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ORIGINAL ARTICLE

Repetibility of the yield traits of Brazil nut cultivated in Roraima

Repetibilidade de variáveis da produção de castanheiras-do-brasil cultivadas em Roraima

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Abstract

The objective of this study was to estimate the spatial repeatability coefficients of *Bertholletia excelsa* fruits and nuts using different statistical methods, as well as to define the minimum number of fruits and nuts to be evaluated for the selection of superior genotypes. Twenty-one genotypes in the 2017 crop and 28 genotypes in the 2018 crop were evaluated. From each genotype, 10 fruits and 10 nuts per fruit were sampled. Seven fruit traits and three nut traits were measured, which were used to estimate repeatability coefficients by four statistical methods: 1) analysis of variance; 2) main components based on the correlation matrix; 3) principal components based on the covariance matrix and 4) structural analysis based on the correlation matrix. Estimates of repeatability coefficients varied among crops, traits and estimation methods. In general, the coefficients presented moderate magnitudes, and the methods based on principal components provided the highest estimates. For the most economically important traits for the Brazil nut market, minimum sampling of 8 fruits and 7 nuts per genotype is required to select genotypes with determination coefficients above 85%.

Keywords: Variability; *Bertholletia excelsa*; Genetic improvement.

Resumo

Este estudo teve como objetivos estimar coeficientes de repetibilidade espacial de variáveis do fruto e da castanha de *Bertholletia excelsa* utilizando diferentes métodos estatísticos, bem como definir o número mínimo de frutos e castanhas a serem avaliadas para seleção de genótipos superiores. Foram avaliados 21 genótipos na safra de 2017 e 28 genótipos na safra de 2018. De cada genótipo foram amostrados 10 frutos e 10 castanhas por fruto. Foram mensuradas sete variáveis do fruto e três variáveis da castanha, as quais foram utilizadas para estimar os coeficientes de repetibilidade por quatro métodos estatísticos: 1) análise de variância; 2) componentes principais com base na matriz de correlações; 3) componentes principais com base na matriz de covariâncias e 4) análise estrutural com base na matriz de correlações. As estimativas dos coeficientes de repetibilidade variaram entre safras, variáveis e métodos de estimação. De forma geral, os coeficientes apresentaram magnitudes moderadas, sendo que os métodos baseados em componentes principais proporcionaram as maiores estimativas. Para as variáveis de maior importância econômica para o mercado da castanha-do-brasil são necessárias amostragens mínimas de 8 frutos e 7 castanhas por genótipo, para seleção de genótipos com coeficientes de determinação acima de 85%.

Palavras-chave: Variabilidade; *Bertholletia excelsa*; Melhoramento genético.

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INTRODUCTION

Brazil nut tree (*Bertholletia excelsa* Bonpl.), also known in Brazil as Pará nut or Amazon nut, produces almonds rich in protein, lipids, vitamins and minerals and can be consumed *in natura* or used in manufacturing of flour, sweets and ice cream. Oil is also extracted from almonds, which is used in the cosmetics industry (Cymerys et al., 2005). Consumption of these almonds represents a great health benefit, acting significantly in reducing cholesterol (Yang, 2009).

The Brazil nut, a product largely produced by extractivism in native areas, represents one of the main non-timber forest products in the northern region of Brazil, where it plays an important role in the subsistence of thousands of families that collect it (Tonini, 2011; Fonseca et al., 2018). However, the loss of competitiveness in production and exportation of the product that has occurred in the country, reinforced by the great potential for increased demand, both in the domestic and foreign markets (Homma et al., 2014), justifying the introduction of cultivated Brazil nut trees.

The long period that Brazil nut trees require to produce fruits and stabilize the production, coupled with the unavailability of varieties recommended for the species, discourage investment in plantations. Thus, the economic viability of Brazil nut cultivation will only be possible through the use of selected genetic and vegetative propagated material and the use of appropriate crop management techniques (Homma et al., 2014; Pimentel et al., 2007).

Since breeding programs are expensive and long-term, especially when it comes to perennial crops, more accurate selection methods are needed (Bruna et al., 2012). The repeatability coefficient, a parameter defined as the correlation between measurements or evaluations performed on the same individual in time or space, can be used in this sense (Vencovsky, 1973; Falconer, 1975; Cruz et al., 2004).

