

Full Length Research Paper

Clonal trial of five genotypes of “camu-camu”, *Myrciaria dubia* (h.b.k) mc. Vaugh, in non-flooded area

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The objective of this research was to evaluate fruit yield, other agronomic characteristics and content of ascorbic acid (aa) of five promissory genotypes of “camu-camu” in non-flooded area of the experimental field “El Dorado”. The plantation has been established for 4 years and is located in 03° 56' 50”S, 73° 25' 13”W and 118 a.s.l. altitude, which is part of INIA-EEA “San Roque”⁴. The clones evaluated were MD-013, MD-014, MD-015, MD-017 and MD-020 and they stood out in the previous analysis in the national camu-camu germplasm collection of INIA. The experiment was established with a completely randomized block statistical design (CRBD) with five treatments and four replications, and each experimental unit consisted of nine plants, with a distance of 3 x 3 m. During the reproductive phenology which was 9 months long, nine variables were evaluated: Leaf length (cm), leaf width (cm), petiole length (cm), number of basal branches, basal branch diameter (cm), number of fruits, fruits weight (g), fruits yield (kg) and ascorbic acid (mg/100 g). As a result, “petiole length” was different statistically ($F = 3.96$, $p = 0.028$). The heritability was low for all the variables: “leaf length” ($h^2 = 0.13$), “leaf width” ($h^2 = 0.06$), “basal branches diameter” ($h^2 = 0.004$), “number of fruits per plant” ($h^2 = 0.17$), “ascorbic acid content” ($h^2 = 0.002$), “petiole length” ($h^2 = 0.43$), “number of basal branches” ($h^2 = 0.33$), “weight of fruits per plant” ($h^2 = 0.29$) and “fruits yield” ($h^2 = 0.26$). However, fruit yield showed a range of 2.0 to 2.6 kg / plant (2200 to 2800 kg / ha).

Key words: Ascorbic acid, “camu-camu”, heritability, *Myrciaria dubia*, yield.

INTRODUCTION

“Camu-camu” (*Myrciaria dubia* (HBK) Mc Vaugh), a native from the Peruvian Amazon, which grows wild in banks flood, has aroused great interest for agribusiness because of its high ascorbic acid content (AA), about 2%, in relation with weight of the pulp (Pinedo, 2007). Several studies of germplasm collection and agricultural research have been carried out since 1970. Six expeditions were performed in the Department of Loreto in order to collect germplasm in natural areas (Mendoza et al., 1989). Pinedo (2007) argues that the production of improved seeds is an ongoing process in the Amazon region.

Although it has been at least 10 years in this process, the availability of the reliable improved seed is still low. Since 2000, INIA began the mass selection of the isolating sources: MD-007, MD-013, MD-014, MD-015, MD-017, MD-020, MD-029 and MD-040, which are characterized by conical form or branching type of top architecture, good production, fruit size and high ascorbic acid content. With this, the material was established as the first improved seedbed (seedbed plantation from known origin SP-KO) (Imán, 2007).

In San Miguel Experimental Center (SMEC-IIAP), a comparison of promising clones, propagated by woody cuttings from producers plantations, natural stands and INIA, was installed in 2004. For the variables evaluated (basal diameter, number of basal branches, number of branches, height and top diameter), significant differences were found between clones. The values of heritability (h^2) were moderate to high for basal stem

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Table 1. Summary of analysis of variance for the nine parameters.

Parameter	Source of variation	Value F	P-value	Signif.	C.V.(%)
Leaf length (cm)	Clones	1.62	0.2328	NS	5.40
	Repetition	1.44	0.2790	NS	
Leaf width (cm)	Clones	1.26	0.3370	NS	6.07
	Repetition	0.48	0.7014	NS	
Petiole length (cm)	Clones	3.96	0.0284	*	3.41
	Repetition	3.75	0.0412	*	
Number of basal branches	Clones	3.01	0.0620	NS	8.75
	Repetition	5.38	0.0141	*	
Basal branch diameter (cm)	Clones	0.08	0.5585	NS	13.41
	Repetition	0.17	0.2191	NS	
Number of fruits	Clones	1.83	0.1882	NS	7.41
	Repetition	1.17	0.3617	NS	
Fruits weight (g)	Clones	2.61	0.0885	NS	1.50
	Repetition	2.96	0.0752	NS	
Fruits yield (kg)	Clones	2.44	0.1042	NS	13.86
	Repetition	1.41	0.2870	NS	
Ascorbic acid (mg/100 g)	Clones	0.45	0.7736	NS	9.90
	Repetition	1.08	0.3957	NS	

