C and potential materials for selection and improvement programs.

There was variability between the individuals for all the analyzed descriptors and the characterization based on these characteristics will collaborate in the conservation strategies and usage of this genetic resource.

Although the statistical models suggest the predilection for some evaluated descriptors (CS, INP, FS and FSU and the quantitative FD, FM, NS, SM), in practice it is known that others are fundamental to compose the characterization of a mangaba tree germplasm, such as height, stalk diameter and vitamin C content of fruit, for example. As a slow growth species, these developmental characteristics as well as their quality attributes cannot be ignored, since the fruit are used for processing.

Conclusion

The used descriptors are efficient to characterize the species *Hancornia speciosa* Gomes.

The high variability among the accesses from the Germplasm Active Bank of Embrapa Coastal Tablelands indicates the conservation importance of these genetic resources and suggests genetic potential for seed collection, selection and improvement.

Eight descriptors were selected for differentiation in mangaba germplasm: crown shape; inflorescence position; shape, diameter and mass of the fruit; number and mass of seeds and fruit size uniformity.

The results of this study contributed to the elaboration of the manual of mangaba tree descriptors, published in 2018 by Bioversity International.

Acknowledgements

To the National Council for Scientific and Technological Development – CNPq (Processes 461020/2014-9 and 301476/2015-2) and Embrapa Coastal Tablelands.

Literature Cited

Association of Official Analytical Chemistry - AOAC. Official methods of analysis of the association of official analytical chemistry. 14.ed. Washington: AOAC, 1992. 1015p.

Azeredo, H. M. C.; Brito, E.S. Tendências em conservação de alimentos. In: Azeredo, H. M. C. Fundamentos de estabilidade de alimentos. Fortaleza: Embrapa Agroindústria Tropical, 2004. p. 135-150.

Brondani, C.; Brondani, R.P.V.; Rangel, P.H. 2006. Utilização de marcadores moleculares em programas de ampliação de base genética de espécies cultivadas. Santo Antônio de Goiás: Embrapa Arroz e Feijão, 2006. 36p. https://www.infoteca.cnptia.embrapa.br/bitstream/doc/212599/1/doc155.pdf. 09 Abr. 2018.

Burle, M.L.; Oliveira, M.S.P. Manual de curadores de germoplasma - vegetal: caracterização morfológica. Brasília: Embrapa Recursos Genéticos e Biotecnologia, 2010. 15p. https://www.embrapa.br/en/busca-de-publicacoes/-/publicacao/913190/manual-de-curadores-de-germoplasma---vegetal-caracterizacao-morfologica. 29 Mar. 2018.

Capinan, G.C.S.; Silva, S.A.; Moreira, R.F.C.; Ribeiro, F.G.; Cunha, E.C. Caracterização agronômica de plantas e frutos de mangabeiras do estado da Bahia. Magistra, v. 19, n.4, p. 290-298, 2007.

Carnelossi, M.A.G.; Toledo, W.F.F.; Souza, D.C.L.; Lira, M.L.; Silva, G.F.; Jalali, V.R.R.; Viégas, P.R.A. Conservação pós-colheita de mangaba (*Hancornia speciosa* Gomes). Ciência e Agrotecnologia, v.28, n.5, p.1119-1125, 2004. https://doi.org/10.1590/S1413-70542004000500021.

Chitarra, M. I. F.; Chitarra, A. B. Pós-colheita de frutos e hortaliças: fisiologia e manuseio. 2.ed. Lavras: UFLA, 2005. 783p

Costa, D.F.; Vieira, F.A.; Fajardo, C.G.; Chagas, K.P.T. Diversidade genética e seleção de iniciadores issr em uma população natural de mangaba (*Hancornia speciosa* Gomes) (Apocynaceae). Revista Brasileira de Fruticultura, v. 37, n.4, p.970-976, 2015. https://doi.org/10.1590/0100-2945-246/14.

Costa, T.S.; Silva, A.V.C.; Lédo, A.S.; Santos, A.R.F. Diversidade genética de acessos do banco de germoplasma de mangaba em Sergipe. Pesquisa Agropecuária Brasileira, v. 46, n.5, p. 499-508, 2011. https://doi.org/10.1590/S0100-204X2011000500007.

Ferreira, D.F. Sisvar: A computer statistical analysis system. Ciência e Agrotecnologia, v. 35, n.6, p.1039-1042, 2011. https://doi.org/10.1590/S1413-70542011000600001.

Fonseca, C.E.L.; Condé, R.C.C. Estimativa da área foliar em mudas de mangabeira (*Hancornia speciosa* Gomes). Pesquisa Agropecuária Brasileira, v. 29, n.4, p.593-599, 1994. https://seer.sct.embrapa.br/index.php/pab/article/view/4091/1382. 29 Mar. 2018.

Freitas, M.K.C.; Coimbra, R.R.; Aguiar, G.B.; Aguiar, C.B.N.; Chagas, D.B.; Ferreira, W.M.; Oliveira, R.J. Variabilidade fenotípica e caracterização morfológica de uma população natural de *Hancornia speciosa* Gomes. Bioscience Journal, v.28, n.5, p. 833-841, 2012. http://www.seer.ufu.br/index.php/biosciencejournal/article/view/13455/10565. 19 Abr. 2018.

Ganga, R.M.D.; Ferreira, G.A.; Chaves, L.J.; Naves, R.V.; Nascimento, J.L. Caracterização de frutos e árvores de populações naturais de *Hancornia speciosa* Gomes do cerrado. Revista Brasileira de Fruticultura, v.32, n.1, p.101-113, 2010. https://doi.org/10.1590/S0100-29452010005000019.

Gonçalves, L.G.V.; Andrade, F.R.; Marimon Junior, B.H.; Schossler, T.R.; Lenza, E. E Marimon, B.S. Biometria de frutos e sementes de mangaba (*Hancornia speciosa* Gomes) em vegetação natural na região leste de Mato Grosso, Brasil. Revista de Ciências Agrárias, v.36, n.1, p.31–40, 2013. http://www.scielo.mec.pt/scielo.php?script=sci_arttext&pid=S0871-018X2013000100006. 01 Abr. 2018.

Gotor, E.; Alercia, A.; Ramanatha R.A.O, V.; Watts, J.; Caracciolo, F. The scientific information activity of Bioversity International: the descriptor lists. Impact Assessment Discussion Paper 3. Rome: Bioversity International, 2011. 16 p. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/The_scientific_information_activity_of_Bioversity_International__the_descriptor_lists_1430.pdf. 09 Apr. 2018.

Kassambara, A.; Mundt, F. Factoextra: extract and visualize the results of multivariate data analyses. R package, 2005. Vienna: R Foundation for Statistical Computing, 2005.

Lara, J.M.R.A.; Rezende, J.C.; Carvalho, G.R.; Pereira, A.A.; Carvalho, J.P.F.; Guerreiro Filho, O. Caracterização de formas botânicas diversas do Banco Ativo de Germoplasma de cafeeiros do Estado de Minas Gerais, Brasil. Bragantia, v. 73, n. 4, p.383-389, 2014. https://doi.org/10.1590/1678-4499.020.

Lima, J. P.; Fante, C.A.; Pires, C.R.F.; Nunes, E.E.; Alves, R.R.; Elias, H. H. S.; Nunes, C. A.; Boas, E. V. B. V. The antioxidative potential and volatile constituents of mangaba fruit over the storage period. Scientia Horticulturae, v. 194, p. 1-6, 2015. https://doi.org/10.1016/j.scienta.2015.05.035.

Machado, C.F.; Jesus, F.N.; Ledo, C.A.S. Divergência genética de acessos de maracujá utilizando descritores quantitativos e qualitativos. Revista Brasileira de Fruticultura, v. 37, n.2, p. 442-449, 2015. https://doi.org/10.1590/0100-2945-110/14.

Monachino, J. A revision of *Hancornia* (Apocynaceae). Lilloa, v.11, p.19-48, 1945.

Nabout, J.C.; Magalhães, M.R.; Gomes, M.A.A.; Cunha, H.F. The Impact of global climate change on the geographic distribution and sustainable harvest of *Hancornia speciosa* Gomes (Apocynaceae) in Brazil. Environmental Management, v.57, n.4, p.814–821, 2016. https://doi.org/10.1007/s00267-016-0659-5.

Nascimento, R.S.M.; Cardoso, J.A.; Cocozza, F.D.M. Caracterização física e físico-química de frutos de mangabeira (*Hancornia speciosa* Gomes) no oeste da Bahia. Revista Brasileira de Engenharia Agrícola e Ambiental, v.18, n.8, p.856-860, 2014. DOI: https://doi.org/10.1590/1807-1929/agriambi.v18n08p856–860.

Oliveira, E.J; Oliveira Filho, O.S.; Santos, V.S. Classification of cassava genotypes based on qualitative and quantitative data. Genetics and Molecular Research, v.14, n.1, p.906-924, 2015. https://doi.org/10.4238/2015.February.2.14.

Perfeito, D. G. A.; Carvalho, N.; Lopes, M. C. M.; Schmidt, F. L. Caracterização de frutos de mangabas (*Hancornia speciosa* Gomes) e estudo de processos de extração da polpa. Revista de Agricultura Neotropical, v. 2, n.3, p.1-7, 2015. https://doi.org/10.32404/rean.v2i3.269.

Plácido, G.R.; Silva, R.M.; Cagnin, C.; Silva, M.A.P.; Caliari, M. Physical and physicochemical composition of mangaba fruits (*Hancornia speciosa* Gomes) at three maturity stages. African Journal of Agricultural Research, v.11, n.19, p.1772-1776, 2016. https://doi.org/10.5897/AJAR2015.9712.

Pohlert, T. The pairwise multiple comparison of mean ranks package (PMCMR). R. package, 2016. Vienna: R Foundation for Statistical Computing, 2016.

R Development Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing, 2015.

Sacramento, C.K.; Matos, C.B.; Souza, C.N.; Barretto, W. S.; Faria, J. C. Características físicas, físico-químicas e químicas de cajás oriundos de diversos municípios da região sul da Bahia. Magistra, v.19, n.4, p.283-289, 2007.

Santos, M.B.; Cardoso, R.L.; Fonseca, A.A.O.; Conceição,M.N. Caracterização e qualidade de frutos de umbu-cajá (*Spondias tuberosa* X *S. mombin*) provenientes do Recôncavo Sul da Bahia. Revista Brasileira de Fruticultura, v.32, n.4, p.1089-1097, 2010. https://doi.org/10.1590/S0100-29452011005000015.

Santos, P.S.; Freitas, L. S.; Santana, J.G.S.; Muniz, E.N.; Rabbani, A.R.C.; Silva, A.V.C. Genetic diversity and the quality of mangabeira tree fruits (*Hancornia speciosa* Gomes - Apocynaceae), a native species from Brazil. Scientia Horticulturae, v.226, p.372-378, 2017. https://doi.org/10.1016/j.scienta.2017.09.008.

Scott, A. J.; Knott, M. A cluster analysis method for grouping means in the analysis of variance. Biometrics, v. 30, n.3, p. 507-512, 1974. https://doi.org/10.2307/2529204.

Silva Júnior, J.F.; Muniz, A.V.C.; Lédo, A.S.; Maia, M.C.C.; Silva, S.M.C.; Dulloo, E.S.; Alercia, A. Descriptors for Mangaba (*Hancornia speciosa* Gomes). Rome: Bioversity International; Aracaju: Brazilian Agriculture Research Corporation, Embrapa Tabuleiros Costeiros, 2018. 56p. https://hdl.handle.net/10568/90693. 03 Jan. 2018.

Silva, A. V. C.; Lédo, A.S.; Muniz, E. N.; Santos, J. S.; Feitosa, R. B.; Almeida, C. S. Postharvest characterization of mangaba (*Hancornia speciosa* Gomes) from natural populations in Sergipe, Brazil. Acta Horticulturae, v. 945, p. 263-265, 2012. https://doi.org/10.17660/ActaHortic.2012.945.35.

Silva, S.A.; Cruz, E.M.O.; Reis, R.V.; Ferreira, C.F.; Passos, A.R. Caracterização morfológica e molecular de genótipos de mangaba. Revista Brasileira de Fruticultura, v.35, n.4, p.1093-1100, 2013. https://doi.org/10.1590/S0100-29452013000400021.

Soares, F.P.; Paiva, R.; Campos, A.L.; Porto, J.M.P.; Nogueira, R.C.; Stein, V.C. Germinação de sementes de mangabeira (*Hancornia speciosa* Gomes) em diferentes substratos. Revista Brasileira de Biociências, v.5, supl. 2, p.1180-1182, 2007. http://www.ufrgs.br/seerbio/ojs/index.php/rbb/article/download/1041/774. 10 Abr. 2018.

Soares, F.P.; Paiva, R.; Nogueira, R.C.; Oliveira, L.M.; Silva, D.R.G.; Paiva, P.D.O. 2006. Cultura da Mangabeira (*Hancornia speciosa* Gomes). Boletim Agropecuário, n.67, p.1-12, 2006. http://livraria.editora.ufla.br/upload/boletim/tecnico/boletim-tecnico-67.pdf. 09 Abr. 2018.

Souza, F.G.; Figueiredo, R.W.; Alves, R.E.; Maia, G.A.; Araújo, I.A. Qualidade pós colheita de frutos de diferentes clones de mangabeira (Hancornia speciosa Gomes). Ciência e Agrotecnologia, v. 31, n.5, p.1449-1454, 2007. https://doi.org/10.1590/S1413-70542007000500027.

Zimmermann, A.P.L.; Costa, E.A.; Schroder, T.; Fleig, F.D. Modelação de incremento diamétrico de *Pinus taeda* em função das variáveis coroa e índice de competição. Revista Floresta, v.46, n.1, p.115-122, 2016. https://doi.org/10.5380/rf.v46i1.42424.