https://dx.doi.org/10.22161/ijaers.76.7 ISSN: 2349-6495(P) | 2456-1908(O)

Biometric evaluation of *Passiflora cincinnata* seeds obtained from the herbaceous extract of the caatinga biome

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***Abstract*— *Seed biometrics is an important tool to detect genetic variability within populations of the same species. In this sense, the objective was to evaluate biometric evaluation of Passiflora cincinnata seeds obtained from the herbaceous extract of the caatinga biome. The work was developed at the Federal Rural University of the Semi-arid, Mossoró, Brazil, in the year 2019. 300 units of seeds of various genotypes of Passiflora cincinnata were collected, in an area of the herbaceous extract of the caatinga biome, where the following were evaluated characteristics: a) morphological characterization of Passiflora cincinnata, determining the length and width of 300 seeds, with the help of a caliper, being expressed in millimeters b) thickness of the seeds, being expressed in millimeters; and c) seed weight, expressed in grams. There was a regular degree of symmetry for the frequency distributions of the length, width, thickness, length/width ratio and weight of Passiflora cincinnata seeds, being different from zero. A degree of flattening or kurtosis of the platicurtic and leptocurtic type was found for the evaluated characteristics. Responses from scientific research on descriptive measures of location, variability or scale, asymmetry and kurtosis may serve as a basis for future studies of descriptive analysis and statistical inference, for comparison of different environments, genetic studies and plant breeding, as well as in construction of the so-called variance components, for simulation and modeling studies applied to agriculture.*

Keywords*— Wild passion fruit, Descriptive statistics, Inference.

I. INTRODUCTION

Fruit growing has great relevance in the Brazilian economic scenario, being the third largest fruit producer in the world [1]. Among the fruit trees, Brazil stands out as the largest producer and consumer of passion fruit. With an approximate area of 51 thousand hectares cultivated in almost all states of the federation, with a total production of 694 thousand tons per year [2].

This fruit has great economic importance for the country, contributing to the increase in income among producers, in addition to being a promising market for the juice industry.

Passion fruit belong to the Passifloraceae family, which is predominantly from Tropical America, encompasses about 19 genera and 530 species, the majority belonging to the Passiflora genus, approximately 400 species such as at least 120 are native to Brazil [3].

In the caatinga biome there is a wide variety of fruit trees, adapted to the climate and soil conditions with exotic flavors, which meet the current trends in the consumption of natural products, which reinforces the initiatives of collection, characterization and cultivation in commercial areas [4]. There are only about 70 species of *Passiflora* actually edible [5]. Among them, the wild species *Passiflora cincinnata* Mast stands out, popularly known in Brazil as “Maracujádo-Mato” or “Maracujá-de-Boi” [6].

In the Northeast region, it is sold in the off-season of yellow passion fruit, presenting an excellent income option for small farmers, since it is a species adapted to local growing conditions, as it is native to the region. The seeds of this species are generally oval and flat, 5.5 mm long and 3.5 mm wide, with a reticulated aspect, covered by lighter punctuations when dried, surrounded by a juicy, yellow and aromatic pulp [7].

The size and characteristics of the seeds are of great importance for the study of a species. It is a basic parameter to understand the dispersion and establishment of seedlings [8], being also used to differentiate pioneer and non-pioneer species in tropical forests [9].

In the literature, there is a large number of articles specialized in the field of fruit seed biometry [10,11,12,13,14 and 15].

Biometrics is an important tool to detect genetic variability within populations of the same species and the relationships with environmental factors, providing important subsidies for the differentiation of species of the same genus [16 and 17].

Given the above, the objective was to evaluate, through statistical techniques of exploratory data analysis, the biometric variables referring to the seeds of *Passiflora cincinnata* Mast obtained from plants of the caatinga herbaceous extract.

II. MATERIALS AND METHODS

The study was carried out in Mossoró, Rio Grande do Norte-RN, Brazil, in 2019, whose geographic coordinates are: 5°11'S and 37°20' W, with 18 m altitude, annual average temperature around 27.5 °C and relative humidity of 68.9% [18]. According to [19] and the classification of Köppen, the local climate is BSwh', dry and very hot, the dry season being normally from June to January, and a rainy season being from February to May. The average annual rainfall is 673.9 mm and the average relative humidity is 68.9%.

A total of 300 seed units of various genotypes of *Passiflora cincinnata*, were collected in an area of the caatinga biome herbaceous extract, located within the campus of the Federal Rural University of the Semi-arid (UFERSA) in May 2018 and taken to the phytotechnics laboratory, where the following characteristics were evaluated: a) morphological characterization of Passiflora cincinnata, determining the length and width of 300 seeds, with the aid of a caliper, being expressed in millimeters b) thickness of seeds, being expressed in millimeters; and c) seed weight, expressed in grams.

