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ARTICLE

Genetic study with *Heliconia psittacorum* and interspecific hybrids

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ABSTRACT - *A genetic study of seven cultivars of* H. psittacorum *and* Heliconia interspecific *hybrids was carried out. The heritability estimate and genetic variation coefficient were highest for stem diameter (SD) (99.32% and 56.90%, respectively) and for CVg/CVe (1.85), indicating a favorable situation for selection. The genetic correlations of SD with days to inflorescence emergence (DIE) (0.64), period from shoot emergence to stem cut (CYCLE) (0.63) and stem weight (SW) (0.96) showed that the time from inflorescence emergence to cut is longer and the stem weight is greater for genotypes with larger stem diameter. Inflorescence length (IL), SD and DIE were the most important traits, accounting for 99.55% of the total variation. For SD and IL, the repeatability values exceeded 0.60 and for SD, SW, DIE and IL the coefficients of determination exceeded 93%.*

Key words*:* floriculture, tropical flowers, genetic parameters, genetic divergence.

INTRODUCTION

The cultivation of the species Heliconia in Brazil is widespread, and a promising market for growers of flowers and ornamental plants has grown (Castro et al. 2007a). The cultivars of *Heliconia psittacorum* and especially of the hybrids of *H. psittacorum* and *H. spathocircinata* Aristeguietia, are some of the most sold heliconia in the world (Castro et al. 2006). The inflorescences are terminal and erect, have a variable number of bracts and flowers of different colors and are suitable as cut flowers due to the array of bracts in a single plane on light inflorescences, facilitating packaging (Loges et al. 2005). The production is remarkably high and flowering lasts all year round under the conditions of the Zona da Mata, state of Pernambuco (Costa et al. 2007).

The natural variability in heliconia plants and populations is high (Berry and Kress 1991), and can be exploited for breeding purposes. Thus, based on agronomic characterization and on the assessment of genetic parameters such as heritability, phenotypic, genotypic and environmental correlations underlying the knowledge of genetic variability, this potential can be evaluated with a view to genetic gains, besides guiding the choice of the most suitable breeding methods. Furthermore, the use of statistical tools such as principal components allows the identification of the most divergent parents and the traits that contribute most to this divergence. Thus, in breeding programs, the crossing of these parents increases the likelihood of amplifying the genetic basis in segregating populations (Cruz et al. 2004).

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Knowing the association between traits in breeding programs is important if simultaneous or indirect trait selection is desired, particularly when the heritability of the trait of interest is low or difficult to measure or identify. If in this case another trait with high heritability, easy measurable, easy to identify and strongly correlated with the desired trait is selected, the breeding progress can be faster than by direct selection (Cruz et al. 2004).

To raise the efficiency index of selection methods, repeatability has been estimated in various crops of agricultural importance. Repeatability is the correlation between measurements in a same plant, evaluated repeatedly in time or space (Cruz et al. 2004). Studies of repeatability for heliconia traits become interesting and necessary because little research has been done on genetic improvement and its parameters in this genus.

The purpose of this study was the agronomic characterization, the estimation of genetic parameters and their genetic divergence of seven cultivars of *H. psittacorum* and interspecific hybrids of the Heliconia genebank.

MATERIAL AND METHODS

Seven genotypes were evaluated, consisting of *H. psittacorum* cultivars and interspecific hybrids with this species (Table 1), from the Heliconia genebank of the Federal Rural University of Pernambuco (UFRPE). The genebank was founded in December 2003 in Camaragibe, PE, lat 8° 1' 19" S, long 34° 59' 33" W, 100 m asl. The annual average temperature is 25.1 °C and average monthly rainfall 171.4 mm (maximum 377.2 mm and minimum 37.8 mm) (ITEP 2006).

The experiment was evaluated in a randomized block design with four replications. The rhizomes of these genotypes had been donated by local farmers. For planting, the rhizomes were washed, the roots cut and chemically treated with nematicide, insecticide and fungicide. The plants were spaced 1.5 m between rhizomes in the same line and 3.0 m between lines, forming a plot area of 2.25 m², for the development of the clump. The crop was irrigated by a micro sprinkler. Each clump was considered a plot (experimental unit).

