REPEATABILITY AND NUMBER OF MEASUREMENTS FOR ESTIMATING ACEROLA QUALITY TRAITS

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Abstract: The aim of this study was to estimate the repeatability coefficient and number of required measurements for quality traits in selection of acerola genotypes. Fruits of thirty-five genotypes were analyzed in a randomized block design, with four replicates of three plants per plot. The repeatability coefficient (r) for ten quality traits was estimated. The r values were high for all quality traits. A total of ten fruits are required for evaluation of quality traits in acerola genotypes, with an accuracy of 95%.

Keywords: *Malpighia emarginata* DC.; genetic breeding; fruit quality; number of measurements; vitamin C.

INTRODUCTION

Acerola (*Malpighia emarginata* DC.) is a tropical fruit native to the Caribbean and Central and Northern South America, which is well adapted to edaphoclimatic conditions of Brazilian Northeast region, characterized as tropical semi-arid (FERREIRA et al., 2021).

Brazilian acerola genotypes present high variability due to seed propagation, which result in uneven commercial plantations, with low productivity and poor fruit quality (RITZINGER et al., 2017). Thus, the use of biometric tools is important for the characterization and identification of superior acerola genotypes.

Repeatability coefficient is a biometric estimator that expresses the proportion of phenotypic variance attributed to genetic differences confused with the permanent effects on the individual (CRUZ et al., 2012. Thus, the higher repeatability coefficient, the lower required number of measurements to predict the real value of the individual (DIEL et al., 2020).

The aim of this study was to estimate the repeatability coefficient and number of required measurements for quality traits in selection of acerola genotypes.

MATERIAL AND METHODS

This study was conducted in an experimental orchard located in Petrolina, Pernambuco State, Brazil (9°09'S latitude, 40º22' W longitude and 365 m altitude). According to Köppen's classification, the climate of the region is BSh, characterized as dry semi-arid (ALVARES et al., 2013). Technical recommendations were followed for cultural practices (RITZINGER et al., 2003).

A total of 35 genotypes were evaluated in September 2019. The experimental design used was randomized blocks, with four replicates of three plants per plot.

After harvest, the fruits were evaluated for the following quality traits: fruit diameter (FD), determined with a digital calliper; fruit mass (FM), evaluated using a semi-analytical balance; skin color, determined with a colorimeter (Konica Minolta CR-400, Japan), with results expressed in three color parameters – lightness (L^*, 0 – black, 100 – white), chroma (C^*, 0 – gray/opaque color, 100 – vivid color) and hue angle (h, 0/360° – red, 90° – yellow, 180° – green, 270° – blue); pulp firmness (PF, in N), determined with a texture analyzer; soluble solids (SS), evaluated with a digital refractometer, with results expressed in percentage; titratable acidity (TA), determined by titration with 0.1 N NaOH, with results in % of malic acid; SS/TA ratio; and ascorbic acid content (AsA), determined by Tillman's method, through titration with 0.02% DFI solution (AOAC, 2016).

For each quality trait, four methods were adopted for determination of the repeatability coefficient (r): a) analysis of variance (ANOVA), based on variance components (genetic and residual effects) (CRUZ et al., 2012); b) principal component analysis based on the correlation matrix (PCA-Cor); c) principal component analysis based on the covariance matrix (PCA-Cov) (ABEYWARDENA, 1972); and d) structural analysis based on the correlation matrix (SA-Cor) between the accessions in each evaluation pair (MANSOUR et al., 1981).

The repeatability coefficient was classified as follows: high repeatability ($r \geq 0.60$); medium repeatability ($0.30 < r < 0.60$) and low repeatability ($r \leq 0.30$) (CRUZ et al., 2012). The number of required measurements (η_0) to predict the real value of the genotypes was determined for each quality trait, based on predefined coefficients of determination (R^2) of 90% and 95%, from the formula: $\eta_0 = [R^2 (1 - r)] / [(1 - R^2) r]$, where r is the repeatability coefficient.

RESULTS AND DISCUSSION

In fruit genetic breeding, the repeatability coefficient is adopted for estimating the ability of the expression of a given genetic characteristic in time (CRUZ et al., 2012). The repeatability coefficient ranged from 0.67 (hue angle) and 0.95 (fruit mass) (Figure 1).

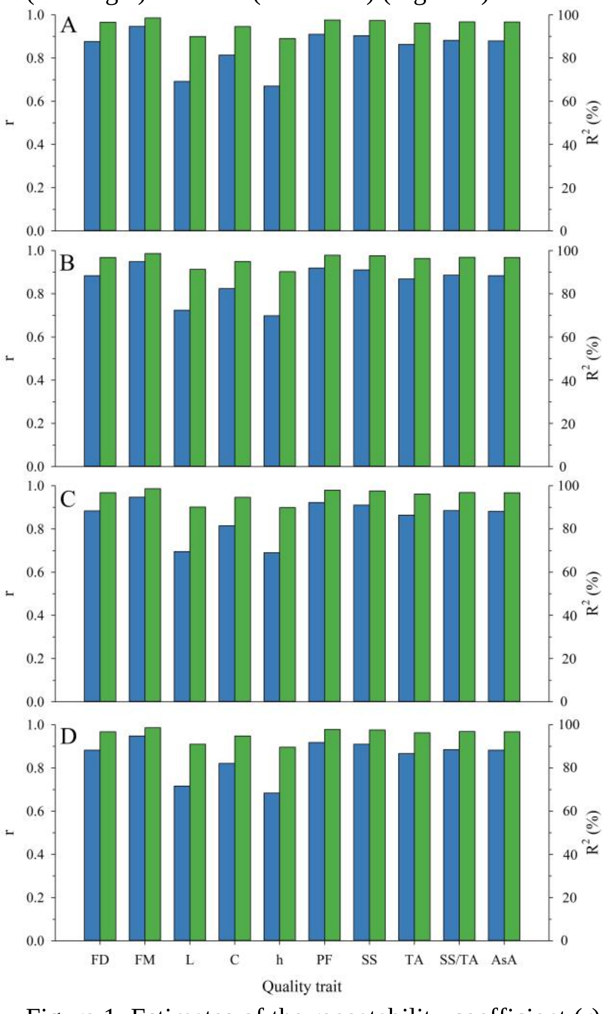

Figure 1. Estimates of the repeatability coefficient (r) (blue bar) and its determination coefficients (R^2) (green bar) estimated by (A) ANOVA, (B) principal component analysis based on correlation matrix and (C) covariance matrix and (D) structural analysis using the correlation matrix, for ten acerola quality traits.

FD: fruit diameter; FM: fruit mass; L: lightness; C: chroma; h: hue angle; PF: pulp firmness; SS: soluble solids; TA: titratable acidity; AsA: ascorbic acid.

According to classification of Cruz et al. (2012), all quality traits evaluated had high repeatability coefficients. The values found in acerola quality traits are slightly higher than those found in peach (MATIAS et al., 2014), orange (NEGREIROS et al., 2014) and strawberry (ANDRADE JÚNIOR et al., 2022; DIEL et al., 2020). Higher would repeatability coefficients indicate genotype stability and an accurate evaluation of phenotypic values, which optimize fruit breeding studies.

From repeatability coefficients, the number of measurements (η_0) for prediction of the real value of the genotypes were estimated at 90% and 95% of accuracy and are shown in Table 1.

Table 1. Number of required measurements for certain R² (90% and 95%) estimated by ANOVA, principal component analysis based on correlation matrix (PCA-Cor) and covariance matrix (PCA-Cov) and structural analysis using the correlation matrix (SA-Cor), for ten acerola quality traits.

Quality trait	ANOVA		PCA-Cor		PCA-Cov		AS-Cor	
	90%	95%	90%	95%	90%	95%	90%	95%
FD	2	3	2	3	2	3	2	3
FM	1	2	1	2	1	2	1	2
L	5	9	4	8	4	9	4	8
C	3	5	2	5	3	5	2	5
h	5	10	4	9	5	9	5	9
PF	1	2	1	2	1	2	1	2
SS	1	3	1	2	1	2	1	2
TA	2	4	2	3	2	3	2	3
SS/TA	2	3	2	3	2	3	2	3
AsA	2	3	2	3	2	3	2	3

FD: fruit diameter; FM: fruit mass; L: lightness; C: chroma; h: hue angle; PF: pulp firmness; SS: soluble solids; TA: titratable acidity; AsA: ascorbic acid. (η_0)

As for the prediction of the real value of all quality traits, the results indicate that five fruits should be evaluated in each experimental plot, with a 90% confidence. With a higher accuracy (95%), ten fruits are required. The four methods were consistent on estimating η_0.

CONCLUSION

The estimates of repeatability coefficients were high for all acerola quality traits. A total of ten fruits are required for an effective selection of genotypes, considering an accuracy of 95%.

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REFERENCES

ABEYWARDENA, V. An application of principal component analysis in genetics. **Journal of Genetics**, v. 61, n. 1, p. 27-51, 1972.

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. D. M.; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, v. 22, n. 6, p. 711-728, 2013.

ANDRADE JÚNIOR, V. C.; OLIVEIRA, A. J.; GUIMARÃES, A. G.; FERREIRA, M. A. M.; CAVALCANTI, V. P. FERNANDES, J. S. C. Repeatability and heritability of production characters in strawberry fruits. **Horticultura Brasileira**, v. 38, n. 1, p. 89-93, 2020.

AOAC. **Official methods of analysis of AOAC International**. 20 ed. Rockville: AOAC International, 2016.

CRUZ, C. D.; REGAZZI, A. J.; CARNEIRO, P. C. S. **Modelos biométricos aplicados ao melhoramento genético**. 4 ed. Viçosa: Editora UFV, 2012.

DIEL, M. I.; LÚCIO, A. D. C.; OLIVOTO, T.; PINHEIRO, M. V. M.; KRYSCZUN, D. K.; SARI, B. G.; SCHMIDT, D. Repeatability coefficients and number of measurements for evaluating traits in strawberry. **Acta Scientiarum. Agronomy**, v. 42, p. e43357, 2020.

FERREIRA, I. C.; SILVA, V. P.; VILVERT, J. C. SOUZA, F. F.; FREITAS, S. T.; LIMA, M. S. (2021). Brazilian varieties of acerola (*Malpighia emarginata* DC.) produced under tropical semi-arid conditions: Bioactive phenolic compounds, sugars, organic acids, and antioxidant capacity. **Journal of Food Biochemistry**, v. 45, n. 8, p. e13829, 2021.

MANSOUR, H.; NORDHEIM, E. V.; RUTLEDGE, J. J. Estimators of repeatability. **Theoretical and applied Genetics**, v. 60, n. 3, p. 151-156, 1981.

MATIAS, R. G. P.; BRUCKNER, C. H.; CARNEIRO, P. C. S.; SILVA, D. F. P.; SILVA, J. O. D. C. Repetibilidade, correlações e análise de trilha de características físicas e químicas de frutos de pessegueiro. **Revista Brasileira de Fruticultura**, v. 36, n. 4, 971-979, 2014.

NEGREIROS, J. R. D. S.; ANDRADE-NETO, R. D. C.; MIQUELONI, D. P.; LESSA, L. S. Estimativa de repetibilidade para caracteres de qualidade de frutos de laranjeira-doce. **Pesquisa Agropecuária Brasileira**, v. 49, n. 1, p. 40-48, 2014.

RITZINGER, R.; KOBAYASHI, A. K.; OLIVEIRA, J. R. P. **A cultura da aceroleira**. Cruz das Almas: Embrapa Mandioca e Fruticultura, 2003.

RITZINGER, R.; RITZINGER, C. H. S. P.; FONSECA, N.; MACHADO, C. F. Advances in the propagation of acerola. **Revista Brasileira de Fruticultura**, v. 40, n. 3, p. e928, 2017.