Descriptive and graphic analyzes were performed using the software package [20].

III. RESULTS AND DISCUSSION

In estimating the important quantitative aspects of the distribution of the values of the random variables length, width, length / width ratio, thickness and seed weight, the present work was supported by specialized statistical literature [21,22,23,24,25,26 and 27].

In this study, exploratory data analysis was adopted, using frequency distributions, statistical series and heterogeneous series, box plot graphs, as well as the statistical estimators of the variables under study, which are the main typical measures of position, dispersion measures, variation or scale, asymmetry measures, flattening or kurtosis measures, using descriptive statistics.

The main parameters used were: arithmetic mean, median, total amplitude, variance, standard deviation, standard error of the mean, variation coefficient, asymmetry coefficient, kurtosis coefficient, quartiles, interquartile deviation, Pearson's correlation coefficient, as well as the application of statistical inference techniques, such as hypothesis or significance tests and the Z test at a significance level of 5% probability, based on Student's t distribution and Normal distribution, respectively, in the construction of intervals of confidence with 95% probability (Tables 1 to 5 and Figures 1 to 11).

Table 1. Descriptive and inductive statistical analysis of 300 sample units of seeds for the variables length, width, length/width ratio, thickness (mm) and weight in grams (g) of passion fruit (Passiflora cincinnata L.).

Sample or estimator statistics	Length	Width	Length/width ratio	Thickness	Weight
Sample Size (number of seeds)	300	300	300	300	300
Minimum value	2.85	2.10	1.01	1.27	0.002
Maximum value	5.96	3.10	2.70	1.99	0.015
Total Range	3.11	0.90	1.60	0.72	0.013
Arithmetic Average	5.15	2.46	2.10	1.69	0.011
Median or Second Quartile	5.18	2.44	2.10	1.70	0.011
Varinace	0.11	0.03	0.01	0.03	0.00001
First quartile	4.97	2.35	1.99	1.63	0.0097
Third quartile	5.33	2.59	2.22	1.77	0.012
Standard deviation	0.33	0.17	0.18	0.12	0.0019
Average standard error	0.019	0.001	0.010	0.007	0.0001
Coefficient of variation (%)	6.34	6.91	8.41	7.18	18.09
Skweness	-1.33	0.35	-0.61	-0.39	-1.08
Kurtosis	8.00	-0.20	3.378	0.55	2.23
Interquartile Range (IR)	0.36	0.24	0.23	0.15	0.0021
Z Test for the mean at 0.1% probability	271***	246***	210***	241***	110***
Confidence Interval for the average 95% probability	5.11 a 5.19	2.45 a 2.46	2.08 a 2.12	1.68 a 1.70	0.010 a 0.012
Fitting to Normal Distribution (D'Agostino-Pearson Test)	Valor p = 0.01 fit to Normal Distribution	Valor p = 0.73 fit to Normal Distribution	Valor p = 0.01 fit to Normal Distribution	Valor p = 0.01 fit to Normal Distribution	Valor p = 0.05 fit to Normal Distribution

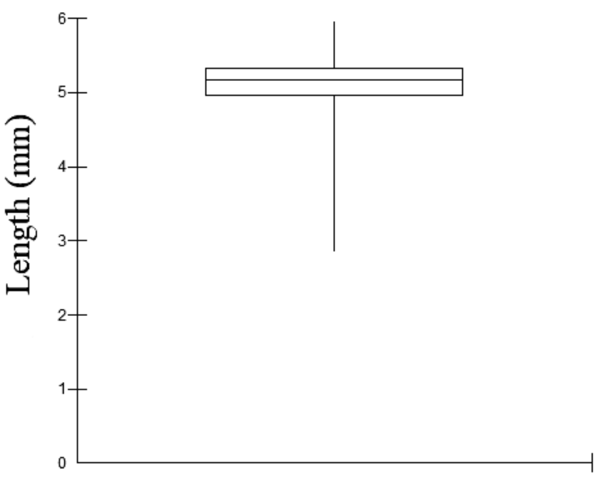

Fig.1: Boxplot with median and quartiles for the length of passion fruit seeds (Passiflora cincinnata L.).

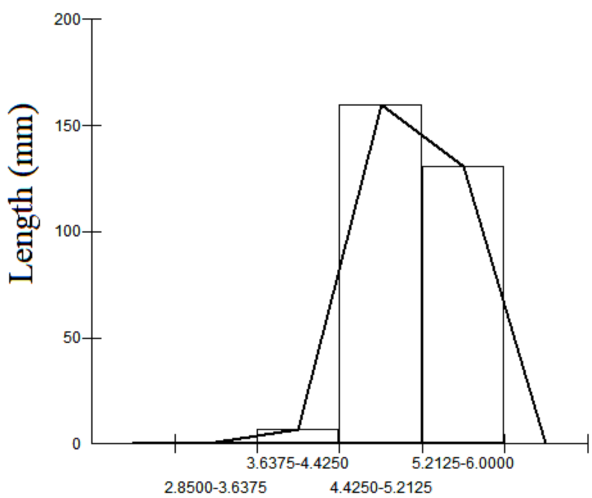

Fig.2: Histogram and polygon of frequencies for the length distribution of passion fruit seeds (Passiflora cincinnata L.).

