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Scientific Article

Evaluation and morpho-agronomic characterization of pumpkin accessions from the semiarid region of the northeast of Brazil

Avaliação e caracterização morfoagronômica de acessos de abóbora provenientes do semiárido do nordeste brasileiro

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ABSTRACT – The objective of this study was to evaluate morpho-agronomic characteristics of different *Cucurbita moschata* (Duch) accessions from the Semiarid region of the Northeast of Brazil. Two experiments were conducted at the experimental field of the Bahia State University (Department of Technology and Social Sciences), Juazeiro, BA, Brazil, one from May to October 2021 and another from February to July 2022. Eighteen *C. moschata* accessions were evaluated in the first experiment, and 11 S_1 progenies were evaluated in the second. Quantitative descriptors were analyzed in both experiments: fruit weight (FW; kg); fruit diameter (FD; cm); fruit length (FL; cm); fruit internal cavity diameter (FICD; cm); fruit internal cavity length (FICL cm); average of fruit skin thickness (AFST; mm); average of fruit flesh thickness (AFFT; mm); soluble solids content (SS; °Brix); 100-seed fresh weight (100SFW; g); 100-seed dry weight (100SDW; g). Qualitative descriptors evaluated included fruit shape, fruit ribbing, skin color, flesh color, flesh texture, and skin texture. Significant differences were found for FW, FD, FL, FICD, FICL, AFST, AFFT, and SS in the first experiment, and or FD, FL, FICD, FICL, AFST, SS, and 100SDW in the second experiment. The results indicate genetic variability among accessions for quantitative and qualitative morphological fruit characteristics.

Keywords: Analysis. *Cucurbita moschata*. Fruit. Qualitative. Quantitative.

RESUMO – O trabalho teve como objetivo caracterizar morfoagronômicamente diferentes acessos de abóbora (*Cucurbita moschata* Duch) do semiárido nordestino. Foram realizados dois experimentos, em campo experimental da Universidade do Estado da Bahia, no Departamento de Tecnologia e Ciências Sociais, em Juazeiro-BA, nos períodos de maio a outubro de 2021 e fevereiro a julho de 2022. No primeiro experimento foram avaliados 18 acessos de abóbora e no segundo 11 progênies S_1. Foram analisados os descritores quantitativos para ambos os experimentos: massa do fruto (kg) – MF; diâmetro do fruto (cm) – DF; comprimento do fruto (cm) – CF; diâmetro da cavidade interna do fruto (cm) – DCIF; comprimento da cavidade interna do fruto (cm) – CCIF; espessura média da casca do fruto (mm) – EMCF; espessura média da polpa do fruto (mm) – EMPF; sólidos solúveis (°Brix) – SS; massa fresca de 100 sementes (g) – MF100S; massa seca de 100 sementes (g) – MS100S. Os descritores qualitativos estudados foram: formato do fruto, nervura do fruto, cor da casca, cor da polpa, textura da polpa e textura da casca. Observou-se diferenças significativas para a MF, DF, CF, DCIF, CCIF, EMCF, EMPF e SS no primeiro experimento. Já para o segundo experimento houve uma diferença significativa para o DF, CF, DCIF, CCIF, EMCF, SS e MS100S. Os resultados obtidos evidenciam a variabilidade genética dos diferentes acessos para as características morfológicas dos frutos, tanto as quantitativas como as qualitativas.

Palavras-chave: Análise. *Cucurbita moschata*. Fruto. Qualitativo. Quantitativo.

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INTRODUCTION

Archeological findings indicate that the species *Cucurbita moschata* Duch. already existed in Latin America before colonization and were part of the diet of indigenous people (DILLEHAY et al., 2007). *C. moschata* is an annual plant species with an indeterminate growth habit, whose stems can reach six meters long; it can develop well in several soil types, except for excessively moist soils (AMARO et al., 2021). According to Priori et al. (2017), squashes have been used as foods since ancient times.

Currently, squashes, including pumpkins, present increasing value for crop diversification in family farming and intercropping with other crops (HERNÁNDEZ-ROSALES et al., 2020). They are also considered a food that contributes to human nutrition and health due to their high contents of antioxidants, mainly carotenoids (MILJIĆ et al., 2021). The variability of this vegetable in Brazil is closely connected to family farmers (GOMES et al., 2020) through the exchange of germplasm among growers (CARDOSO; SOUZA NETO, 2016) to obtain different seeds. These exchanges of germplasm are essential when farmers lose seeds due to local edaphoclimatic conditions.