The plants were evaluated from December 2004 to May 2006 (in the 13th and 30th month after planting, MAP). The flower stems were harvested twice a week, when two or three bracts on the inflorescences had opened. The stems were cut 20 cm above the ground. The following traits were evaluated in the field: DIE – days from shoot growth to inflorescence emergence, according to the modified methodology of Criley et al. (2001); PSC – period from inflorescence emergence to stem cut; CYCLE – period from shoot emergence until stem cut (DIE + PSC); NLS - number of leaves on the pseudostem at inflorescence emergence. The following traits were evaluated in the Laboratory of Floriculture, UFRPE: SW (g) – flower stem weight without leaves; SL (cm) – stem length, i.e., sum of the length of pseudostem and of inflorescence; SD (mm) – stem diameter at a distance of 20 cm from the inflorescence; IL (cm) – inflorescence length, from the tip to the colored part of the peduncle, and NOB – number of open bracts on the inflorescences.

To estimate the genetic parameters, the data were grouped quarterly, in six quarters from December 2004 to May 2006. Data were subjected to analysis of variance and the means compared by the Tukey test at 5% probability. The covariance and correlation coefficient between the traits also were estimated.

The genetic diversity of genotypes was analyzed using principal components. The repeatability coefficients were obtained by the method of principal component based on the correlation matrix (Cruz et al. 2004). For this analysis, the data of 15 cut flower stems per block were considered, for all traits throughout the study period. Data were analyzed statistically using the software Genes (Cruz 2006), based on the biometric models pointed out by Cruz et al. (2004).

RESULTS AND DISCUSSION

Significant differences were observed for all variables between the 13th and 30th MAP, indicating the variability among genotypes (Table 2).

For the trait days to inflorescence emergence (DIE), the averages of the genotypes Red Opal (169.6 days) and Nickeriensis (176.6 days) were the highest (Table 2) and the mean of genotype Suriname Sassy was lowest (98.0 days). These results agree with Costa et al. (2007), who observed the lowest average DIE for genotype Suriname Sassy, one year after planting.

The period until stem cut (PSC) was shortest for genotype Suriname Sassy (13.8 days) and longest for genotype Nickeriensis (16.2 days) (Table 2). The trait PSC is of interest because it enables producers, based on inflorescence emergence, to estimate how many flowers can be cut in how many days, allowing market planning. Although the genotypes Red Opal, Strawberries and

Table 1. Description of *Heliconia psittacorum* cultivars and interspecific hybrids of the Heliconia genebank

Code	Species	Cultivar	Plant height	Inflorescence position	Predominant bract color	Production months
1	*Heliconia psittacorum* L.f.	Red Gold	short	upright	yellow-orange	17
2	*Heliconia psittacorum* L.f.	Red Opal	short	upright	orangish	18
3	*Heliconia psittacorum* L.f.	Strawberries	short	upright	pink-yellow	18
4	*Heliconia psittacorum* L.f.	Suriname Sassy	short	upright	pink -green	18
5	*H. psittacorum* L.f. x *H. spathocircinata* Aristeguieta	Golden Torch Adrian	short	upright	yellow-red	18
6	*H. psittacorum* L.f. x *H. spathocircinata* Aristeguieta	Golden Torch	short	upright	yellow	18
7	*H. psittacorum x H. marginata* (*Heliconia* x *Nickeriensis* Maas & de Rooij)	Nickeriensis	short	upright	yellow-orange	18

Identification and description of the species and cultivars based on Berry and Kress (1991).

Table 2. Traits of flower stems of *Heliconia psittacorum* cultivars and interspecific hybrids

Cultivars	DIE	PSC	Cycle	NLS (n)	SW (g)	SD (mm)	SL	IL	NOB (n)
	(days)						(cm)		
Red Gold	118.2bcd	15.8ab	133.5bcd	5.13b	65.2b	8.4b	89.3b	19.9b	2.4b
Red Opal	169.6a	14.8ab	184.8a	5.18b	94.2a	18.7a	85.1b	23.3a	2.4b
Strawberries	122.9bc	14.4ab	137.5bc	5.68ab	29.5c	4.5d	82.5b	12.1e	2.7ab
Suriname Sassy	98.0d	13.8b	113.0d	5.52b	55.3b	5.5cd	107.6a	15.2d	2.8a
Golden Torch	116.2cd	15.7ab	131.7cd	5.17b	58.6b	7.8b	87.9b	16.7c	2.4b
Golden Torch Adrian	135.4b	15.5ab	150.9b	5.13b	58.3b	8.8b	84.1b	15.0d	2.5b
Nickeriensis	176.6a	16.2a	192.6a	6.29a	52.3b	7.1bc	89.2b	15.3d	2.7a

DIE = days to inflorescence emergence; PSC = period from inflorescence emergence until stem cut; cycle = DIE + PSC; NLS = number of leaves on the pseudostem at inflorescence emergence; SW = stem weight without leaves; SL = stem length; SD = stem diameter; IL = inflorescence length; NOB = number of open bracts on the inflorescences. Means followed by the same letter in a column belong to the same class, according to the test of Scott-Knott, at 5% probability.