diameter (0.160), average basal diameter (0.235), number of basal branches (0.216), plant height (0.122), top diameter (0.197), number of branches (0.169) and number of flowers (0.128) (Pinedo, 2007). Studies on camu-camu cloning have allowed their application to genetic improvement on grafting (Enciso, 1992), woody cuttings rooting (Bardales, 2006) and air offset (Imán, 2005). By cuttings and air offset, it is possible to obtain complete plants suitable for transplantation in three months (Imán, 2007). In this research, the objective was to evaluate five promissory genotypes of “camu-camu” fruit with regard to fruit yield, ascorbic acid content and agronomic characteristics in non-flooded area.

MATERIALS AND METHODS

The plot, whose agroecological classification is a tropical rainforest (b-TH), is located in the Experimental Field of “El Dorado”, Km 25 Iquitos - Nauta Road, INIA-EEA “San Roque”. This plantation was established 4 years ago in this area, with coordinates of 03°56'50”S and 73°25'13”W and is set at 118 a.s.l. Evaluated clones were: MD-013 (Anguilla, Nanay, Maynas and Loreto), MD-014 (Samito, Nanay, Maynas and Loreto), MD-015 (Yuto, Nanay, Maynas and Loreto), MD-017 (Nina Rumi, Nanay, Maynas and Loreto) and MD-020 (Cocha Tipishca, Itaya, Maynas and Loreto). The experiment was established with a completely randomized block statistical design (CRBD) with five treatments and four replications, and each experimental unit consisted of nine plants, with a distance of 3 x 3 m. During the reproductive phenology which was 9 months long, nine variables were evaluated: leaf length (cm), leaf width (cm),

petiole length (cm), number of basal branches, basal branch diameter (cm), number of fruits, fruits weight (g), fruits yield (kg) and ascorbic acid (mg/100 g). The variables were processed and analyzed using the statistical programmes INFOGEN (<http://www.info-gen.com.ar/-2009>) software designed to facilitate the handling of genetic database and SELEGEN-REML/BLUP (Resende, 2006) software that predicts which interest characters showed a high level of heritability.

RESULTS AND DISCUSSION

Petiole length

According to the analysis of variance for the nine variables, in the summary shown in Table 1, significant difference was detected only in the variable “petiole length” ($F = 3.96$; $p = 0.028$). On the other variables, significant differences between clones were not found. The low values of the coefficient of variation (C.V. %), shown in Table 1, for each one of the variable, indicate that the level of accuracy of the experiment was satisfactory. Duncan test for “petiole length”, showed significant difference of means ($p < 0.05$), between genotypes, whose overall average was 0.67 cm, with a coefficient of variation of 3.41%. Imán (2007) found similar results with an average of 0.6561 cm for the same variable. However, petiole length could be a component of leaf and branches' distribution and could have an indirect influence on productivity.