Table 2. Frequency distribution of the length of passion fruit seeds (Passiflora cincinnata L.).

Length in mm	f_i	X_i	f %
2.85[---------)3.64	1	3.24	0.33
3.64 [---------) 4.43	7	4.03	2.34
4.43[---------) 5.21	161	4.82	53.52
5.21 [---------)6.00	131	5.61	43.81
Total	300	--------	100

Table 3. Frequency distribution of the width of passion fruit seeds (Passiflora cincinnata L.).

Width in mm	f_i	X_i	f %
2.10 |— 2.27	30	2.18	10.03
2.27 |— 2.43	116	2.35	38.80
2.43 |— 2.60	81	2.52	27.09
2.60 |— 2.77	56	2.68	18.73
2.77 |— 2.93	15	2.85	5.02
2.93 |— 3.10	2	3.02	0.67
Total	300	--------	100

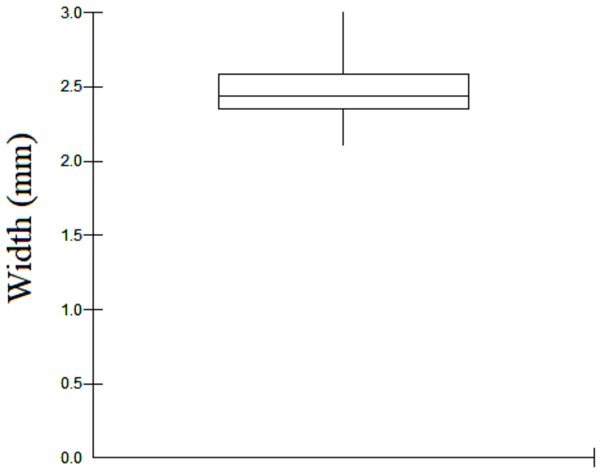

Fig.3: Boxplot with median and quartiles for the width of passion fruit seeds (Passiflora cincinnata L.).

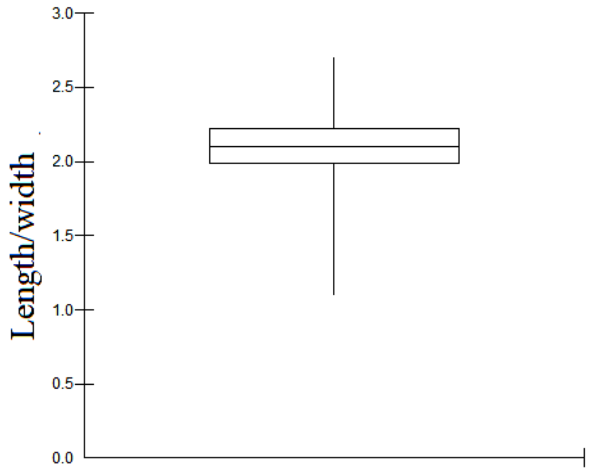

Fig.5: Boxplot with median and quartiles for the length-width ratio, dimensionless value of passion fruit seeds (Passiflora cincinnata L.).

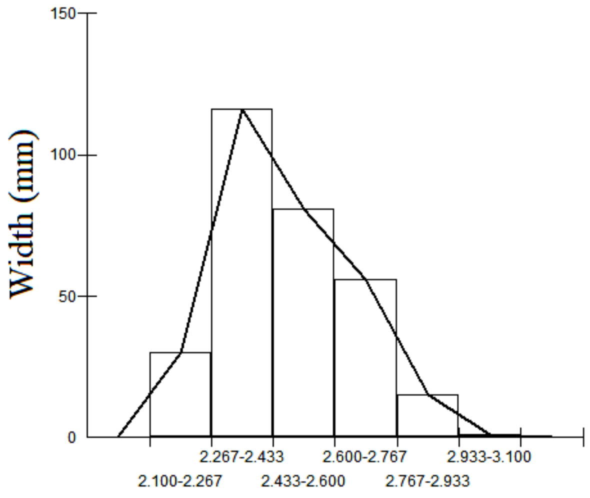

Fig.4: Histogram and polygon of frequencies for the width distribution of passion fruit seeds (Passiflora cincinnata L.).