Suriname Sassy did not differ from each other in PSC, inflorescence emergence of genotype Red Opal begins 46.6 days after Strawberries and 71.6 days after genotype Suriname Sassy. Therefore, PSC has les influence on the trait number of days from shoot emergence to stem cut (CYCLE = DIE + PSC) than DIE.

The cycles of the genotypes Nickeriensis and Red Opal were the longest (192.6 and 184.8 days, respectively) and that of genotype Suriname Sassy the shortest (113.0 days), similarly as observed for DIE (Table 2). Castro et al. (2007) observed that the cycle of cv. Golden Torch plants, grown in a greenhouse under macronutrient deficiency ranged from 181.2 days (treatment with Mg omission) to 184.6 days (complete treatment). In the said study, the cycle was at least 30 days loner than observed for the same genotype in our experiment.

Genotypes with shorter periods between shoot emergence and stem cut are more interesting, since the stems occupy the field for less time, input and labor costs (crop management) are reduced, aside from a reduced exposure to damage caused by biotic and abiotic factors (Costa et al. 2007).

The number of leaves on the stem (NLS) on the pseudostem at inflorescence emergence ranged from 5.13 to 6.29, demonstrating significant differences among genotypes for this trait (Table 2). Atehortua (1998) claims that the flowering of heliconia may begin when a given number of leaves is present on the pseudostem, which varies according to genotypes. Therefore, from a practical point of view, the NLS observed at the time of inflorescence emergence may be a useful indicator for producers to quantify the plants expected to bloom for market planning. However,

Geertsen (1990) states that soil and climatic factors such as light and moisture can influence the time of leaf growth, hampering the determination of this trait as a marker of heliconia flowering. Therefore, a more detailed monitoring of this trait under different environmental conditions is required to allow the use of number of leaves as an indicator of flowering.

The lowest stem fresh weight (SW) was observed in genotype Strawberries (29.0 g) and highest in Red Gold (94.0 g) (Table 2). The result observed with the fresh weight of the stems of genotype Red Opal (94.0 g) in the 13th to the 30th MAP was almost twice as high as observed by Costa et al. (2007) until 12 months after planting (51.6 g). A light flower stem is a desirable characteristic for cut heliconia (Criley et al. 2001). The fresh weight of the flower stems affects the transportation costs and can be a limiting factor for the export of tropical flowers such as heliconia (Pizano 2005). However, although lighter stems reduce transport costs, Nowak and Rudnicki (1990) pointed out that flower stems with greater weight contain a higher amount of carbohydrates and are, consequently, more durable. The post-harvest durability of the stems of these genotypes must be evaluated to verify this correlation.

The stem diameter (SD) varied among genotypes. The genotype Red Opal had the highest SD (18.7 mm) (Table 2). In this case, the inflorescence peduncle of genotype Red Opal is very short, and thus, the inflorescence is very close to the leaf petioles, which increases the stem diameter. This is not the case with the other genotypes, since the inflorescence peduncles are longer and reach a height above the leaf petioles. This trait related to the bearing force of the inflorescence stem is important, since damage such as breaking can occur during handling and transport (Castro et al. 2007b).

Genotype Suriname Sassy had the greatest stem length (SL) (107.6 cm), different from the other genotypes. SL of *H. psittacorum* reported by Lalrinawani and Talukder (2000) was similar, but different from Costa et al. (2007), who stated a shorter stem length, confirming the need for an evaluation period exceeding 12 months. The stem size is essential to achieve the quality standard for heliconia marketing, since the stems are sold with a length of 80 cm (Loges et al. 2005).

The inflorescence length (IL) was greatest for genotype Red Opal (23.3 cm) and shortest in genotype Strawberries (12.1 cm). For the other genotypes, IL ranged from 15.0 cm (cv. Golden Torch Adrian) to 19.9 cm (cv. Red Gold). An IL of 18.5 cm was observed in one-year-old *H. psittacorum* (Lalrinawani and Talukder 2000).