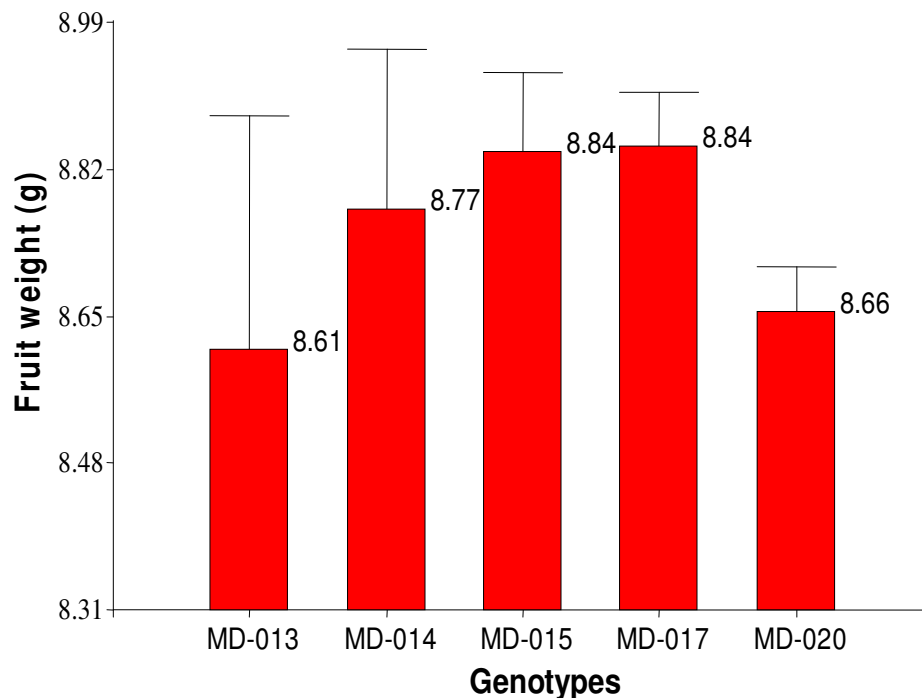


Figure 1. Fruit weight in 5 "camu-camu" genotypes, CE El Dorado (2009).

Fruit weight

INIA (Iman, 2007) indicates an overall average of 8.458 g in fruit weight, although in this study we can show a slight increase of 0.288 g in fruit weight. Figure 1 shows most deviations of mean in clones MD-013 and MD-014 compared to other promising clones involved in this research, although the ranges of variation are very close. Clones MD-015 and MD017 had the greatest weight (8.84 g on average), followed by clones MD-014 (8.77 g), MD-020 (8.66 g) and MD-013 (8.61 g).

Fruit yield

The overall average of fruit yield is 2.36 kg/plant, with a coefficient of variation of 13.86%. INIA (2008), in the same genotypes, when they were 3 years old, found an overall average of 1.0872 kg in fruits per plant. In this study, we can observe an increase of 1.27 kg of fruits per plant, in relation to this assessment. Figure 2 shows that for the variable (fruit yield), clone MD-014 produced the highest yield in average with 2.65 kg / plant (equivalent to 2889 kg / ha), followed by the MD-015 clone with 2.54 kg per plant (2772 kg / ha).

Ascorbic acid

The overall average of ascorbic acid is 2337.38 mg/100 g of pulp, with a coefficient of variation of 9.9%. The clones

The overall average of fruit weight is 8.746 g, with a coefficient of variation of 1.5%. Regarding this variable, MD-014 and MD-015 are 2432.67 and 2409.68 mg aa/100 g, respectively (Figure 3).

Correlation analysis

The results of the correlation analysis is presented in Table 2.

Between the significant correlations (in boldfaces and asterisk), it turns out that "length of petiole" with "weight of fruit" are important (Corr. Pearson = 0.543; $p = 0.013$). This is because the measurement of "length of petiole" could predict the weight of the fruit, which is one of three parameters of major importance for the selection in camu-camu.

Heritability

Table 3 shows that the inheritability for all the evaluated variables is of low magnitude ($h^2 < 0.49$), since it is a question of plants clonadas. De La Cruz and Sahagún (1992) mention that the characters that present high heritability are suitable for improvement by selection, whereas the characters with low heritability require hybridization. In a comparison of 37 clones of camu-camu, Ramos (2009) found low heritability ($h^2 = 0.34$) in

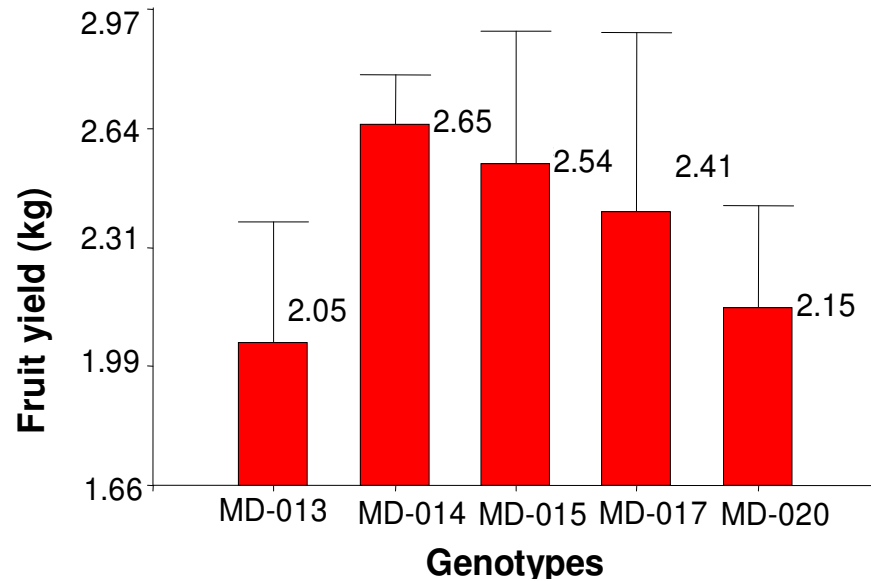


Figure 2. Fruit yield.