Spatial repeatability coefficients can be used to determine the minimum number of fruits to be evaluated per plant, aiming to increase the efficiency of selection of genotypes with characteristics of interest and with the minimum cost of time and labor (Lopes et al., 2001; Costa, 2003; Bruna et al., 2012).

Spatial repeatability studies were carried out for several native forest species such as peach palm (*Bactris gasipaes* Kunth), guava (*Psidium cattleyanum* Sabine), pitanga (*Eugenia uniflora* L.), bacabi (*Oenocarpus mapora* H. Karsten), macauba (*Acrocomia aculeata* (Jacq.) Lodd. Ex Martius) and cupuassu (*Theobroma grandiflorum* (Willd. Ex Spreng. K. Schum.) (Farias Neto et al., 2002; Danner et al., 2010; Oliveira & Moura, 2010; Manfio et al., 2011; Alcoforado et al., 2019).

Studies on temporal repeatability of Brazil nut trees were performed by Pedrozo et al. (2015), Azevedo et al. (2016) and Baldoni et al. (2017). Regarding these studies involving temporal repeatability for the species, only the one performed by Oliveira & Rosse (1999) in native genotypes of Acre is available in the literature for spatial repeatability. In the latter study, moderate to high repeatability coefficients were obtained for three fruit traits (nut mass, total nut mass and number of nuts per fruit). No information on Brazil nut repeatability under cultivation conditions is available.

The objectives of this study were to estimate spatial repeatability coefficients for *Bertholletia excelsa* fruit and nut traits, using different statistical methods, as well as to define the minimum number of fruits and nuts to be evaluated for the selection of superior genotypes under growing conditions as an Agroforestry System in Roraima.

MATERIALS AND METHODS

The study was carried out in an Agroforestry System implemented in 1995, at the Confiança Experimental Field (geographic coordinates: 02º15’00” N and 60º39’54” W), belonging to Embrapa Roraima and located in the municipality of Cantá - RR (Brazil). The site is characterized by the presence of forest-savannah transition area, climate Ami under Köppen’s classification system and rainfall ranging from 1,795 to 2,385 mm.year^{-1}, with a rainy season concentrated between May and July (Ferreira & Tonini, 2009).

The Agroforestry System edge is composed of gliricidia [*Gliricidia sepium* (Jacq.) Steud.], while the central portion is composed of Brazil nut, cupiuba (*Goupia glabra* Aubl), cupuassu; coffee (*Coffea canephora* Pierre ex Froehner), saman [*Samanea saman* (Jacq.) Merr.], abiu [*Micropholis venulosa* (Mart. & Eichler) Pierre] and andiroba (*Carapa guianensis* Aubl).

A total of 21 Brazil nut genotypes were evaluated in the 2017 crop and 28 genotypes in the 2018 crop, each genotype represented by sexually propagated plant from the state of Amazonas (Brazil). A total of 15 genotypes coincided between the two crops. From each genotype, 10 fruits collected at random under the crown of each tree were evaluated. The fruits were identified and taken to the Embrapa Roraima Forest and Agroforestry Laboratory, where they were evaluated for the following traits: moist fruit mass (FWM; g); moist mass of fruit nuts (MMFN; g); dry mass of fruit nuts (DMFN; g); fruit length (FL; cm); fruit diameter (FD; cm); fruit pericarp thickness (FPT, mm) and number of fruit nuts (NFN). From each fruit, 10 nuts were sampled, totaling 100 nuts per genotype, which were evaluated for the wet mass of the nut (WMN; g); nut length (NL; cm) and nut width (NW; cm). Mass measurements were evaluated using analytical scales, while those related to width, diameter, length and thickness were evaluated with digital caliper or graded ruler.

Fruit and nut data for each crop were used to estimate repeatability coefficients (r) by four methods (Mansour et al., 1981; Cruz et al., 2004): 1) analysis of variance (ANOVA); 2) main components based on the correlation matrix (CPC); 3) main components based on the covariance matrix (CPCV); and 4) structural analysis based on the correlation matrix (SA).

1) ANOVA method (ANOVA)

To estimate the repeatability coefficients by the ANOVA method, analysis of variance was initially performed for all traits, adopting the following model:

$$Y_{ij} = \mu + g_i + \varepsilon_{ij}$$

Where Y_{ij}: is observation concerning the ith genotype in the ith fruit or nut; μ is overall mean; g_i is the random effect of the ith genotype under the influence of the permanent environment (i = 1, 2, ..., 21 for the 2017 crop or i = 1,2, ..., 28 for the 2018 crop); and ε_{ij} is the effect of the experimental error associated with the observation Y_{ij}.