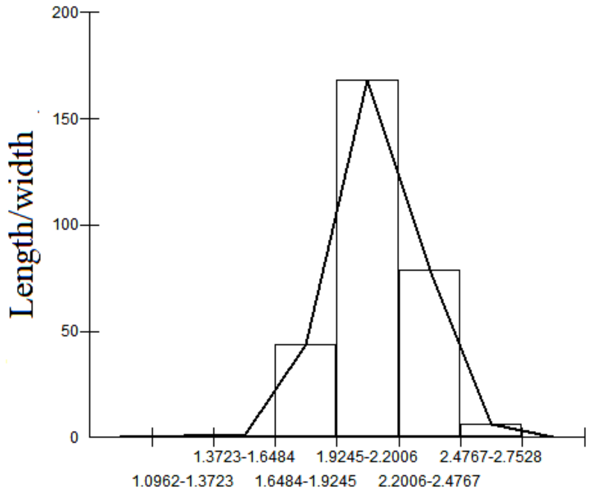

Fig.6: Histogram and polygon of frequencies for the length-width ratio, dimensionless value of passion fruit seeds (Passiflora cincinnata L.).

https://dx.doi.org/10.22161/ijaers.76.7 ISSN: 2349-6495(P) | 2456-1908(O)

Table 4. Frequency distribution of the length-width ratio, dimensionless value of passion fruit seeds (Passiflora cincinnata L.).

Length/Width	f_i	X_i	f %
1.10 |— 1.37	1	1.23	0.33
1.37 |— 1.65	1	1.51	0.33
1.65 |— 1.92	44	1.79	14.72
1.92 |— 2.20	168	2.06	56.19
2.20 |— 2.48	80	2.34	26.67
2.48 |— 2.75	6	2.61	2.01
Total	300	--------	100

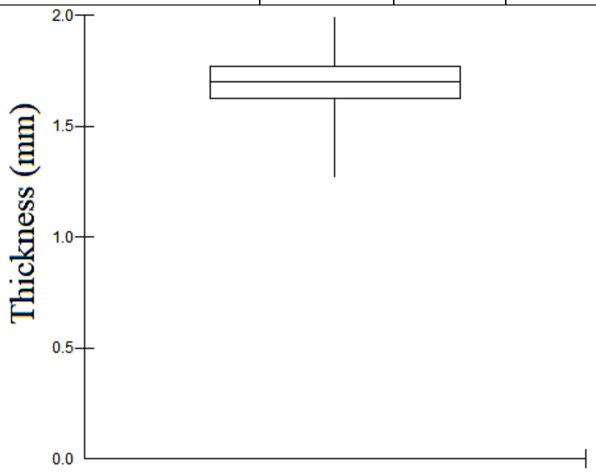

Fig.7: Boxplot with median and quartiles for the thickness of passion fruit seeds (Passiflora cincinnata L.).

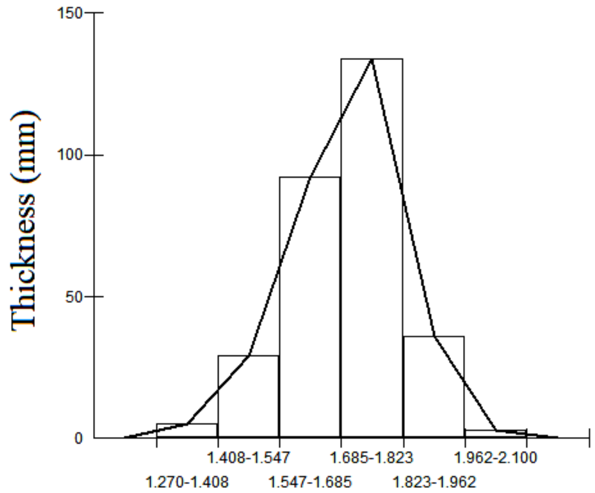

Fig.8: Histogram and polygon of frequencies for the thickness of passion fruit seeds (Passiflora cincinnata L.).

Table 5. Frequency distribution of the thickness of passion fruit seeds (Passiflora cincinnata L.).

Thickness in mm	f_i	X_i	f %
1.27 |— 1.41	5	1.34	1.67
1.41 |— 1.55	30	1.48	10.00
1.55|— 1.69	92	1.62	30.77
1.69 |— 1.82	134	1.75	44.82
1.82 |— 1.96	36	1.89	12.04
1.96|— 2.10	3	2.03	1.00
Total	300	--------	100

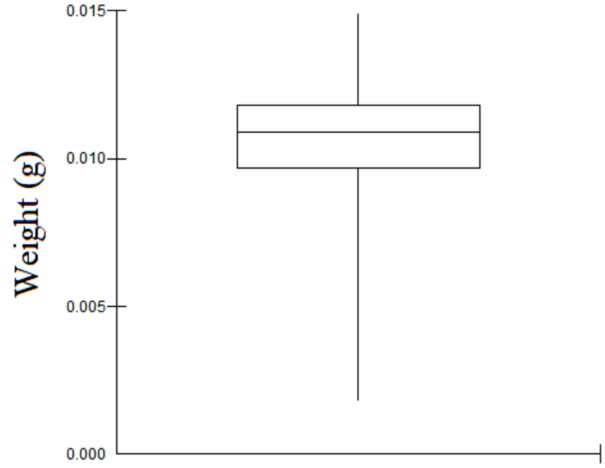

Fig.9: Boxplot with median and quartiles for the weight of passion fruit seeds (Passiflora cincinnata L.).