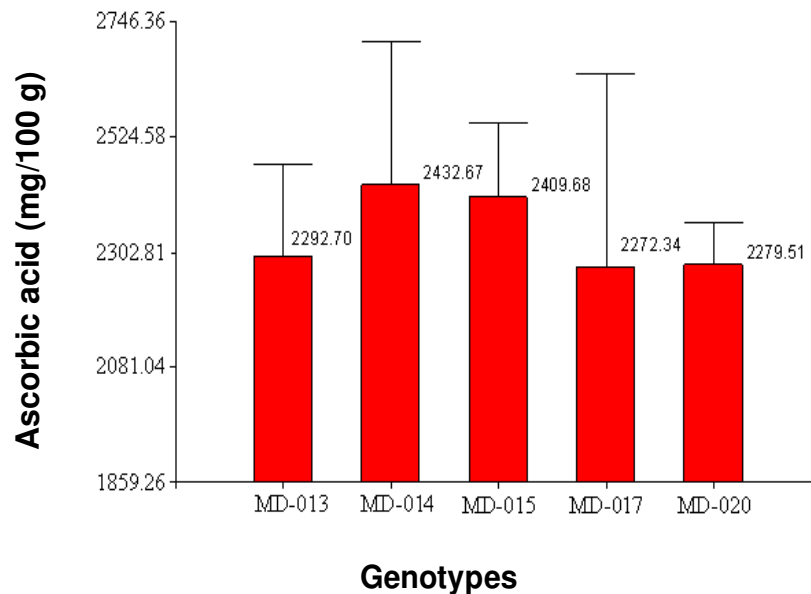


Figure 3. Ascorbic acid.

the “yield of fruit”, coinciding with Oliva and Resende (2008) finding, where in 5 consecutive harvests, the character “yield of fruit” presented a low level of heritability ($h^2 = 0.41$). Figure 4 shows the similarity/proximity of the 5 promissory camu-camu genotypes for “length of petiole”. According to Crisci and Lopez (1983), high values indicate less similarity. In this case, the closeness and similarity between clones MD-017 (Nina Rumi, Nanay, Maynas and Loreto) and MD-015 (Yuto, Nanay, Maynas and Loreto) and 0.22 Euclidean is

evident. Likewise, clones MD-013 (Anguilla, Nanay, Maynas and Loreto) and MD-020 (Cocha Tipishca, Itaya, Maynas and Loreto) are grouped with 0.22 Euclidean.

Table 4 shows the characteristics of the five genotypes and noted the similarity of the characters. The clone, MD-020, stands out because of its red fruits, unlike the other ones that have dark red color. As such, this feature has implications in the level of anthocyanins obtained from the product. The five clones had acceptable levels of ascorbic acid (higher than 2,000 mg) and the fruit yields

Table 2. Summary of correlation between nine parameters for five genotypes.