After performing the analysis of variance, the repeatability coefficient was calculated by the following expression:

$$\widehat{r} = \frac{\hat{\sigma}_g^2}{\hat{\sigma}^2 + \hat{\sigma}_g^2}$$

Where $\hat{\sigma}_g^2$ is the estimate of the variance between genotypes and $\hat{\sigma}^2$ é the variance estimate of the experimental error, obtained through the mean squares of the analysis of variance.

2) CPC Method

The CPC method consists of obtaining a correlation matrix between the genotypes for each pair of measurements, in this matrix the eigenvalues and normalized eigenvectors being determined. The eigenvector whose elements have the same signal and close magnitudes is the one that expresses the tendency of genotypes to maintain their relative positions throughout the measurements. The eigenvalue ratio associated with this eigenvector is the repeatability coefficient estimator:

$$\hat{r} = \frac{\left(\lambda\hat{R} - 1\right)}{\eta - 1}$$

Where: η is the number of measurements taken in each crop and $\lambda\hat{R}$ is the estimate of the highest eigenvalue associated with the estimate of the correlation matrix between repeated measurements ($\hat{r}$).

3) CPCV Method

Considering the parametric matrix of phenotypic variances and covariance, the repeatability coefficient estimator by the CPCV method is as follows:

$$\hat{r} = \frac{\hat{\lambda}_{\hat{r}} - \hat{\sigma}_y^2}{\hat{\sigma}_y^2\left(\eta - 1\right)}$$

Where: η is the number of measurements taken in each crop, $\hat{\sigma}_y^2$ is the estimator for the sum of the residual variance with the permanent environment variance and $\hat{\lambda}_{\hat{R}}$ is the estimate of the highest eigenvalue associated with the covariance matrix estimate between the repeated measurements ($\hat{r}$).

4) SA Method

The structural analysis is based on the matrix of correlations between genotypes in each pair of evaluations, with the repeatability coefficient estimated by the following expression:

$$\hat{r} = \frac{\alpha'\hat{R}_a - 1}{\eta - 1} = \frac{2}{\eta\left(\eta - 1\right)}\sum_{j}\sum_{<j}\hat{\rho}_{jj'}$$

Where: α is the auto-vector associated with the highest auto-value of the correlation matrix estimate between repeated measures ($\hat{R}$); η is the number of measurements taken in each crop and $\hat{\rho}_{jj}$ represents the estimates of correlations between repeated measurements.

The repeatability coefficients estimated by the four mentioned methods were used to estimate the number of measurements (η_0) needed to predict the true value of the genotypes for each trait and crop evaluated:

$$\eta_0 = \frac{R^2.\left(1 - \hat{r}\right)}{\left(1 - R^2\right).\hat{r}}$$

Where: R^2 represents the genotypic coefficient of determination, which is calculated as follows:

$$R^2 = \frac{\eta.r}{1 + r.\left(\eta - 1\right)}$$

The computer program Genes was used for genetic-statistical analysis (Cruz, 2009).

RESULTS AND DISCUSSION

For both crops (2017 and 2018), significant differences were observed ($p < 0,01$) between the Brazil nut genotypes for all fruit and nut traits (Table 1), indicating variability for the genotypes. Since there was no repetition of genotypes, but repetition of fruits and nuts within genotypes, the differences observed may be due to both genetic and environmental causes. The coefficients of variation ranged from low to moderate (6.45% to 21.93%), being similar between the crops.

Table 1. Summary of variance analysis of fruit and nut traits of Brazil nut genotypes, evaluated in two crops (2017 and 2018), in an Agroforestry System.