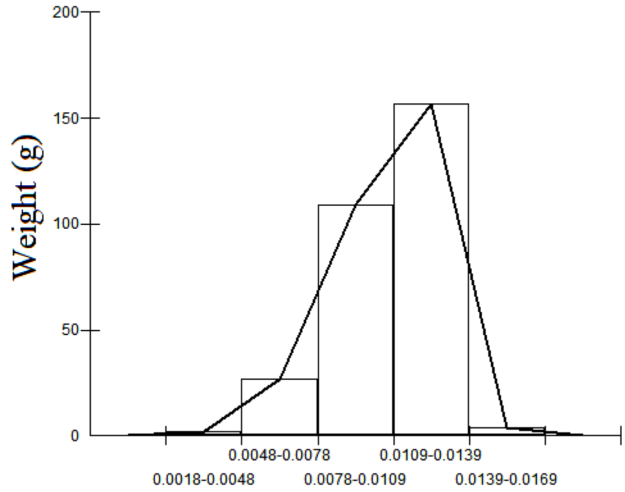

Fig.10: Histogram and polygon of frequencies for the weight of passion fruit seeds (Passiflora cincinnata L.).

Table 6. Frequency distribution of the weight of passion fruit seeds (Passiflora cincinnata L.).

Weight in g	f_i	X_i	f %
0.0018 |— 0.0048	2	0.0033	0.67
0.0048 |— 0.0078	27	0.0063	9.03
0.0078 |— 0.0109	109	0.0094	36.45
0.0109 |— 0.0139	157	0.0124	52.51
0.0139 |— 0.0169	4	0.0154	1.34
Total	300	--------	100

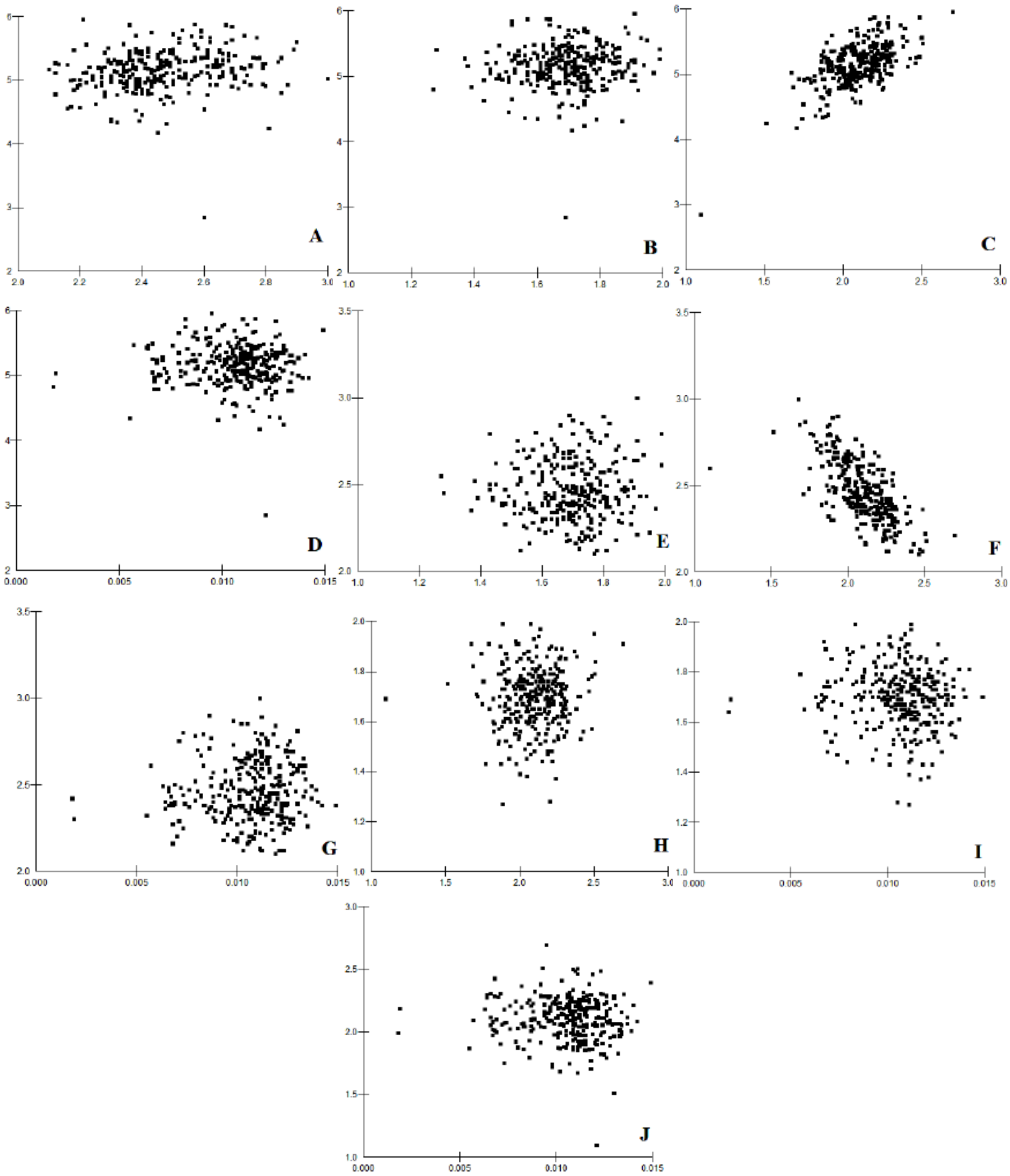

Fig.11: Dispersion plots of correlations between pairs of variables: length versus width (A), length versus thickness (B), length versus length/width ratio (C), width versus length/width ratio (D), length versus weight (E), width versus thickness (F) thickness versus length / width (G) width versus weight (H) thickness versus weight (I) and length/width versus weight (J) of passion fruit seeds (Passiflora cincinnata L.).

Table 7. Matrix of Pearson's linear correlation coefficients between pairs of variables: length, width, length/width ratio, thickness, and weight of the of passion fruit seeds (Passiflora cincinnata L.).

Variables studied	Variables studied				
	Length	Width	Length/width ratio	Thickness	Weight
Length	1,00	-----	-----	-----	-----
Width	0,17	1,00	-----	-----	-----
Leng/width ratio	0,07	0,02	1,00	-----	-----
Thickness	0,60	-0,68	0,05	1,00	-----
Weight	-0,02	0,06	-0,07	-0,06	1,00
95 % confidence intervals	Length x Width	Length x Length/Width	Length x Thickness	Length x Weight	Width X Length/Width
	0.06 a 0.28	-0,04 a 0.18	0.53 a 0.67	-0.13 a 0.10	-0.10 a 0.13
	Width x Thickness	Width x Weight	Length/Width x Thickness	Length/Width x Weight	Thickness x Weight
	-0,73 a -0,61	-0.06 a 0.17	-0.06 a 0,16	-0.18 a 0.04	-0.17 a 0.06
P-value of Student's t-Test	0,0030	0,2315	<0,0001	0,7657	0,7938
	< 0.0001	0.3121	0,3776	0,2347	0,3259

The descriptive results (Table 1) show that the variables: length, width, thickness, expressed in millimeters and the weight in grams of the seeds of *Passiflora cincinnata*, showed a high range of variation, except for the length / width ratio, being observed low for the relative variation of all variables, measured by their coefficients of variation, being great for Pearson's coefficients of variation, except for weight, as it presented a relatively high value for the coefficient of variation which corroborates with the fact to be a characteristic of high genetic variability [28].

With regard to homogeneity, the characteristics are presented with a high degree, the relative variation in length being similar to that of thickness, and width with that of the length/width ratio.

There was a reasonable degree of symmetry for the variables: length/width ratio, thickness and weight, and therefore a symmetrical and mesocurtic distribution for length, width, length/width ratio, and for the weight of *Passiflora cincinnata* seeds, except for the thickness that showed a close behavior with the mesocurtic curve.

A simple positive linear correlation was observed between length and width, length and thickness, width and length/width, width and thickness and length / width and thickness. The average relation between length/width and the weight of the seeds, showed a significant difference between the averages whose results were 2.10 dimensionless and 0.011 grams, respectively.

However, it can be said that the seeds do not have a center of gravity in the distribution of these variables, showing that the length and thickness of the seeds are respectively distant, with average values of 5.15 and 2.46 millimeters, respectively. On the other hand, the weights are not very close to the average weight of 0.011 grams, due to the value of the coefficient of variation (18.9%).

The coefficients of variation, between the variables, were the most appropriate for comparing dispersion between samples, as they do not depend on the magnitude of the variable, as well as on its unit of measurement, and therefore the most correct procedure.

The values obtained from the variation coefficients were 6.34%, 6.91%, 8.41% and 7.18% for the length, width, length / width ratio and thickness, respectively, showing a similar or close relative dispersion for the four characteristics evaluated, thus showing an extremely similar and statistically equal relative variability for these

https://dx.doi.org/10.22161/ijaers.76.7 ISSN: 2349-6495(P) | 2456-1908(O)

characteristics [29,30]. The coefficient of variation for the seed weight was 18.09%, which shows a high relative dispersion for this variable, showing a relatively high genetic variability.

The values obtained for the means and medians in the characteristics of *Passiflora cincinnata* seeds, as shown in Table 1, were close, these values being 5.15 and 5.18 mm for length, 2.46 and 2.44 mm for width, 2.10 and 2.10 in the length/width ratio, 1.69 and 1.70 mm for thickness and weight with values of 0.011 and 0.0011 g, respectively. These values indicated a certain degree of asymmetry, with values of -1.33; 0.35; 0.61; 0.39 and 1.08 for length, width, length / width ratio, thickness and weight, respectively.

In a symmetric frequency distribution, the measures of central position or tendency, such as arithmetic mean, median and mode are the same. However, the fact that the three means are close together does not imply that the frequency distribution of their values is symmetric [31].

On the other hand, the kurtosis coefficients were: 8.00; -0.20; 3,378; 0.550 and 2.230 for length, width, length/width ratio, thickness and weight, respectively (Table 1). These values presented a platicurtic distribution for length, leptocurtic for width, and platicurtic for length/width, thickness and weight, respectively.

However, it is worth noting that the characterization of the degree of asymmetry and kurtosis of a distribution, according to [22], [25], [32], [33], [31] and [34], can not be evaluated only by measures of position or central tendency, as is the case of the mean and median, but also by the coefficients of asymmetry and kurtosis, as well as through box plot diagrams, histograms and frequency polygons (Figures 1 to 10). Asymmetry describes how the sample differs in the form of a symmetric distribution.

A normal distribution has an asymmetry coefficient equal to zero. A distribution in which the value of the asymmetry coefficient is greater than zero has asymmetry on the right, that is, there is a long tail of larger observations, that is, on the right of the mean. In contrast, if the asymmetry coefficient is less than zero, it has asymmetry to the left, in this case, there is a long tail of smaller observations, that is, to the left of the mean.

Platicurtic distributions (flattened), have a kurtosis coefficient less than zero, compared to the normal distribution, in this case, there is more probability mass in the center of the distribution and less probability in the tails. In contrast, leptocurtic (tapered) distributions have a value for the kurtosis coefficient greater than zero. Leptocurtic distributions have less probability mass in the center and relatively heavy probability tails [31].

Regarding the quantiles, the first quartile shows that 25% of the lowest values for the length, width and thickness of the seeds of Passiflora cincinnata, when they reached a maximum of 4.97; 2.35; and 1.63 mm, respectively, and the length/width ratio, with a dimensionless value of 1.99, on the other hand, the weight reaches a value of 0.0097 g.

The 25% greater length, width and thickness of the seeds of *Passiflora cincinnata* were represented by the values of 5.33; 2.59 and 1.77 mm, respectively. In relation to length / width it reaches a ratio of 2.22 and weight of 0.012 grams, results corroborated by [35]. In this case, the interquartile range obtained, which serves to verify the dispersion of the data in relation to the median and thus to identify the presence of atypical or Outlier's data, was 0.36; 0.24 and 0.15 mm, for the length, width and thickness, since the length/width ratio reaches this level at a rate of 0.23, on the other hand, the weight presented an amplitude value of 0.0021 grams (Table 1).

Regarding the application of the Z test for population mean μ (Table 1), very high values were observed for both length and width, and for the length / width ratio, for thickness and also for weight of *Passiflora cincinnata* seeds, concluding that the average values of these characteristics were highly significant, or statistically different from zero.

Pearson's degree of association or simple linear correlation (Table 7), whose physical definition field ranges from - 1 to + 1, which can be zero or null, is a measure of the degree of association between two quantitative variables, and these associations between two variables can be measured mathematically through the correlation coefficient [36].

Correlations between the variables were observed: length and width, obtained a value of 0.17, insignificant correlation; length/width and length ratio, obtained a value of 0.07, insignificant correlation; length/width and width ratio, obtained a value of 0.02, insignificant correlation; thickness and length, obtained a value of 0.60, a marked correlation; thickness and width, obtained a value of -0.68, striking correlation, thickness and length/width ratio, obtained a value of 0.05, insignificant correlation; weight and length, obtained a value of -0.02, insignificant correlation, weight and width, obtained a value of 0.06, insignificant correlation; weight and length/width ratio, obtained a value of -0.07, insignificant correlation and weight and thickness, obtained a value of -0.06, insignificant correlation, according to what [36].

The correlations thickness and length and thickness and width showed a simple direct or positive linear correlation between these characteristics, and thus these results bluntly revealed three important aspects, the direction, the shape and the strength or intensity of the association between the variables studied. , which was significant by the Student's "t" test at 0.01 probability, showing that when the thickness value increases or decreases the length values, as well as the thickness and width ratio also increase or decrease in a relatively proportion very close [35], where the x and y pairs grow in the same proportion, showing a normal bivariate distribution (Figure 11).

In addition, inferential statistical analyzes through the construction of 95% and 99% probability confidence intervals, showed that in repeated samples there is a high reliability that these results occur at least ninety-nine times, on the other hand, also in function from the application of Student's t-parametric test, it was found that it produced levels described for that test of results, with very high probability values not allowing researchers to reject the null hypothesis as the true population coefficient. Pearson's linear correlation ρ between these variables is null, that is, the null hypothesis H0: ρ = 0 is rejected.

It is worth mentioning that the null hypothesis used in this work will always be equal to zero, in order to guarantee the symmetry of the sample distribution of the estimate so that it can be modeled through the curve of a theoretical distribution of Student's t. probability, since it is assumed that this theoretical coefficient of the population is different from zero, that is, H0: ρ 0 would have to be applied a Fisher zeta transform in order to guarantee such symmetry of the sample distribution of the simple linear Pearson's correlation coefficient r, and thus allow the construction of confidence intervals and the application of the parametric tests of the Student t hypothesis [33].

These results reinforce the need to carry out work repeated in time and space, to verify convergent or divergent results, guiding researchers in the evaluation of genetics and plant improvement and the productive yield of this species to make it commercially viable.

The box plot graph using the median and quartiles is a graphic tool widely used by researchers in general in the areas of physical, biological, medical and social sciences, showing, in the box, the median, the first and the third quartiles. This graph also displays the lowest and highest score across the lower and upper limits of straight vertical lines, which originate from the first and third quartiles, respectively. According to the results shown in Figures 1, 3, 5, 7 and 9, there was a strong concentration of data on length, width, length/width ratio, thickness of *Passiflora cincinnata* seeds in millimeters, with a lower concentration for weight of seeds in grams.

Under the graphic, visual or geometric asect, the scatter diagram (Figure 11), showed a certain pattern of the cloud of pairs of points, where an upward direction is seen from left to right, showing a positive coefficient, a shape close to a straight line, and also a relatively high association force, therefore, the longer the seeds of Passiflora cincinnata in millimeters, the proportionally wider and thicker seeds, the exception was for the point cloud between length versus weight ; width versus thickness and thickness versus length / width (Figure 11).

In general, the results of descriptive measures of location, variability, asymmetry and kurtosis can serve as a basis for future studies of descriptive analysis and statistical inference, for the comparison of different environments, studies of plant genetic improvement, subsidize criteria used for the grouping of experiments in joint analysis, in stability analysis of passion fruit cultivars, as well as in the construction of the so-called variance components [21,35,22,24,25,26 and 27].

According to [31], the law of large numbers proves that for an infinitely large number of observations, it is an approximation of the population mean, where is a sample of size n of a random variable Y with expected value. The standard deviation is simply the square root of the variance, so that is the same as the standard error of the mean, so we have an estimate of the standard deviation of the variance.

Extensive observational surveys covering large spatial scales with a significant number of samples are likely to be representative of the population of interest as a whole, therefore the standard error of the mean should be used, while small, controlled experiments with few replicates are probably based on a single group, and possibly little representative of individuals, therefore, it is recommended to use the standard deviation to characterize or measure the degree of absolute dispersion of the samples.

IV. CONCLUSIONS

It is concluded that the length, the width, the length/width ratio, the thickness of the seeds of Passiflora cincinnata, all expressed in millimeters, presented a reasonable adjustment to the normal distribution of probabilities, as well as a low total amplitude of variation and coefficient of variation. The weight, on the other hand, showed a reasonable degree of homogeneity for these evaluated characteristics, including absolute dispersion, with a high coefficient of variation.

All characteristics had a low standard deviation.

Only the length and weight of seeds adjusted to a normal distribution, being evidenced by the histogram and frequency polygon as well as through the result of the application of the D'Agostino-Pearson normality test.

There was a regular degree of symmetry for the frequency distributions of the length, width, thickness, length/width ratio and weight of *Passiflora cincinnata* seeds, being different from zero. A degree of flattening or kurtosis of the platicurtic and leptocurtic type was found for the evaluated characteristics.

Responses from scientific research on descriptive measures of location, variability or scale, asymmetry and kurtosis may serve as a basis for future studies of descriptive analysis and statistical inference, for comparison of different environments, genetic studies and plant breeding, as well as in construction of the so-called variance components, for simulation and modeling studies applied to agriculture.

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