Knowing the values of the genetic parameters of these traits is extremely important with a view to future heliconia breeding programs. Therefore, the traits with higher CVg than CVe are more interesting for breeding and indicate good conditions for selection gains by simple improvement methods, such as mass selection (Vencovsky and Barriga 1992). High heritability values and index values b1 (CVg/CVe) > 1.0 were observed, indicating little interference of the environment with the traits, except for PSC, SL, and NOB (Table 3).

For the trait days from shoot growth to inflorescence emergence (DEI), heritability was 97.99%, the coefficient of genetic variation (CVg) 22.48% and CVg/CVe (b1) 1.07. For the trait period from inflorescence emergence until stem cut (PSC) the heritability estimate was lowest (66.43%), followed by lowest CVg and b1, respectively 3.83% and 0.21, indicating less chance of selection progress for this character. The coefficients of heritability of the other traits exceeded 93% and CVg from 6.50 to 56.90 % (Table 3).

The values of the genetic parameters of traits of *H. psittacorum* cultivars and interspecific hybrids observed in the 13th and 30th MAP (Table 3) were close to or higher than those observed by Costa et al. (2007) until 12 MAP, although the values for b1 were lower. This indicates that the values of CVg were lower and of CVe higher from 13th to the 30th month than 12 MAP. Therefore, since heliconia is a perennial crop, evaluations conducted over a longer period allowed the establishment and development of the genotypes, influencing the observed values of genetic parameters.

The analysis of genotypic correlations (Table 4) showed that DIE was not correlated with PSC, however correlated with CYCLE (0.94). This indicates a strong effect of DIE on CYCLE and that genotypes with a longer period until inflorescence emergence consequently have a longer CYCLE. Therefore, based on genotypic correlations of CYCLE with DIE it is noted that an evaluation of CYCLE would be more appropriate, without requiring the measurement of the period from inflorescence emergence to stem cut (PSC), reducing the breeders' work.

The positive and significant genotypic correlations of DIE and CYCLE with SD and SW (Table 4) show that in genotypes with greater period from shoot emergence to inflorescence emergence and cut, the diameter and fresh stem weight are greater .

In this study, no genotypic correlation was observed between NLS and DIE and SL (Table 4), as reported by

Table 3. Estimates of genetic parameters of flower stems of de *Heliconia psittacorum* cultivars and interspecific hybrids

Parameters	DIE	PSC	Cycle	NLS	SW	SD	SL	IL	NOB
	(days)			(n)	(g)	(mm)	(cm)		(n)
Mean	135.58	15.19	150.90	5.40	62.20	9.43	89.50	17.10	2.55
$\sigma^2 f$	948.11	0.50	945.56	0.18	0.39	29.00	73.56	15.31	0.02
$\sigma^2 g$	929.14	0.33	924.05	0.17	0.40	28.80	68.21	15.20	0.02
$h^2 m$ (%)	97.99	66.43	97.72	97.90	97.97	99.32	92.72	99.30	93.69
CVg(%)	22.48	3.83	20.14	7.80	31.86	56.90	9.22	22.79	6.50
CVe(%)	20.99	17.79	20.09	7.46	29.98	30.72	16.89	12.42	11.04
CVg/CVe	1.07	0.21	1.00	1.04	1.06	1.85	0.54	1.83	0.59

DIE = days to inflorescence emergence; PSC = period from inflorescence emergence until stem cut; cycle = DIE + PSC; NLS = number of leaves on the pseudostem at inflorescence emergence; SW = stem weight without leaves; SL = stem length; SD = stem diameter; IL = inflorescence length; NOB = number of open bracts on the inflorescences.
ó²f = phenotypic variance; ó²g = genetic variance; h²m (%) = coefficient of heritability in the broad sense; CVg (%) = genetic coefficient of variation; CVe (%) = experimental coefficient of variation; CVg/CVe = ratio of CVg and CVe.

Table 4. Estimate of the genotypic correlation coefficient for traits of flower stems of *Heliconia psittacorum* cultivars and interspecific hybrids

Traits	DIE	PSC	Cycle	NLS	SW	SD	SL	IL
PSC	0.30							
Cycle	0.94*	0.30						
NLS	0.37	0.20	0.38					
SW	0.53*	-0.10	0.53*	-0.43				
SD	0.64*	-0.19	0.63*	-0.38	0.96*			
SL	-0.60*	-0.42	-0.49	0.21	-0.23	-0.42		
IL	0.22	-0.17	0.49	-0.40	0.97*	0.93*	-0.23	
NOB	0.03	-0.46	-0.11	0.78*	-0.51	-0.54*	0.77*	-0.51

DIE = days to inflorescence emergence; PSC = period from inflorescence emergence to stem cut; cycle = DIE + PSC; NLS = number of leaves on the pseudostem at inflorescence emergence; SW = stem weight without leaves; SL = stem length; SD = stem diameter; IL = inflorescence length; NOB = number of open bracts on the inflorescences.