Trait	Crop	QM genotypes	QM residue	Average	CV (%)
FWM (g)	2017	161283.9941**	14584.8	672.62	17.95
	2018	239358.3856**	18149.8	747.18	18.03
MMFN (g)	2017	13221.8341**	1026.71	150.54	21.28
	2018	11683.9029**	1162.11	160.6	21.23
DMFN (g)	2017	5272.5176**	606.512	112.33	21.93
	2018	8133.8349**	556.375	129.87	18.16
FL (cm)	2017	7.5436**	0.6716	10.18	8.05
	2018	8.1131**	0.6341	10.33	7.71
FD (cm)	2017	3.3649**	0.4639	10.57	6.45
	2018	6.215**	0.6171	11.06	7.10
FPT (mm)	2017	0.2971**	0.062	1.49	16.76
	2018	0.4484**	0.0435	1.63	12.81
NFN	2017	59.4757**	6.118	18	13.62
	2018	51.0402**	5.9881	18	13.86
WMN (g)	2017	227.6453**	3.0823	8.05	21.82
	2018	217.5747**	2.9572	8.73	19.69
NL (cm)	2017	1321.3846**	19.4006	41.54	10.60
	2018	1076.9423**	19.7650	44.39	9.97
NW (cm)	2017	379.5193**	6.6038	25.22	10.19
	2018	227.5645**	6.3873	26.44	9.56

**Significant at the 1% probability level by the F test; QM: mean square; CV: coefficient of variation; FWM: moist fruit mass; MMFN: moist mass of fruit nuts; DMFN: dry mass of fruit nuts; FL: fruit length; FD: fruit diameter; FPT: fruit pericarp thickness; NFN: number of nuts in the fruit; WMN: wet mass of the nut; NL: nut length; NW: nut width.

Variation in estimates of repeatability coefficients (r) was observed between crops, traits and estimation methods (Table 2). Five fruit traits (moist fruit mass - FWM, dry mass of fruit nuts - DMFN, fruit length - FL, fruit diameter - FD and fruit pericarp thickness - FPT) had the highest estimates of r obtained in the 2018 crop, while two traits (moist mass of fruit nuts - MMFN and number of nuts in the fruit - NFN) had the highest estimates obtained in 2017. Moist fruit mass (FWM), moist mass of fruit nuts (MMFN) and fruit length (FL) presented the highest estimates of r (above 0.48) considering the two crops and the four estimation methods.

From the estimates of r obtained, it can be concluded that, in general, there is moderate regularity, both in relation to the fruit and the nut traits. Oliveira and Rosse (1999), when evaluating fruits of native Brazil nut trees in Acre, obtained higher r estimates than those obtained in the present study for MMFN, NFN and wet nut mass (0.664; 0.569 and 0.844, respectively). The fact that these authors worked with native trees may, partially, explain the differences in results between the studies. The repeatability varies depending on the nature of the trait, the genetic properties of the population, and the environmental conditions under which individuals are evaluated (Cruz et al., 2004). Another possible explanation for the differences between the studies is the fruit sampling. Oliveira and Rosse (1999) evaluated only three fruits per genotype, while in the present study 10 fruits were evaluated.

For most of the fruit and nut traits, the estimates of r obtained by the ANOVA method were lower than those obtained by the other methods. In some cases, especially in 2017, the estimates obtained by the structural analysis (SA) method were lower or at least equal to those obtained by the ANOVA method. Baldoni et al. (2017) had also observed that the estimates obtained by the ANOVA method were lower than those obtained by the methods based on principal components (CPC and CPCV) and close to those obtained by the SA method, in a study of temporal repeatability with native Brazil nut genotypes from Mato Grosso (Brazil).

Table 2. Estimates of repeatability coefficients (r) and determination coefficients (R^2) using the method of analysis of variance (ANOVA), principal components based on correlation matrix (CPC), principal components based on covariance matrix ((CPCV) and structural analysis based on the correlation matrix (SE) for fruit and nut traits of Brazil nuts grown in an Agroforestry System and evaluated in two crops (2017 and 2018).