Variable	Unidades	LongHoja	AnchoHoja	LongPeciole	NumRamas	DiamBasal	NumFrutos	PesoFruto	RendFruto	AcidAscorbic
LongHoja	Corr. Pearson Sig. (bilateral)	1	0.442 0.051	0.573* 0.008	-0.057 0.813	0.06 0.81	-0.012 0.960	0.171 0.471	0.020 0.932	0.055 0.817
AnchoHoja	Corr. Pearson Sig. (bilateral)	0.4420 0.051	1 0.824	-0.053 0.824	0.009 0.970	-0.17 0.47	-0.131 0.582	0.073 0.758	-0.114 0.633	-0.088 0.714
LongPeciole	Corr. Pearson Sig. (bilateral)	0.573* 0.008	-0.053 0.824	1 0.824	0.432 0.057	0.495* 0.03	0.304 0.192	0.543* 0.013	0.371 0.107	0.053 0.823
NumRamas	Corr. Pearson Sig. (bilateral)	-0.057 0.813	0.009 0.970	0.009 0.970	1 0.970	0.42 0.07	0.392 0.087	0.385 0.094	0.432 0.057	-0.300 0.199
DiamBasal	Corr. Pearson Sig. (bilateral)	0.059 0.805	-0.173 0.466	0.495* 0.027	0.417 0.068	1 0.366	0.366 0.112	-0.018 0.941	0.355 0.124	-0.243 0.302
NumFrutos	Corr. Pearson Sig. (bilateral)	-0.012 0.960	-0.131 0.582	0.304 0.192	0.392 0.087	0.366 0.112	1 0.038	0.038 0.872	0.992* 0.000	-0.041 0.864
PesoFruto	Corr. Pearson Sig. (bilateral)	0.171 0.471	0.073 0.758	0.543* 0.013	0.385 0.094	-0.018 0.941	0.038 0.872	1 0.161	0.161 0.498	-0.032 0.892
RendFruto	Corr. Pearson Sig. (bilateral)	0.020 0.932	-0.114 0.633	0.371 0.107	0.432 0.057	0.355 0.124	0.992* 0.000	0.161 0.498	1 0.844	-0.047 0.844
AcidAscorbic	Corr. Pearson Sig. (bilateral)	0.055 0.817	-0.088 0.714	0.053 0.823	-0.300 0.199	-0.243 0.302	-0.041 0.864	-0.032 0.892	-0.047 0.844	1 0.844

LongHoja = Length of leaf; AnchoHoja = Wide of leaf; LongPeciole = Length of peciole; NumRamas = Number of branches; basales/plant; DiamBasal = Basal diameter of trunk; PesoFruto = Weigh average of fruit; RendFruto = Yield of fruit/plant; AcidAscorbic = Content of ascorbic acid; NumFrutos = Number of fruits/plant.

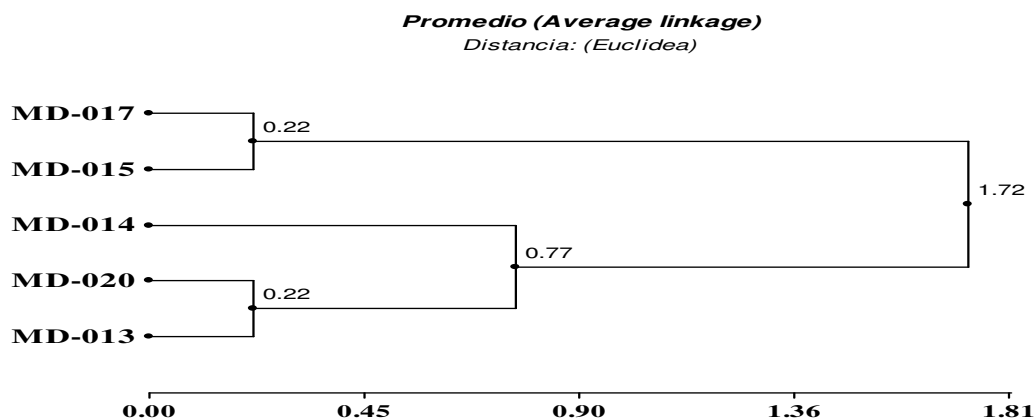
Table 3. Summary of heritability analysis for the nine parameters.

Variable	Unit	$h^2 * 1$	Overall average
Ascorbic acid	mg aa/100 g	0.002529 ± 0.0318	2337.38
Leaf length	cm	0.133996 ± 0.2315	7.49
Leaf width	cm	0.062307 ± 0.1579	3.05
Petiole length	cm	0.424895 ± 0.4123	0.67
Number of basal branches	Number	0.334331 ± 0.3657	4.32

¹ Inheritability in the broad sense, or, of the total genotypic effects.

Table 3. Contd.

Basal branch diameter	cm	0.004138 ± 0.0407	2.38
Number of fruits	Number	0.171556 ± 0.2620	270.10
Fruits weight	G	0.287178 ± 0.3389	8.74
Fruits yield	Kg	0.264134 ± 0.3250	2.36

**Figure 4.** Dendrogram of Euclidean distance coefficient of 5 camu-camu genotypes for "length of petiole", C.E. "El Dorado" - 2009.**Table 4.** Qualitative and quantitative characteristics of five genotypes in 2009.

Characteristics/Clones	MD-013	MD-14	MD-015	MD-017	MD-020
Source (Lake and River from Maynas Province, Loreto Department)	Anguilla and Nanay	Samito and Nanay	Yuto and Nanay	Nina Rumi and Nanay	Tipishca and Itaya
Plant architecture	Open top	Open top	Open top	Open top	Open top
Plant height (m)	2.50	2.50	2.50	2.50	2.50
Number of branches	4.00	5.22	3.72	4.70	3.95
Branches diameter (cm)	2.44	2.29	2.56	2.44	2.20
Ripe fruit color	Dark red	Dark red	Dark red	Dark red	Red
Number of seeds/fruit	3	3	3	3	3
Fruit weight average (g)	8.61	8.77	8.84	8.85	8.66
Pulp weight/fruit (g)	5.60	5.70	5.75	5.75	5.63
Peel weight (g)	1.29	1.32	1.33	1.32	1.30
Seed weight (g)	1.72	1.75	1.76	1.78	1.73
Yield/plant (kg/plant)	2.052	2.653	2.546	2.412	2.149
Ascorbic acid (mg/100 g)	2,292.70	2,432.67	2,409.68	2,272.35	2,279.51

(range 2052 - 2546 kg/pl) were considered as acceptable to the years of these plants.

Conclusions

With regard to the important commercial parameters, such as level of ascorbic acid, yield of fruit and average weight of fruit, the five evaluated genotypes

showed similar levels (not significantly different). As for "length of petiole", the genotypes were significantly different. Even if, for all the evaluated parameters, the magnitude of inheritability was low, the higher degree of inheritability was expressed for "length of petiole", "number of basal branches", "weight of fruit" and "yield of fruit". However, the lower degree of heritability was shown for the priority character, "ascorbic acid content". The fruit yields for the 5 clones studied were between 2.0 and 2.6 kg/plant (2200 to 2800 kg/ha of fruit per hectare),

at 4 years of planting. In reference to ascorbic acid, which stands from the rest, the genotypes, MD-014 and MD-15, had 2432.67 and 2409.68 mg/100 g of pulp, respectively.

REFERENCES

- Bardales R (2006). Effect of 3 diameters and 3 AIB applications in Camu-camu shrub (*Myrciaria dubia*) multiplicative rate. Undergraduate Thesis. Peruvian Amazon National University (UNAP), Iquitos- Perú.
- De la Cruz E, Sahagun J (1992). Determination of components of genetic variance and inheritability in characters of interest in avocado). Mexico. Department of Genetics, National Institute for Nuclear Research, p. 12.
- Enciso R (1992). Camu-camu (*Myrciaria dubia*) propagation by grafting. Technical Report No. 18, Lima (Peru). PICT-INIAA, p. 17.
- Imán S (2005). Characterization and evaluation of Camu-camu (*Myrciaria dubia* H.B.K.) Germplasm. Iquitos – Perú, pp. 6-8.
- Imán S (2007). Camu-camu (*Myrciaria dubia* H.B.K.) cultivation in Loreto Region. Manual No. 07-2007. SUDIRGEB. INIA. Iquitos - Perú, p. 26.
- Mendoza O, Picón C, Gonzales R (1989). Report of the expedition to Camu-camu (*Myrciaria dubia*) germplasm collect, in Peruvian Amazon. Technical Report No. 11, PICT-INIAA, Lima –Perú, p. 19.
- Oliva C, Resende M (2008). Genetic improvement and rate of fertilization of the camu-camu in the Peruvian Amazonia. Brazilian J. Orchards, 30(2): 450-454.
- Pinedo M, Oliva C, Del Castillo D, Linares C (2007). Subproject Profile of Strategic Research INCAGRO “Genetic evaluation of camu-camu (*Myrciaria dubia* H.B.K. Mc Vaugh) upper plants in Loreto and Ucayali, (Unpublished), p. 7.
- Ramos J (2009). Comparative of 37 genotypes of camu-camu. IIAP, Iquitos, Peru, p. 95.
- Resende V (2006). Software Selegen-REML/BLUP. EMBRAPA. Campo Grande, p. 305.