Costa et al. (2007), after one year of evaluation, confirming the need to assess the genotypes during more than one year, to allow the full plant development. No genetic correlation was observed between NLS and DIE, PSC and CYCLE, so it would not be reasonable to say that heliconia flowering begins when a given number of leaves is present on the pseudostem.

The character SW showed genotypic correlations with the traits IL (0.97) and SD (0.96), indicating that higher values for fresh weight are observed in genotypes with greater diameter and inflorescences (Table 4), as stated by Costa et al. (2007). Thus, if the goal is stems with less fresh weight, genotypes with lower CYCLE should be selected, since the genotypic correlation of SD with SW and CYCLE is significant.

Based on the graphic dispersion by the technique of principal components (Figure 1), involving the two main components, which account for 82.24 % of total variation among the seven genotypes, it was noted that Suriname Sassy and Red Opal were the most divergent genotypes by the first principal component, rather different from the other genotypes. However, according to the second main component, the genotypes with highest genetic divergence were Suriname Sassy and Nickeriensis. The most similar genotypes were Golden Torch Adrian and Red Gold.

The principal component analysis showed that the traits with most divergence in heliconia, in descending order, were DIE, IL and SD, accounting for 99.55 % of the total variation. On account of these traits, Suriname Sassy and Red Opal may be indicated as parents in breeding programs for genotypes with greater inflorescence length, smaller stem diameter and shorter period to inflorescence emergence (Table 2), aside from a differentiated bract coloration (Table 1).

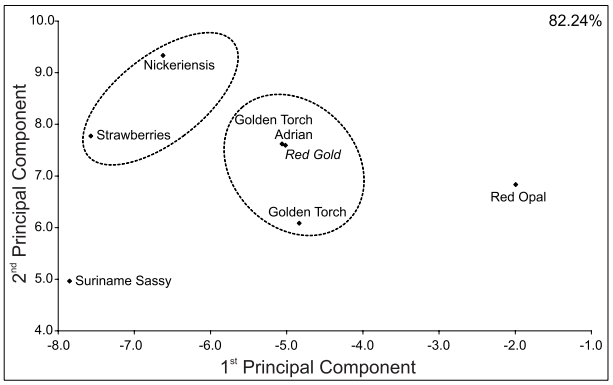

Figure 1. Dispersion diagram of the principal component analysis based on traits of *Heliconia psittacorum* cultivars and interspecific hybrids.

The repeatability coefficients ranged from 0.06 (PSC) and 0.64 (IL). The repeatability coefficients were estimated at over 0.52 for the traits DIE, IL and SD (Table 5), indicating that the magnitude of environmental variance was lower than the genetic variance, demonstrating the regularity of the genotype performance in the various measurements. These values also indicate that the environmental variance for these traits was relatively low compared with the variance between clumps.

The estimates of repeatability coefficient for the traits PSC, NLS, SW, SL, and NOB indicated low regularity of clumps from one evaluation to another. The number of measurements for a level of certainty of 99% for these traits would be extremely high and becomes impractical, requiring more time and labor and increasing production costs. However, the number of measurements to obtain predictions with a reliability of 95 % was less than 58 for all traits.

Coefficients of determination higher than 96 % were obtained for the traits DIE, IL and SD, which were the traits with the highest repeatability coefficients. Less than 15 measurements were required for these traits to reach levels of certainty of 95 % to predict real values for the traits evaluated in the flower stems of clumps. This number of measurements was lower than that for the traits with a repeatability coefficient below 0.38.

The traits DIE, IL and SD contain important information for heliconia improvement due to the observed values for genetic parameters, for correlations with other traits such as SW and CYCLE, and for repeatability. The measurement of these traits reduces the time, labor and resources required to conduct the evaluation and characterization activities in heliconia genebanks. They are therefore important in the characterization of Heliconia genotypes, in view of the great variability of the assessed genotypes.

Table 5. Estimates of residual variance, genetic variance, coefficient of repeatability, coefficient of determination and the number of measurements required to obtain levels of 95 and 99% of certainty, for traits of *Heliconia psittacorum* cultivars and interspecific hybrids

Traits	Residual variance (within clumps)	Genetic variance (among clumps)	Coefficient of repeatability	Coefficient of determination	Number* of measurements for R^2	
					0 95	0 99
DIE	862.448	870.112	0.52	96.44	15	78
PSC	17.378	0.748	0.06	59.40	48	251
NLS	0.582	0.331	0.37	93.55	26	136
SW	0.008	0.004	0.38	93.93	20	103
SD	14.353	15.874	0.60	97.43	10	53
SL	232.430	106.383	0.38	93.80	28	144
IL	7.035	10.639	0.64	97.79	9	49
NOB	0.372	0.047	0.08	24.51	58	282

DIE - days until inflorescence emergence; PSC - period from inflorescence emergence until stem cut; CYCLE = DIE + PSC; NLS - number of leaves on the pseudostem at inflorescence emergence; SW - stem weight without leaves; SL - stem length; SD – stem diameter; IL - inflorescence length; NOB – number of open bracts on the inflorescences. Estimate calculated based on mean values in two blocks containing 15 flower stems in each block.*absolute values

Estudo genético com *Heliconia psittacorum* e híbridos interespecíficos

RESUMO - *Um estudo genético sobre sete cultivares de* H. psittacorum *e híbridos interespecíficos de Heliconia foi conduzido. O diâmetro da haste (DH) apresentou maior estimativa de herdabilidade (99,32 %), maior coeficiente de variação genética (56,90 %) e CVg/CVe (1,85), refletindo uma situação favorável para seleção. As correlações genéticas de DH com dias para emissão da inflorescência (DEI) (0,64), período desde a emissão do perfilho até a colheita da inflorescência (CICLO) (0,63) e massa da haste (MH) (0,96), demonstram que, genótipos com hastes de diâmetro maior, apresentaram maior tempo da emissão à colheita da inflorescência e maior massa da haste. O comprimento da inflorescência (CI), DH e DEI foram os caracteres mais importantes, responsáveis por 99,55 % da variação total. Os valores de repetibilidade foram acima de 0,60 para DH e CI e os coeficientes de determinação acima de 93 % para DH, MH, DEI e CI.*

Palavras-chave*: floricultura, flores tropicais, parâmetros genéticos, divergência genética.*

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REFERENCES

Atehortua L (1998) **Aves del paraiso Strelitzia Gingers Alpinia Heliconia**. Universidad De Antioquia, Medellín, 66p.

Berry F and Kress WJ (1991) **Heliconia: an identification guide**. Smithsonian Institution Press, Washington and London, 334p.

Castro ACR, Loges V, Costa AS, Castro MFA, Aragão FAS and Willadino LG (2007a) Hastes florais de helicônia sob deficiência de macronutrientes. **Pesquisa Agropecuária Brasileira 42:** 1299-1306.

Castro CEF, May A and Gonçalves C (2006) Espécies de helicônia como flores de corte. **Revista Brasileira de Horticultura Ornamental 12:** 87-96.

Castro CEF, May A and Gonçalves C (2007b) Atualização da nomenclatura de espécies do gênero *Heliconia* (Heliconiaceae). **Revista Brasileira de Horticultura Ornamental 13**: 38-62.

Costa AS, Loges V, Castro ACR, Bezerra GJM and Santos VF (2007) Variabilidade genética e correlações entre caracteres de cultivares e híbridos de *Heliconia psittacorum*. **Revista Brasileira de Ciências Agrária 2**: 187-192.

Criley RA, Maciel N, Fu Z and Uchida J (2001) Productivity of three heliconia hybrids. **Bulletin Heliconia Society International 10**: 1-3

Cruz CD (2006) **Programa Genes**: Biometria. Editora UFV, Viçosa, v.1, 382p.

Cruz CD, Regazzi JA and Carneiro PCS (2004) **Modelos biométricos aplicados ao melhoramento genético**. Editora UFV, Viçosa, v.1, 480p.

Geertsen V (1990) Influence of photoperiod and temperature on the growth and flowering of *Heliconia aurantiaca*. **HortScience 25**: 646-648.

ITEP - Instituto de Tecnologia de Pernambuco (2006) Available at http://www.inmet.gov.br Assessed on dec, 9.

Lalrinawani and Talukder MC (2000) