Ciência Rural, Santa Maria, v.54:09, e20230055, 2024 http://doi.org/10.1590/0103-8478cr20230055

ISSNe 1678-4596
CROP PRODUCTION

Agronomic characterization of acerola tree genotypes in the Gurgueia Valley region, Piauí, Brazil

Francisco Almir Campelo Monte Junior[1] Thamyres Yara Lima Evangelista[1*] Cibele Divino Aguiar[1] Emanuela Sousa Cavalcante[1] Jenilton Gomes da Cunha[1] Gustavo Alves Pereira[2] Flávio de França Souza[3] Gabriel Barbosa da Silva Júnior[1]

[1]Departamento de Ciências Agrárias, Universidade Federal do Piauí (UFPI), 64900-000, Bom Jesus, PI, Brasil. E-mail: thamyresevangelista@outlook.com. *Corresponding author.
[2]Departamento de Ciências Agrárias, Universidade Federal do Piauí (UFPI), Teresina, PI, Brasil.
[3]Empresa Brasileira de Pesquisa Agropecuária, Embrapa Semiárido, Petrolina, PE, Brasil.

ABSTRACT: Plant selection conducted in commercial orchards is mainly based on plant features. This study characterizes and selects acerola tree genotypes with promising features for cultivation in the Gurguéia Valley region, Piauí. Twenty-five genotypes were used, consisting of 15 clones (CL 03, CL 08, CL 09, CL 12, CL 13, CL 14, CL 20, CL 23, CL 26, CL 27, CL 30, CL 31, CL 33, CL 36, and CL 38) and 10 cultivars (BRS 235, BRS 236, BRS 237, BRS 238, BRS 366, Sertaneja, Costa Rita, Morena, Tropicana, and Junko). The experiment was set up in a randomized block design with three blocks and three plants per experimental unit in 4 m x 3 m spacing. A total of 40% of the genotypes evaluated showed an umbrella shape, 36% showed a semi-open shape, and 24% showed an open shape. Clones 09, 14, and 12 presented the highest cultivation potential in the region, with monthly production of 5.01, 4.30, and 3.70 kg plant-^{1} per year and productivity of 4.16, 3.59, and 3. 08-ton ha-^{1}, respectively. Clone 27, cultivars BRS 236 and BRS 235, and clone 14 were the earliest genotypes, requiring 1,503.3, 1,535.6, 1,686.6, and 1,686.6 DD; respectively, to complete their cycle. Clones 09 and 14 stood out from the others and are potentially promising for cultivation in the Gurgueia Valley region.
Key words: *Malpighia emarginata* DC, Junko, degree days, Sertaneja.

Caracterização agronômica de genótipos de aceroleira na região do Vale do Gurgueia, Piauí

RESUMO: A seleção de plantas conduzida em pomares comerciais é baseada principalmente nas características da planta. Este trabalho teve como objetivo caracterizar e selecionar genótipos de aceroleira com características promissoras para cultivo na região do Vale do Gurguéia, Piauí. Foram utilizados 25 genótipos, sendo 15 clones (CL 03, CL 08, CL 09, CL 12, CL 13, CL 14, CL 20, CL 23, CL 26, CL 27, CL 30, CL 31, CL 33, CL 36 e CL 38) e 10 cultivares (BRS 235, BRS 236, BRS 237, BRS 238, BRS 366, Sertaneja, Costa Rita, Morena, Tropicana e Junko). O experimento foi instalado no delineamento de blocos casualizados com três blocos e três plantas por unidade experimental no espaçamento de 4 m x 3 m. Um total de 40% dos genótipos avaliados apresentou formato guarda-chuva, 36% formato semiaberto e 24% formato aberto. Os clones 09, 14 e 12 apresentaram o maior potencial de cultivo da região, com produção mensal de 5,01, 4,30 e 3,70 kg planta-^{1} por ano e produtividade de 4,16, 3,59 e 3,08 ton ha-^{1}, respectivamente. O clone 27, as cultivares BRS 236 e BRS 235 e o clone 14 foram os genótipos mais precoces, requerendo 1.503,3, 1.535,6, 1.686,6 e 1.686,6 DD, respectivamente, para completar seu ciclo. Os clones 09 e 14 se destacaram em relação aos demais e são potencialmente promissores para cultivo na região do Vale do Gurgueia.
Palavras-chave: *Malpighia emarginata* DC, Junko, grau-dias, Sertaneja.

INTRODUCTION

Among the fruit species commercially grown in Brazil, the acerola tree (*Malpighia emarginata* DC) has aroused great interest among producers and consumers for both fresh consumption (*in nature*) and industrialization (PRAKASH & BASKARAN, 2018; FERREIRA et al., 2022) due to its antioxidant properties (CRUZ et al., 2019), antimicrobial potential (REZENDE et al., 2017), and high ascorbic acid content (FARINELLI et al., 2021).

Also, Brazil is known as the largest producer, consumer, and exporter of acerola trees (SANTOS & LIMA, 2020), which is mainly due to the favorable edaphoclimatic conditions associated with pruning and supplementary irrigation techniques (MARTINS et al., 2016), thus allowing the commercial cultivation of the species throughout the

Received 02.01.23 Approved 12.13.23 Returned by the author 02.24.24
CR-2023-0055.R2
Editors: Leandro Souza da Silva Mara Fernandes Moura

year (SILVA et al., 2016), especially in the Northeast region. Acerola tree cultivation in northeastern Brazil, especially in valley regions, has shown to be an excellent agricultural investment in recent years.

Given its rusticity, the acerola tree is a tropical fruit species (CORRÊA et al., 2017) with good adaptability to different soils and climates (LIMA et al., 2014). The ideal cultivation temperature ranges from 15 °C to 32 °C, with paralyzed growth and development at temperatures from 10° to 14 °C. Moreover, the ideal cumulative rainfall for satisfactory development ranges from 1,200 to 2,000 mm year^{-1} (PRAKASH & BASKARAN, 2018**)**. As a result, the cultivation of this species in regions with less than 1,200 mm year^{-1} should be supplemented with irrigation (MARTINS et al., 2016).

In general, acerola tree orchards in these regions are formed by sexual propagation, which increases genetic variability and results in plants and fruits with uneven growth habits, differing both qualitatively and quantitatively (RITZINGER et al., 2018). In many cases, the genotypes are not identified and/or selected, showing agronomical features that do not meet the standards of the consuming market (LIMA et al., 2014) and highlighting the essentiality of characterizing and selecting adequate materials for each cultivation scenario. In this perspective, the present research covered 25 acerola genotypes, to agronomically characterize and select the most promising ones for cultivation in the Gurguéia Valley region.

MATERIALS AND METHODS

Description of the study area

The collection of acerola tree genotypes was established at the experimental field of the Fruit Farming Study Group (FRUTAGRO) at the School Farm Alvorada do Gurgueia (FEAG), Federal University of Piaui, Campus Professora Cinobelina Elvas (UFPI-CPCE), in partnership with the Brazilian Agricultural Research Corporation (EMBRAPA Semiárido).

The region is located at 08° 22'24.89 S, 43° 51'11.89" W, at an elevation of 231 meters a.s.l., with a mean annual temperature of 27 °C, and air relative humidity around 34.25%, according to the National Institute of Meteorology of Brazil (INMET, 2019), using data from the automatic station A336 (Figure 1). The climate of the region is classified as A*w*, i.e., tropical hot and humid (KOPPEN, 1948). The soil was classified as a Yellow Latosol with a sandy texture (SANTOS et al., 2013).

Characterization of the experiment

The genotypes were introduced by asexual propagation with seedlings grafted at a spacing of 4.0 x 3.0 m, with nine plants per accession. Twenty-five acerola trees genotypes were used, consisting of 15 clones (CL 03, CL 08, CL 09, CL 12, CL 13, CL 14, CL 20, CL 23, CL 26, CL 27, CL 30, CL 31, CL 33, CL 36, and CL 38) and 10 cultivars (BRS 235,

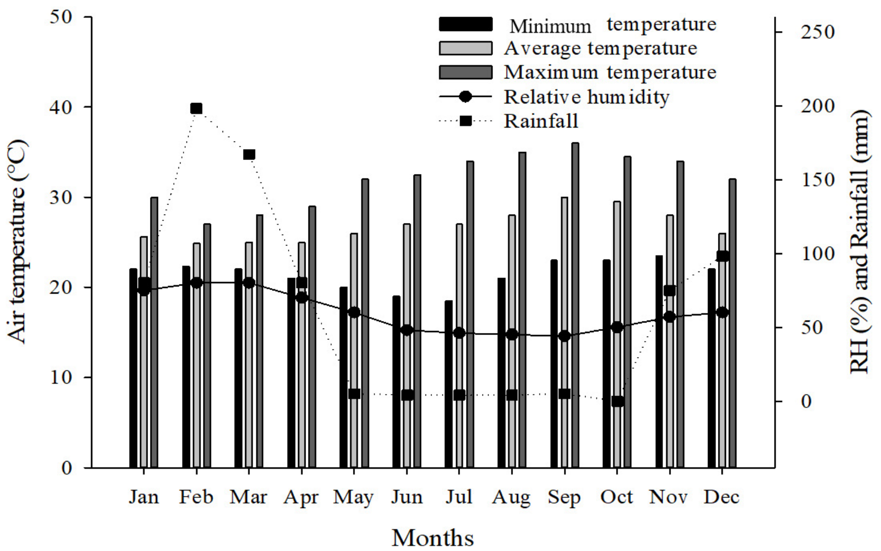

Figure 1 - Minimum, average, and maximum temperatures (°C), relative humidity (%), and precipitation (mm), from January to December 2019, Alvorada do Gurguéia, Piauí, Brazil.

BRS 236, BRS 237, BRS 238, BRS 366, Sertaneja, Costa Rita, Morena, Tropicana, and Junko), with one year of age.

From January to December 2019, the following characteristics were evaluated: canopy height (m), canopy diameter (m), canopy shape (open, semi-open, and with an umbrella shape) (Figure 2), number of degree days necessary for plants to complete their cycle, production of mature fruits (kg plant-^{1} per cycle) in two harvests, and yield estimate (ton ha-^{1}), and yield estimate (ton ha-^{1}).

The experiment was divided into three phenological stages during the vegetative period: 1) from transplanting to the first pruning at 50 cm from the ground; 2) from the first pruning to the beginning of sprouting; 3) from sprouting to the pruning of 50 cm of the structural branches. The degree days (DD) were estimated using the least variability method proposed by ARNOLD (1959), considering the minimum base temperature (Tb) of 10 °C and the maximum base temperature (TB) of 36 °C.

Statistical Analysis

The study was performed in a randomized block design (RBD) with three replications, and the experimental unit was composed of three plants of each genotype. The data were subjected to analysis of variance by the F-rest. In case of significance, the means were grouped by the Scott-Knott test using the R environment, version 3.2.5, through the statistical package ExpDes.pt (R CORE TEAM, 2018).

RESULTS AND DISCUSSION

There were significant differences between the genotypes for all variables analyzed, according to the Scott Knott test at P > 0.05 of probability. Clone 36 and the cultivar 'Costa Rica' stood out in the growth, height, and diameter analyses shown in table 1. On the other hand, the cultivar 'Morena' showed the lowest height (0.95 m) and canopy diameter (1.06 m).

The values of canopy height and diameter were lower for canopy height (with a mean of 1.30 meters) than for canopy diameter (with 1.86 meters). This scenario is mainly due to the canopy shape of the genotypes evaluated (Figure 2), with 40% showing an umbrella shape, 36% showing a semi-open shape, and 24% showing an open shape, thus affecting the longitudinal to transverse diameter ratio of plants.

Acerola tree plants with an umbrella or inverted cup canopy shape and with maximum canopy heights of around two meters are more easily managed since this configuration facilitates fruit harvest, usually not requiring formative pruning (SANTOS & LIMA, 2020). However, management should be performed carefully since the insertion of acerola tree branches is significantly fragile, easily breaking in the presence of strong winds and consequently causing the fall of flowers and fruits, with subsequent yield reductions (RITZINGER et al., 2018).

MARTINS et al. (2016) evaluated the production of acerola trees under risk conditions and observed that the canopy volume is also related to the water volume used for irrigation, influencing the regularization of flowering cycles and favoring the seasonality of production. Clones 09, 14, and 12 showed the highest potential for cultivation in the region, with a monthly production of 5.01, 4.30, and 3.70 kg ha-^{1} and a yield of 4.16, 3.59, and 3.08 tons ha-^{1}, respectively. Conversely, the varieties 'Costa Rica' and 'Tropicana' showed the lowest means, with a monthly production of 1.10 and 1.13 kg ha-^{1} and a yield of 0.91 and 0.94 tons ha-^{1}, respectively.

When analyzing the edaphoclimatic conditions studied and the management adopted for

Figure 2 - The shape of the crown: (A) open, (B) semi-open, and (C) umbrella-shaped.

Table 1 - Means of canopy height, diameter, and shape of 25 acerola tree genotypes cultivated in Alvorada do Gurgueia, PI.

Identification of the genotypes	Canopy height (m)	Canopy diameter (m)	Canopy shape	Production (kg plant-¹ per year)	Yield (ton ha-¹)
Clone 03	1.00	1.76	Umbrella	2.91 b	2.42 b
Clone 08	1.09	1.63	Semi-open	1.44 c	1.20 c
Clone 09	1.17	1.64	Umbrella	5.01 a	4.16 a
Clone 12	1.26	1.73	Umbrella	3.70 a	3.08 a
Clone 13	1.21	1.65	Open	1.53 c	1.27 c
Clone 14	1.49	1.91	Semi-open	4.30 a	3.59 a
Clone 20	1.17	1.54	Semi-open	1.17 c	0.98 c
Clone 23	1.31	1.96	Semi-open	1.21 c	1.01 c
Clone 26	1.38	1.98	Umbrella	1.58 c	1.31 c
Clone 27	1.20	2.15	Open	1.81 c	1.51 c
Clone 30	1.28	1.84	Umbrella	1.48 c	1.23 c
Clone 31	1.24	2.21	Umbrella	2.04 c	1.0 c
Clone 33	1.45	2.31	Semi-open	1.87 c	1.55 c
Clone 36	1.70	2.29	Open	1.83 c	1.52 c
Clone 38	1.45	2.11	Semi-open	1.89 c	1.57 c
BRS 235	1.65	2.24	Open	2.03 c	1.69 c
BRS 236	1.38	1.98	Semi-open	2.09 c	1.74 c
BRS 237	1.26	1.42	Umbrella	1.83 c	1.52 c
BRS 238	1.46	2.14	Umbrella	1.55 c	1.29 c
BRS 366	1.08	1.70	Umbrella	3.35 b	2.79 b
Costa Rica	1.56	2.40	Open	1.10 c	0.91 c
Junko	1.17	1.45	Semi-open	2.35 c	1.96 c
Morena	0.95	1.06	Umbrella	1.77 c	1.47 c
Sertaneja	1.41	2.02	Open	2.44 c	2.03 c
Tropicana	1.21	1.60	Semi-open	1.13 c	0.94 c

Equal means in the column do not differ at $P < 0.05$ probability by the Scott-Knott test.

acerola trees cultivation in the Vale do Gurgueia region, the results highlighted promising conditions for the occurrence of six production cycles per year, considering that the data presented herein correspond only to the first production cycle and that the acerola trees genotypes had less than two years in the evaluated period.

According to OLIVEIRA et al. (2003), acerola tree production is intensified in the third year of cultivation, stabilizing in the fourth or fifth year. These statements corroborated the data presented by CALGARO & BRAGA (2012) when evaluating acerola trees in the irrigated perimeter Senador Nilo Coelho (PISNC) in Petrolina, PE, observing a mean yield of 0.0 ton.ha-¹ in the first year and 12, 15, 20, and 20 ton.ha-¹ in the second, third, fourth, and fifth years of cultivation, respectively.

These scenarios highlighted a yield growth trend in the very first years of cultivation. According to the Development Company of the Francisco and Parnaíba Valleys (CODEVASF, 2015), acerola trees orchards already established produce, on average, 24.97 tons.ha-¹, which enables the projection of a selection of some of these genotypes for release as new varieties and their establishment in the Gurgueia Valley region and similar areas.

Therefore, it is essential to determine the phenological cycle of each genotype as well as their thermal requirements. Thus, table 2 shows the number of degree days necessary for acerola tree plants to complete their vegetative cycle in the Gurgueia Valley region. The average duration of the acerola tree cycle, from transplanting to pruning, was five months (153.24 days), requiring 2,924.40 DD to complete the development.

Clone 27, cultivars BRS 236, BRS 235, and clone 14, were the earliest genotypes, requiring 1,503.3, 1,535.6, 1,686.6, and 1,686.6 DD, respectively, to complete their cycle. In turn, genotypes BRS 20, 'Costa Rica', BRS 31, BRS 30, and 'Sertaneja', were the latest, with 3,194.4, 2,768.2, 2,748.2, 2,735.5, and 2,721.3 DD, respectively.

The differences observed in the thermal accumulations of each genotype are due to the air temperature variations recorded throughout crop development. In general, the lowest variation occurred during sprouting, which is related to the increased temperature during this period, with an average of 32.5 °C; consequently increasing the metabolic activity of the crop (SEGANTINI et al., 2014).

In tropical fruit species, the temperature is the climatic factor that most influences the growth rate, with variations of up to 80% (SEGANTINI et al., 2014). There are studies available on acerola trees during the reproductive stage, especially fruit setting (CARPENTIERI-PÍPOLO et al., 2008). However, the literature is still scarce regarding the vegetative development cycle.

Knowing the early stages of plant growth is essential for classifying and selecting earlier genotypes, thus optimizing the planning for production management. However, it should be noted that these results, in isolation, do not define an acerola tree genotype as promising and fit for release as a commercial variety, thus requiring their association with other variables that might add market value, e.g., pulp and fruit color and the vitamin C content. Therefore, future studies are necessary to complement this research.

CONCLUSION

Among the 26 evaluated genotypes, "Clone 09" (umbrella-shaped crown) and "Clone 14" (semi-open crown) are the most promising for the Gurgueia Valley region, with the production of 5.01 and 4 .30 kg plant-¹ per year and productivity of 4.16 and 3.59-ton ha-¹, respectively. These genotypes are the earliest to meet the thermal requirements, requiring 1901.1 and 1686.6 DD to complete their development.

Table 2 - Number of degree days (DD) in 25 acerola tree genotypes cultivated in Alvorada do Gurgueia, PI. (T) transplanting, (1st P) first pruning, (B) sprouting, (2nd P) second pruning.

Identification of the genotypes	T – 1st P (days)	DD	1st P - B (days)	DD	B – 2nd P (days)	DD	∑days	∑DD
Clone 03	46	728.75	2	48.35	92	1464.95	140	2242.1
Clone 08	60	943.50	2	48.35	97	1546.35	159	2538.2
Clone 09	40	618.50	2	50.70	78	1232.70	120	1901.9
Clone 12	45	712.10	2	50.70	77	1215.70	124	1978.5
Clone 13	72	1124.00	3	64.65	84	1335.10	159	2523.8
Clone 14	48	682.95	2	50.70	61	952.90	111	1686.6
Clone 20	64	1005.75	3	67.00	132	2121.60	199	3194.4
Clone 23	66	1034.55	2	50.70	89	1415.75	157	2501
Clone 26	62	973.10	2	50.70	103	1641.40	167	2665.2
Clone 27	47	744.35	2	50.70	46	708.20	95	1503.3
Clone 30	59	929.55	3	67.00	109	1738.90	171	2735.5
Clone 31	43	682.95	2	50.70	126	2014.55	171	2748.2
Clone 33	47	744.35	3	67.00	86	1368.10	136	2179.5
Clone 36	52	823.10	2	50.70	64	1002.15	118	1876
Clone 38	51	807.05	2	50.70	87	1383.50	140	2241.3
BRS 235	43	682.95	2	50.70	61	952.90	106	1686.6
BRS 236	66	1034.55	2	50.70	141	14270.84	209	15356
BRS 237	69	1081.60	3	67.00	96	1530.95	168	2679.6
BRS 238	57	899.65	4	78.65	83	1335.10	144	2313.4
BRS 366	45	712.10	2	50.70	89	1415.75	136	2178.6
Costa Rica	76	1188.05	2	50.70	96	1529.40	174	2768.2
Junko	56	883.75	2	50.70	112	1785.20	170	2719.7
Morena	67	1049.45	3	67.00	121	1931.65	191	3048.1
Sertaneja	75	1172.65	2	67.00	93	1481.65	170	2721.3
Tropicana	77	1204.35	4	82.40	115	1836.40	196	3123.2

ACKNOWLEDGMENTS

The Universidade Federal do Piauí (UFPI) "Campus Professora Cinobelina Elvas" and the FRUTAGRO experiment group. Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), for financial support.

DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORS' CONTRIBUTION

All authors contributed equally to the conception and writing of the manuscript. All authors critically revised the manuscript and approved the final version.

REFERENCES

ARNOLD, C. Y. The determination and significance of the base temperature in a linear heat unit system. **Proceedings of the American Society for Horticultural Science**, v.74, p.430-445, 1959. Available from: <https://www.scienceopen.com/document?vid=25255475-adce-42f0-914d-95a8a60e7006>. Accessed: Jul. 10, 2020.

CALGARO, M.; BRAGA, M .B. **A cultura da acerola**. 3a ed. Brasília, DF: Embrapa. (Coleção Plantar; 69), 2012. 144p.

CARPENTIERI-PÍPOLO, V. et al. Fruiting and development of acerola fruits in Northern Paraná. **Ciência Rural**, v.38, p.1871-1876, 2008. Available from: <https://doi.org/10.1590/S0103-84782008000700011>. Accessed: Jul. 10, 2020.

CODEVASF – Companhia De Desenvolvimento Do Vale Do São Francisco e Do Parnaíba. **Relatório de Administração 2015**. Available from: <https://www.codevasf.gov.br>. Accessed: May, 12, 2019.

CORRÊA, C. V. et al. Influence of ripening stages on physicochemical characteristics of acerola fruits. **Revista de Ciências Agrárias**, v.40, p.808-813, 2017. Available from: <http://dx.doi.org/10.19084/RCA17116>. Accessed: May, 12, 2019.

CRUZ, R. G. D. et al. Comparison of the antioxidant property of acerola extracts with synthetic antioxidants using an in vivo method with yeasts. **Food Chemistry**, v.277, p.698–705, 2019. Available from: <https://scite.ai/reports/10.1016/j.foodchem.2018.10.099>. Accessed: Jul. 12, 2020.

FARINELLI, D. et al. Variability of Fruit Quality among 103 Acerola (*Malpighia emarginata* DC) Phenotypes from the Subtropical Region of Brazil. **Agriculture**, v.11, p.1078, 2021. Available from: <https://doi.org/10.3390/agriculture11111078>.

FERREIRA, M. A. R., et al. A multivariate selection index of acerola genotypes for fresh consumption based on fruit physicochemical attributes. **Euphytica**, v.218, p.1-16, 2022. Available from: <https://doi.org/10.1007/s10681-022-02978-1>. Accessed: Mar. 20, 2019.

INMET - National Institute of Meteorology, **Available at: Andlt**; 2019. Available from: <http://www.inmet.gov.br/portal/Andgt>. Accessed: Mar. 20, 2019.

KOPPEN, W. **Climatologia: con um estúdio de los climas de la tierra**. Mexico: Fondo de cultura Económica, 1948. 478p.

LIMA, P. C. C. et al. Caracterização e avaliação de frutos de aceroleira. **Revista Brasileira de Fruticultura**, v.36, p.550-555, 2014. Available from: <http://dx.doi.org/10.1590/0100-2945-336/13>. Accessed: Mar. 20, 2019.

MARTINS, E. A. et al. Rentabilidade da produção de acerola orgânica sob condições determinística e de risco: estudo do distrito de irrigação tabuleiro litorâneo do Piauí. **Revista de Economia e Sociologia Rural**, v.54, p.9-28, 2016. Available from: <https://doi.org/10.1590/1234-56781806-9479005401001>. Accessed: Apr. 01, 2019.

OLIVEIRA, J. R. P. et al. **Colheita**. In: RITZINGER, R. et al. **A cultura da aceroleira**. Embrapa Mandioca e Fruticultura, Cruz das Almas, Bahia. 2003, 198p. Accessed: Apr. 01, 2019.

PRAKASH, A.; BASKARAN, R. Acerola, an untapped functional superfruit: a review on latest frontiers. **International Journal of Food Science & Technology**, v.55, p. 3373–3384, 2018. Available from: <https://doi.org/10.1007 / s13197-018-3309-5>. Accessed: Mar. 20, 2019.

R DEVELOPMENT CORE TEAM. **A language and environment for statistical computing**. R. Foundation for Statistical Computing, Vienna, Austria. Available from: <http://www.R-project.org>. Accessed: Nov. 20, 2018.

REZENDE, Y. R. R. S. et al. Comparison and optimization of conventional and ultrasound-assisted extraction for bioactive compounds and antioxidant activity from agroindustrial acerola (*Malpighia emarginata* DC) residue. **Food Science and Technology**, v.85, p.158-169, 2017. Available from: <https://doi.org/10.1016/j.lwt.2017.07.020>. Accessed: Oct. 20, 2019.

RITZINGER, R., et al. Advances in the propagation of acerola. **Revista Brasileira de fruticultura**, v.40, p.e-928, 2018. Available from: <https://doi.org/10.1590/0100-29452018928>. Accessed: Oct. 20, 2019.

SANTOS, H. G. **Brazilian soil classification system**. 3. ed. Rio de Janeiro, RJ: National Soil Research Center. 2013, 353 p.

SANTOS, T. S. R.; LIMA, R. A. Cultivo de *Malpighia emarginata* L. no Brasil: uma revisão integrativa. **Journal of Biotechnology and Biodiversity**, v.8, p.333-338, 2020. Available from: <https://doi.org/10.20873/jbb.uft.cemaf.v8n4.santos>. Accessed: Oct. 20, 2019.

SEGANTINI, D. M. et al. Exigência térmica e produtividade da amoreira-preta em função das épocas de poda. **Revista Brasileira de Fruticultura**, v.36, p.568-575, 2014. Available from: <https://doi.org/10.1590/0100-2945-295/13>. Accessed: Oct. 20, 2019.

SILVA, P. C. et al. Crescimento de mudas de *Malpighia emarginata* em diferentes substratos. **Engenharia Ambiental: Pesquisa e Tecnologia**, v.13, p.862-874, 2016. <http://dx.doi.org/10.9771/cp.v13i3.32946>. Accessed: Oct. 20, 2019.