The Northeast region of Brazil stands out as an area with high genetic variability of squashes regarding skin color, flesh color, fruit shape and size, among other traits (FERREIRA et al., 2016). According to Amaro et al. (2021), the Brazilian Northeastern states of Bahia, Maranhão, Pernambuco, Ceará, and Rio Grande do Norte present higher yields and significant consumption of these vegetables compared to other regions of the country Brazil. Genetic diversity in these regions is maintained by farmers, who preserve their own local species populations (PRIORI et al., 2018). Some of this diversity has been collected by researchers and stored in active germplasm banks of several institutions in Brazil (CARDOSO; SOUZA NETO, 2016), including the Brazilian Agricultural Research Corporation (EMBRAPA Semiárido), which has an active germplasm bank for Cucurbitaceae species from the Northeast region of Brazil. According to Silva et al. (2022), squash plants are well adapted to the climate conditions of the Northeast of Brazil and can be grown throughout the year when there is water available for irrigation.

Considering the diversity found in active germplasm banks, the collection, characterization, and evaluation of *C. moschata* accessions can enable the maintenance of genetic variability (OLIVEIRA et al., 2016). The determination of morpho-agronomic characteristics in these genetic resources is important for pumpkin breeding programs (DARRUDI et al., 2018). Existing groups of quantitative or qualitative descriptors for the identification of these characteristics can assist in the description of characteristics of each genotype, thus identifying differences between or within accessions (BARBIERI; CASTRO, 2015). Considering the nutritional and social importance of this crop in the Northeast region of Brazil, the objective of this study was to evaluate quantitative and qualitative morpho-agronomic characteristics of different *Cucurbita moschata* (Duch) accessions collected from family farmers in the Semiarid region of the Northeast of Brazil.

MATERIAL AND METHODS

Experimental Area

The study was conducted in two phases, in the experimental field and in the Molecular Biology Laboratory of the Bahia State University (Department of Technology and Social Sciences; UNEB/DTCS), Campus III, in Juazeiro, BA Brazil (9°25'43.6"S, 40°32'14"W, and altitude of 384 m). Two experiments were conducted: the first from May to October 2021, and the second from February to July 2022.

Treatments and Experiment Design

Eighteen *Cucurbita moschata* accessions were used in the first experiment. These accessions were acquired from street markets, supermarkets, rural properties, and from the farmer's market (Mercado do Produtor) in Juazeiro and are stored in the active germplasm bank for Cucurbitaceae at the Brazilian Agricultural Research Corporation (EMBRAPA Semiárido, Petrolina, PE, Brazil). The accessions were collected in three states of the Northeast region: Bahia, Pernambuco, and Rio Grande do Norte. The commercial cultivar Jacarezinho was used as control (Table 1).

Seeds from 11 *C. moschata* progenies of the S_1 generation from the first experiment were used in the second experiment; they were obtained by controlled pollination (self-fertilization). The commercial cultivar Jacarezinho was also used as a control (Table 1).

Table 1. Passport data for the Cucurbita moschata accessions used in the experiments, including code, region of origin, and year of collection. Active Germplasm Bank for Cucurbitaceae in the Northeast region of Brazil.

Accessions	Place of Collection	Municipality of Collection	State	Year of Collection
A03MP*-BA**	Farmer's Market	Casa Nova	BA	2017
A04MP-BA**	Farmer's Market	Casa Nova	BA	2017
A16MP-BA**	Farmer's Market	Curaçá	BA	2017
A17MP-BA	Farmer's Market	Curaçá	BA	2017
A23BA**	Rural Property	Maniçoba - Juazeiro	BA	2020
A24BA**	Rural Property	Maniçoba - Juazeiro	BA	2020
A25BA**	Rural Property	Maniçoba - Juazeiro	BA	2020
A26BA	Rural Property	Maniçoba - Juazeiro	BA	2020
A01MP-PE**	Farmer's Market	São José do Belmonte	PE	2017
A02MP-PE**	Farmer's Market	Projeto Maria Tereza – Petrolina	PE	2017
A05PE**	Street Market	Petrolina	PE	2015
A08PE	Street Market	Petrolina	PE	2016
A14PE	Street Market	Petrolina	PE	2016
A20PE	Supermarket	Petrolina	PE	2020
A21PE**	Supermarket	Petrolina	PE	2020
A22PE	Supermarket	Petrolina	PE	2020
A08RN	Street Market	Mossoró	RN	2011
A10RN**	Street Market	Mossoró	RN	2011
Jacarezinho**	Commercial Cultivar – Isla			2019

*Fruits grown in several municipalities, acquired in the Farmer's Market in Juazeiro; **Accessions used for obtaining S_1 progenies for the second experiment.

The seedlings used in both experiments were grown in 288-cell expanded polyethylene trays containing a commercial substrate (Tropstrato®) and transplanted to the field at the stage of second fully expanded true leaf (22 days after sowing). The planting spacing used was 3.0 × 3.0 meters. The soil was prepared through harrowing and plowing; fertilizer applications were based on soil analysis and the recommendations for the crop (COSTA; FARIA; PEREIRA, 2008). Cultural practices were carried out as recommended for pumpkin crops by Amaro et al. (2021).

A randomized block design with three replications was used in both experiments; each plot consisted of five plants, considering the three central plants for analyses.

Harvesting was carried out in October 2021 in the first experiment and in July 2022 in the second experiment.

The harvested fruits from both experiments were taken to the Molecular Biology Laboratory of UNEB/DTCS for morpho-agronomic analyses.

Morpho-Agronomic Characterization of Fruits

Morpho-agronomic characterization of fruits was carried out using 11 quantitative and six qualitative descriptors, adapted from the European Cooperative Programme for Plant Genetic Resources (ECPGR, 2008).

The quantitative descriptors assessed were: fruit weight (FW; kg), fruit diameter (FD; cm), fruit length (FL; cm), fruit internal cavity diameter (FICD; cm), fruit internal cavity length (FICL; cm), average of fruit skin thickness (AFST; mm), average of fruit flesh thickness (AFFT; mm), soluble solids content (SS; °Brix), 100-seed fresh weight (100SFW; g), and 100-seed dry weight (100SDW; g).

Qualitative descriptors were evaluated through grading by three trained evaluators, using the descriptor list for pumpkin from ECPGR (2008), with some changes. The descriptors utilized include fruit shape (1 - globular, 2 - flattened, 3 - cylindrical, 4 - elliptical, 5 - pear-shaped, 6 - heart-shaped); fruit ribbing (1 - superficial, 2 - intermediate, 3 - intense), skin color (1 - white, 2 - green, 3 - cream, 4 - yellow, 5 - orange), flesh color (1 - yellow, 2 - orange, 3 - salmon), flesh texture (1 - smooth-firm, 2 - fibrous-gelatinous, 5 - dry-fibrous); and skin texture (1 - smooth, 2 - granulated, 3 - finely wrinkled, 4 - slightly wavy, 5 - warty).

Nine plants and five fruits per plant of each accession were subjected to morphological characterization, following criteria defined by Priori et al. (2018).

Statistical analysis

Quantitative data were subjected to individual analysis of variance (ANOVA) for comparing the means of each variable. Means of the descriptors were grouped using the Scott-Knott test ($p < 0.05$) through the genetic and statistical software Genes (CRUZ, 2016).

Qualitative data were expressed through the mode of each accession for each descriptor. Multivariate analysis was conducted based on both quantitative and qualitative descriptors, generating a dissimilarity matrix among the accessions. Quantitative data were obtained through the Mahalanobis distance, and qualitative data were obtained using the index from Cruz (2016):

$$\sqrt{\left(\frac{1}{v}\right)\sum(b+c)/(a+b+c+d)}$$

The distance and dissimilarity matrices were joined by standardizing the values of d and D^2, resulting in $(D^2)'$ and d' followed by simple summation. The matrix of sum of dissimilarities was used for the clustering analysis, using the unweighted pair group method with arithmetic mean (UPGMA), and the cutoff point was based on the method of Mojena (1977). The cophenetic correlation coefficient was estimated (SOKAL; ROLF, 1962) based on the Pearson correlation coefficient between the distance matrix and cophenetic matrix (CRUZ; CARNEIRO, 2003), using the software Genes (CRUZ, 2016).

RESULTS AND DISCUSSION

A high genetic variability was found for quantitative and qualitative characteristics in both experiments; thus, the identification of agronomically promising genotypes for the evaluated characteristics is possible. The accessions presented significant differences by the F-test ($p < 0.05$) for all quantitative characteristics in both experiments, except for fresh weight and dry weight of 100-seeds in the first experiment, and fruit weight, fruit flesh thickness and 100-seed fresh weight in the second experiment.