	2017				2018			
	r	R^2 (%)	r	R^2 (%)	*r*	R^2 (%)	r	R^2 (%)
	FWM		**MMFN**		**FWM**		**MMFN**	
Anova	0.50	90.96	0.54	92.23	0.55	92.42	0.48	90.05
CPC	0.59	93.47	0.58	93.36	0.58	93.12	0.53	91.80
CPCV	0.51	91.22	0.54	92.17	0.57	93.01	0.49	90.68
SA	0.49	90.62	0.53	91.87	0.57	92.86	0.48	90.13
	DMFN		**FL**		**DMFN**		**FL**	
Anova	0.43	88.50	0.51	91.02	0.58	93.16	0.54	92.18
CPC	0.48	90.07	0.59	93.41	0.61	93.92	0.56	92.70
CPCV	0.45	89.23	0.53	91.88	0.58	93.28	0.55	92.53
SA	0.42	87.82	0.50	91.00	0.57	92.98	0.55	92.47
	FD		**FPT**		**FD**		**FPT**	
Anova	0.38	86.21	0.28	79.14	0.48	90.07	0.48	90.30
CPC	0.46	89.35	0.38	85.72	0.50	90.76	0.51	91.09
CPCV	0.39	86.40	0.32	82.41	0.48	90.35	0.50	90.79
SA	0.37	85.54	0.28	79.35	0.48	90.07	0.49	90.58
	NFN		**NW**		**NFN**		**NW**	
Anova	0.47	89.71	0.36	98.26	0.43	88.27	0.26	97.19
CPC	0.49	90.72	0.40	98.51	0.47	89.75	0.29	97.60
CPCV	0.50	90.75	0.39	98.45	0.46	89.52	0.29	97.60
SA	0.48	90.28	0.37	98.31	0.45	88.41	0.26	97.28
	WMN		**NL**		**WMN**		**NL**	
Anova	0.42	98.65	0.40	98.53	0.42	98.64	0.35	98.16
CPC	0.45	98.81	0.43	98.71	0.45	98.80	0.38	98.37
CPCV	0.45	98.80	0.43	98.64	0.46	98.82	0.37	98.34
SA	0.44	98.75	0.41	98.58	0.44	98.76	0.36	98.22

FWM: moist fruit mass; MMFN: moist mass of fruit nuts; DMFN: dry mass of fruit nuts; FL: fruit length; FD: fruit diameter; FPT: fruit pericarp thickness; NFN: number of nuts in the fruit; WMN: wet mass of the nut; NL: nut length; NW: nut width.

According to Mansour et al. (1981), differences between the estimation methods are expected when the repeatability estimate is not high, a fact observed in the present study. Moreover, according to Costa (2003), lower estimates of repeatability are expected by the ANOVA method, since the genotypic variance estimated by this method is confused with the permanent environment variance between genotypes. Such fact has been confirmed in other studies involving native perennial species such as acerola (Lopes et al., 2001), macauba (Manfio et al., 2011) and cajá-mirim (Silva et al., 2015).

Principal component-based methods provided higher r estimates than ANOVA and SA methods for both fruit and nut traits. These results show the greater efficiency of those two methods for spatial repeatability studies in Brazil nut.

For most traits, the determination coefficients (R^2), presented in Table 2, indicate that the sample sizes of fruits and nuts used in the present study are sufficient to obtain estimates of real values of genotypes with reliability equal to or greater than 80%. This value is considered as the appropriate minimum limit of accuracy according to Cruz et al. (2004).

According to the results presented in Table 3, it is possible to observe variations (between crops, traits and estimation methods) regarding the minimum number of fruits and nuts (η) that should be evaluated, considering different values of R^2. This result was expected as a consequence of the variations obtained for the repeatability estimates (Table 2). Considering the fruit traits, in general, the 2018 crop required lower values of η than the 2017 crop. For the nut traits, the 2017 crop demanded lower values of η for nut length (NL) and nut width (NW). For the wet nut mass (WMN), the values of η were similar between the two crops. Considering the two crops, FWM, MMFN, FL and WMN were the traits that demanded the lowest values of η. Regarding the different methods of estimation of repeatability, in general, smaller variations were observed between them in the 2018 crop.

Table 3. Number of fruits and nuts (η) to be evaluated, considering different determination coefficients (R^2), based on repeatability coefficients estimated by the analysis of variance (ANOVA), methods of the principal components based on the correlation matrix (CPC) and based on the covariance matrix (CPCV), and the structural analysis based on the correlation matrix (SA), for fruit and nut traits of Brazil nut genotypes, grown in an Agroforestry System and evaluated in two crops (2017 and 2018).

	2017												2018										
	R^2 (%)	Anova	CPC	CPCV	SA		R^2 (%)	Anova	CPC	CPCV	SA		R^2 (%)	Anova	CPC	CPCV	SA		R^2 (%)	Anova	CPC	CPCV	SA
FWM	80	4	3	4	4	MMFN	80	3	3	3	4	FWM	80	3	3	3	3	MMFN	80	4	4	4	4
	85	6	4	5	6		85	5	4	5	5		85	5	4	4	4		85	6	5	6	6
	90	9	6	9	9		90	8	6	8	8		90	7	7	7	7		90	10	8	9	10
	95	19	13	18	20		95	16	14	16	17		95	16	14	14	15		95	21	17	20	21
DMFN	80	5	4	5	6	FL	80	4	3	4	4	DMFN	80	3	3	3	3	FL	80	3	3	3	3
	85	7	6	7	8		85	6	4	5	6		85	4	4	4	4		85	5	4	5	5
	90	12	10	11	12		90	9	6	8	9		90	7	6	6	7		90	8	7	7	7
	95	25	21	23	26		95	19	13	17	19		95	14	12	14	14		95	16	15	15	15
FD	80	6	5	6	7	NFN	80	5	5	4	4	FD	80	4	4	4	4	NFN	80	5	5	5	5
	85	9	7	9	10		85	6	6	6	6		85	6	6	6	6		85	8	6	7	7
	90	14	11	14	15		90	10	10	9	10		90	10	9	10	10		90	12	10	11	11
	95	30	23	30	32		95	21	22	19	20		95	21	19	20	21		95	25	22	22	23
FPT	80	11	7	9	10	NW	80	7	6	6	7	FPT	80	4	4	4	4	NW	80	12	10	10	11
	85	14	9	12	15		85	10	9	9	10		85	6	6	6	6		85	16	14	14	16
	90	24	15	19	23		90	16	14	14	15		90	10	9	9	9		90	26	22	23	25
	95	50	32	41	49		95	34	29	30	33		95	20	19	19	20		95	55	47	48	53
WMN	80	5	5	5	5	NL	80	6	5	5	6	WMN	80	6	5	5	5	NL	80	7	7	7	7
	85	8	7	7	7		85	8	7	8	8		85	8	7	7	7		85	11	9	10	10
	90	12	11	11	11		90	13	12	12	13		90	12	11	11	11		90	17	15	15	16
	95	26	23	23	24		95	28	25	25	27		95	26	23	23	23		95	36	31	32	35

FWM: moist fruit mass; MMFN: moist mass of fruit nuts; DMFN: dry mass of fruit nuts; FL: length of the fruit; FD: fruit diameter; FPT: fruit pericarp thickness; NFN: number of nuts in the fruit; WMN: wet mass of the nut; NL: nut length; NW: nut width.

Considering an R^2 of 90%, depending on the fruit trait and the estimation method used, the values of η ranged from 6 to 24 fruits per genotype in 2017 and from 6 to 12 fruits in 2018. Fruit pericarp thickness (FPT), when evaluated in 2017, was the trait that required the largest sample size of fruits (15 to 24 fruits, depending on the method). With an R^2 of 85%, the values of η were from 4 to 15 fruits in 2017 and from 4 to 8 fruits in 2018. Taking into account only the most important fruit traits for the Brazil nut market (FWM, MMFN, DMFN and NFN) and principal component methods, regardless of the crop, the evaluation of at least 8 and 12 fruits per genotype for coefficients of determination of 85% and 90%, respectively would be required.

For the nut traits and by considering a R^2 of 90%, depending on the trait and on the repeatability estimation method, the values of η ranged from 11 to 16 nuts in 2017 and from 11 to 26 nuts in 2018. With an R^2 of 85%, the values were 7 to 10 nuts in 2017 and 7 to 16 nuts in 2018. Since the nut mass has a high correlation with the nut size (Teixeira et al., 2015), the evaluation solely from WMN would be sufficient to characterize the genotypes. Considering WMN and the principal component methods, regardless of the crop, it would be necessary to evaluate 7 and 11 nuts, considering R^2 values of 85% and 90%, respectively.

Considering a coefficient of 85% as satisfactory to predict the true value of genotypes, it is recommended, for the most important traits for the Brazil nut market, to evaluate 8 fruits and 7 nuts per genotype per crop. This number of nuts must be sampled from a total of 100 nuts from 10 fruits (10 nuts per fruit). The recommended number of fruits and nuts can be used in Brazil nut improvement without much time and labor investment for the activity.

CONCLUSIONS

Variability was observed among Brazil nut genotypes cultivated under agroforestry system conditions, regarding fruit and nut traits.

Estimates of spatial repeatability coefficients for fruit and nut traits differed among crops, traits and estimation methods, and were generally considered moderate in the different cases. The methods based on principal component provided higher estimates of repeatability coefficients when compared to the other evaluated methods.

For the most important traits for the Brazil nut market, considering a determination coefficient of 85%, at least 8 fruits and 7 nuts per genotype should be sampled for evaluation of genotypes.

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