The mean fruit weight (FW) found in the first experiment was 2.64 kg; the accession A22PE stood out by presenting FW of 4.46 kg, whereas the cultivar Jacarezinho presented the lowest result: 1.31 kg (Table 2). In the second experiment, no significant difference was found for FW, presenting a mean of 2.32 kg (Table 3). The fruits in the second experiment are progenies from the first experiment; therefore, they presented no difference probably due to the plant material utilized, which was selected. According to Priori et al. (2018), most pumpkins consumed in Brazil weigh up to 3 kg; larger fruits are marketed in large supermarkets in slices placed on trays (SILVA et al. 2022). This denotes the importance of studying and characterizing these accessions for future releases as commercial cultivars that meet the demands of the consumer market.

Fruit diameter (FD) presented ranged from 14.15 cm (A23BA) to 24.53 cm (A22PE) in the first experiment. The control cultivar (Jacarezinho) presented larger FD (15.61 cm) than the accessions A04MP-BA, A23BA, A14PE, and A10RN; however, they were statistically equal (Table 2). In the second experiment, FD was promising for all accessions, except for A04MP-BA, A23BA, and A05PE (Table 3). Oliveira et al. (2016) found similar results: 10.62 cm to 22.51 cm. Laurindo et al. (2017) reported that increases in diameter promote external fruit growth and can directly increase fruit weight. The accessions A10RN and A23BA presented higher fruit lengths (FL) than the others in the first experiment: 24.11 and 25.58 cm, respectively. The cultivar Jacarezinho presented the smallest FL (9.88 cm) among the accessions (Table 2). In the second experiment, the accession A05PE presented longer FL (23.77 cm) than the other accessions and the cultivar Jacarezinho, which presented the smallest result (10.53 cm) (Table 3) due to its smaller and more rounded fruits compared to the accessions. The FL means found in both experiments were similar to that found by Amaro et al. (2017) (17.44 cm), who evaluated the agronomic performance of pumpkin characteristics.

Table 2. Means of morpho-agronomic descriptors for fruits of different accessions of C. *moschata* and the commercial cultivar Jacarezinho in the first experiment (2021).

Accessions	FW (kg)	FD (cm)	FL (cm)	FICD (cm)	FICL (cm)	AFST (mm)	AFFT (mm)	SS (°Brix)
A03MP-BA	1.82 b	17.86 c	12.93 b	12.68 b	8.65 b	3.23 a	20.55 b	12.49 a
A04MP-BA	1.92 b	14.78 d	20.37 a	10.17 c	14.81 a	2.91 a	18.17 b	7.66 c
A16MP-BA	2.87 a	19.94 b	15.27 b	13.47 b	9.97 b	2.60 b	30.38 a	9.29 c
A17MP-BA	2.34 b	17.41 c	15.96 b	11.29 c	10.38 b	2.95 a	25.46 b	8.21 c
A23BA	2.20 b	14.15 d	25.58 a	8.35 c	20.11 a	2.37 b	25.10 b	9.66 c
A24BA	2.46 b	20.23 b	11.46 b	14.53 a	7.22 b	2.91 a	24.22 b	10.16 b
A25BA	3.88 a	17.79 c	21.59 a	10.29 c	15.66 a	1.85 b	33.18 a	9.08 c
A26BA	2.15 b	18.07 c	14.79 b	12.72 b	9.91 b	2.42 b	22.80 b	9.30 c
A01MP-PE	3.35 a	21.04 b	16.43 b	14.63 a	10.47 b	3.17 a	27.44 a	10.58 b
A02MP-PE	3.84 a	20.80 b	16.90 b	12.62 b	11.08 b	3.12 a	33.72 a	9.91 b
A05PE	3.08 a	19.41 b	17.12 b	12.60 b	11.74 b	3.35 a	26.76 a	9.35 c
A08PE	2.96 a	17.97 c	21.56 a	12.87 b	14.29 a	3.08 a	27.09 a	8.24 c
A14PE	1.84 b	14.35 d	20.90 a	9.55 c	14.04 a	2.60 b	19.98 b	8.17 c
A20PE	2.82 a	18.30 c	18.34 b	11.36 c	12.69 b	3.08 a	29.42 a	9.00 c
A21PE	2.58 b	18.14 c	17.20 b	10.71 c	11.26 b	3.37 a	25.08 b	8.16 c
A22PE	4.46 a	24.53 a	15.40 b	17.03 a	9.53 b	4.56 a	31.36 a	7.76 c
A08RN	1.69 b	16.33 d	11.69 b	10.80 c	7.41 b	2.02 b	24.09 b	8.46 c
A10RN	2.55 b	15.11 d	24.11 a	8.49 c	17.79 a	2.10 b	29.50 a	12.11 a
Jacarezinho	1.31 b	15.61 d	9.88 b	11.05 c	5.91 b	1.62 b	19.96 b	10.42 b
Mean	2.64	17.99	17.24	11.85	11.73	2.81	26.01	9.37
Amplitude	3.15	10.38	15.70	8.68	14.20	2.94	15.55	4.83
CV(%)	29.78	11.09	20.50	12.78	24.82	24.93	16.01	13.67
F	3.29**	5.29**	4.43**	6.23**	4.76**	2.78**	3.55**	3.35**

Means followed by the same letters in the columns belong to the same group by the Scott-Knott test at a 5% significance level. FW = fruit weight (kg); FD = fruit diameter (cm); FL = fruit length (cm); FICD = fruit internal cavity diameter (cm); FICL = fruit internal cavity length (cm); AFST = average of fruit skin thickness (mm); AFFT = average of fruit flesh thickness (mm); SS = soluble solids content (°Brix). ** = Significant at 1%. CV(%) = coefficient of variation.

Fruit internal cavity diameter (FICD) and fruit internal cavity length (FICL) in the first experiment varied from 8.35 to 17.03 cm and from 5.91 to 20.11 cm, respectively (Table 2), denoting a high genetic variability. According to Blank et al. (2013), evaluating the fruit internal cavity is important when the purpose is to grow fruits for seed production, as fruits with larger internal cavities have more space for seed production. In the second experiment, FICD varied from 8.02 to 14.41 cm and FICL from 6.50 to 17.70 cm, which were similar to those found in the first experiment (Tables 2 and 3).

The accession A22PE presented the highest mean fruit skin thickness (AFST) in the first experiment (4.56 mm); however, most accessions presented close AFST, except for A23BA, A25BA, A08RN, A10RN, and the control cultivar Jacarezinho (Table 2). For the AFST descriptor the means formed two groups in the second experiment (Table 3). Both experiments presented higher means (2.81 and 2.59 mm, respectively) than that found by Amaro et al. (2017): 2.56 mm. However, fruits with thinner skin thickness provide higher pulp yields (AMARO et al., 2017). Thus, an intermediate skin thickness is desired, as it favors storage and transport for longer periods without affecting pulp yield.

The mean fruit flesh thickness (AFFT) in the first experiment was 26.01 mm, similar to that found by Lima et al. (2019) (25.88 mm), who evaluated different *C. moschata* accessions. Most accessions presented similar AFFT; A02MP-PE presented the highest AFFT (33.72 mm, absolute value), followed by A03MP-BA (20.55 mm), A04MP-BA (18.17 mm), A14PE (19.98 mm), and the cultivar Jacarezinho (19.96 mm), which presented the lowest AFFT (Table 2). In the second experiment AFFT was not significant. Flesh thickness is an important factor for fruit marketing, as fruits that present thicker fleshes have higher pulp yields and are preferable by consumers (BLANK et al., 2013).

Soluble solids content (SS; °Brix) presented high genetic variation, with sugar content from 7.66 °Brix (accession A04MP-BA) to 12.49 °Brix (accession A03MP-BA) in the first experiment (Table 2), and from 8.83 °Brix (A02MP-PE) to 12.88 °Brix (A10RN) in the second experiment (Table 3). Darrudi et al. (2018) evaluated the genetic diversity of accessions of *C. moschata* and found SS from 4.8 to 9.5 °Brix, lower than those found in the present work. Lima et al. (2019) reported that fruits with lower weights present higher SS. This correlation was noticed for some accessions (Tables 2 and 3). Sugar content is a descriptor of commercial importance, as it is connected to fruit sweetness (BORGES FILHO et al., 2016). The SS of pumpkins intended for fresh consumption can be classified as low (SS < 7 °Brix, low sweetness), moderate (7 °Brix > SS <11 °Brix), or high (SS > 11 °Brix, high sweetness) (SANTOS et al., 2015). Therefore, the fruits evaluated presented medium to high SS, and higher SS for those of accessions A03MP-BA and A10RN in both experiments (Tables 2 and 3) and for those of accessions A16MP-BA, A23BA, and A05PE and the cultivar Jacarezinho in the second experiment (Table 3). Fruits with high sugar contents, i.e., sweeter fruits, are preferable by consumers, including the consumer market in Northeast region of Brazil (OLIVEIRA et al., 2016).

Table 3. Means of morpho-agronomic descriptors for fruits from progenies of different accessions of *C. moschata* and the commercial cultivar Jacarezinho in the second experiment (2022).

Accessions	FW (kg)	FD (cm)	FL (cm)	FICD (cm)	FICL (cm)	AFST (mm)	SS (°Brix)	100SDW (g)
A03MP-BA	1.99 a	17.63 a	13.91 b	11.86 a	9.32 b	2.83 a	12.40 a	15.43 a
A04MP-BA	1.25 a	11.41 c	22.80 a	8.02 c	17.47 a	2.23 b	9.66 c	14.05 a
A16MP-BA	2.15 a	18.85 a	12.02 b	12.52 a	8.29 b	2.31 b	11.21 a	15.71 a
A23BA	2.08 a	14.94 b	20.73 a	8.65 c	14.51 a	2.14 b	12.23 a	12.16 b
A24BA	2.82 a	21.14 a	12.57 b	14.41 a	7.88 b	2.35 b	10.52 b	12.39 b
A25BA	2.56 a	18.39 a	16.42 b	10.85 b	10.67 b	3.01 a	9.30 c	13.93 a
A01MP-PE	3.15 a	19.38 a	17.84 a	13.08 a	11.32 b	2.89 a	10.49 b	10.52 b
A02MP-PE	2.52 a	18.30 a	13.40 b	10.80 b	8.30 b	2.88 a	8.83 c	11.55 b
A05PE	2.44 a	15.63 b	23.77 a	10.69 b	17.70 a	3.00 a	11.70 a	17.46 a
A21PE	2.44 a	17.82 a	16.57 b	10.59 b	10.02 b	3.33 a	8.99 c	12.77 b
A10RN	2.72 a	16.60 a	20.96 a	10.82 b	15.56 a	2.21 b	12.88 a	10.54 b
Jacarezinho	1.71 a	17.18 a	10.53 b	11.61 a	6.50 b	1.96 b	11.31 a	12.63 b
Mean	2.32	17.27	16.79	11.16	11.46	2.59	10.79	13.26
Amplitude	1.90	9.73	13.24	6.39	11.20	1.37	4.05	6.94
CV(%)	25.66	11.72	20.16	12.22	23.67	19.55	7.50	17.22
F	2.25ns	4.49**	5.20**	4.96**	6.15**	2.26*	8.77**	2.61*

Means followed by the same letters in the columns belong to the same group by the Scott-Knott test at a 5% significance level. FW = fruit weight (kg); FD = fruit diameter (cm); FL = fruit length (cm); FICD = fruit internal cavity diameter (cm); FICL = fruit internal cavity length (cm); AFST = average of fruit skin thickness (mm); SS = soluble solids content (°Brix); 100SDW = 100-seed dry weight (g). ** = Significant at 1%, * = significant at 5%, and ns = not significant. CV(%) = coefficient of variation.

In the first experiment, 100-seed dry weight (100SFW) and 100-seed dry weight (100SDW) presented no significant difference, whereas in the second experiment, only 100SDW presented significant difference. However, all values were similar, and the accession A05PE presented a greater 100SDW: 17.46 g, absolute value (Table 3).

High coefficients of variation were found for FW, FL, FICL, AFST in the first experiment and for FL and FICL in the second experiment. This may be attributed to the variability within each accession (experiment I) or progeny (experiment II) (Tables 2 and 3).

All evaluated descriptors related to qualitative characteristics presented high variability, except for flesh texture in the first experiment, which presented 100% smooth-firm fleshes (Table 4). In the first experiment, fruit shape, skin color, and skin texture presented greater variation. Fruit shapes were globular, flattened, cylindrical, elliptical, pear-shaped, and heart-shaped. Most accessions presented heart-shaped (66.67%) fruits, followed by globular (44.44%). The fruit skin color of all accessions was predominantly cream (68.42%), and the skin textures were smooth (63.16%), granulated (21.05%), slightly wavy (10.53%), and warty (5.26%) (Table 4).

In the second experiment, the progenies of all accessions presented variation for the evaluated characteristics. Fruit shapes were globular (25%), flattened (16.67%), elliptical (25%) and heart-shaped (33.33%); heart-shaped fruits were predominant, similar to the first experiment. Fruits with orange skin predominated (41.68%). The predominant skin texture was slightly wavy, representing 83.34% of fruits of the different accessions (Table 5), different from the first experiment.

Table 4. Morphological characterization of six qualitative descriptors for fruits of different accessions of *C. moschata* and the cultivar commercial Jacarezinho in the first experiment.

Accessions	FS	FR	SC	FC	FT	ST
A03MP-BA	1	1	3	2	1	1
A04MP-BA	4	1	3	3	1	4
A16MP-BA	1	3	5	2	1	1
A17MP-BA	6	2	3	3	1	1
A23BA	5	2	3	2	1	1
A24BA	2	1	3	2	1	1
A25BA	6	3	3	2	1	4
A26BA	3	1	2	2	1	1
A01MP-PE	2	1	3	2	1	5
A02MP-PE	6	3	3	2	1	1
A05PE	4	2	3	2	1	2
A08PE	6	1	3	2	1	2
A14PE	4	1	3	1	1	1
A20PE	6	1	5	2	1	1
A21PE	6	2	3	2	1	1
A22PE	2	2	3	2	1	2
A08RN	1	2	5	2	1	1
A10RN	3	1	4	2	1	2
Jacarezinho	1	1	2	2	1	1

FS = fruit shape (1 - globular, 2 - flattened, 3 - cylindrical, 4 - elliptical, 5 - pear-shaped, 6 - heart-shaped); FR = fruit ribbing (1 - superficial, 2 - intermediate, 3 - intense); SC = skin color (1 - white, 2 - green, 3 - cream, 4 - yellow, 5 - orange); FC = flesh color (1 - yellow, 2 - orange, 3 - salmon); FT = flesh texture (1 - smooth-firm, 2 - fibrous-gelatinous, 5 - dry-fibrous); and ST = skin texture (1 - smooth, 2 - granulated, 3 - finely wrinkled, 4 - slightly wavy, 5 – warty).

Table 5. Morphological characterization of six qualitative descriptors for fruits from S_1 progenies of different accessions of *C. moschata* and the cultivar commercial Jacarezinho in the second experiment.

Accessions	FS	FR	SC	FC	FT	ST
A03MP-BA	1	1	4	2	1	1
A04MP-BA	4	1	5	2	1	4
A16MP-BA	1	1	5	3	2	4
A23BA	6	1	5	2	2	4
A24BA	2	1	3	2	1	3
A25BA	6	3	1	2	1	4
A01MP-PE	1	1	3	2	1	4
A02MP-PE	6	2	5	2	1	4
A05PE	4	2	3	2	2	4
A21PE	6	2	5	3	1	4
A10RN	4	1	3	2	1	4
Jacarezinho	2	1	2	2	1	4

FS = fruit shape (1 - globular, 2 - flattened, 3 - cylindrical, 4 - elliptical, 5 - pear-shaped, 6 - heart-shaped); FR = fruit ribbing (1 - superficial, 2 - intermediate, 3 - intense); SC = skin color (1 - white, 2 - green, 3 - cream, 4 - yellow, 5 - orange); FC = flesh color (1 - yellow, 2 - orange, 3 - salmon); FT = flesh texture (1 - smooth-firm, 2 - fibrous-gelatinous, 5 - dry-fibrous); and ST = skin texture (1 - smooth, 2 - granulated, 3 - finely wrinkled, 4 - slightly wavy, 5 - warty).

Fruits of the cultivar Jacarezinho exhibited different shapes in the two experiments; they were globular in the first and flattened in the second experiment, as also found by Borges et al. (2019). This variation in fruit shape for the cultivar Jacarezinho may be due to segregation that was not eliminated during the seed production process. A difference was also found for fruit skin texture; it was smooth in the first and slightly wavy in the second experiment. No difference was found for the other characteristics (Tables 4 and 5).

Oliveira et al. (2016) evaluated different accessions of *C. moschata* and found genetic variability in fruit shape, with 35.71% presenting globular fruits, as in the first experiment of the present study. Priori et al. (2018) also found variation in fruit shape for *C. maxima*; most accessions presented flattened fruits, followed by globular and elongated fruits. Borges et al. (2019) reported that studies on morphological characteristics of fruits, including fruit shape, are important for breeding programs focused on increasing fruit yield.

The data from the morpho-agronomic descriptors used in the present study for multivariate analysis allowed for the identification of variability among the evaluated *C. moschata* accessions. In the first experiment, the 18 *C. moschata* accessions and the cultivar Jacarezinho were distributed into seven groups (Figure 1), with a dendrogram showing a cophenetic correlation coefficient (CCC) of 0.69. In the second experiment, the 11 progenies and the control formed four groups (Figure 2), with CCC = 0.78. According to Crispim, Fernandes and Albuquerque (2019), a CCC above 0.7 indicates a good fit for the clustering method; thus, the CCC found in the second experiment showed a suitable fit for the clustering method applied. In the first experiment, the CCC did not exceed 0.7; however, the obtained CCC did not show a significant difference, denoting variability in the consistency of the clustering method.

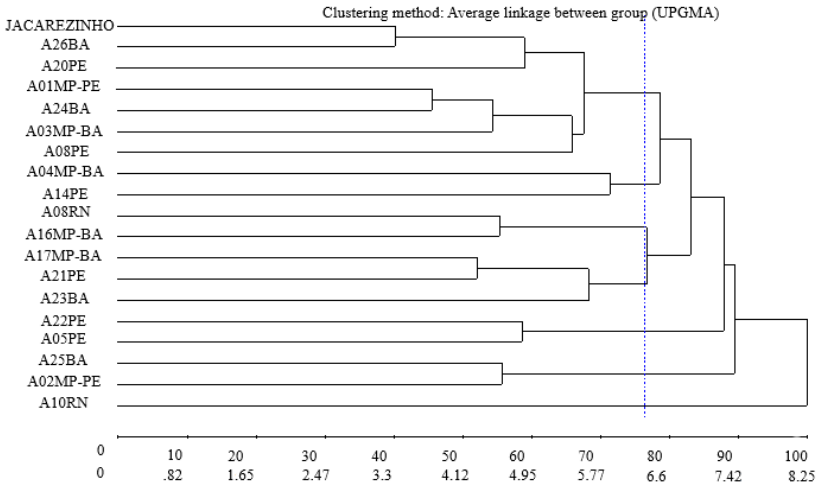

Figure 1. Dendrogram generated by joint analysis of quantitative and qualitative data in the first experiment, using Unweighted Pair Group Method with Arithmetic Mean (UPGMA).

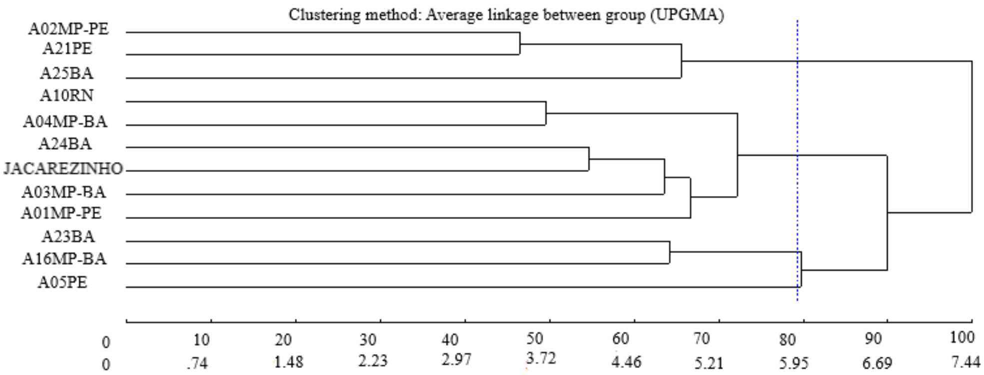

Figure 2. Dendrogram generated by joint analysis of quantitative and qualitative data in the second experiment, using Unweighted Pair Group Method with Arithmetic Mean (UPGMA).

In the first experiment, Group 1 was formed by the cultivar Jacarezinho and the accessions A26BA, A20PE, A01MP, A24BA, A03MP, and A08PE; Group 2 by A04MP and A14PE; Group 3 by A08RN and A16MP; Group 4 by A17MP, A21PE and A23BA; Group 5 by A22PE and A05PE; Group 6 by A25BA and A02MP; and Group 7 consisted of the accession A10RN (Figure 1). The proximity of these accessions may be attributed to morphological similarity regarding fruit length (FL) (Table 2) and the qualitative characteristic of skin color and texture (Table 4).

In the second experiment, four groups were formed by the progenies of the 11 accessions: Group 1 was formed by progenies of the accessions A02MP, A21PE, and A25BA; Group 2 by progenies of the accessions A10RN, A04MP, A24BA, A03MP, and A01MP and the cultivar Jacarezinho; Group 3 by progenies of the accessions A23BA and A16MP; and Group 4 by the progeny of the accession A05PE (Figure 2). Considering their morpho-agronomic data, that may have contributed the most to the separation of these progenies were fruit diameter (FD) and soluble solids content (SS) (Table 3), along with the qualitative descriptors fruit ribbing and flesh texture (Table 5).

CONCLUSIONS

The evaluated accessions and progenies of *Cucurbita moschata* presented genetic variability for several quantitative and qualitative morphological characteristics of fruits. Several *C. moschata* fruits presented high soluble solids content but the fruits of the progenies showed a major proportion of fruits with high soluble solids.

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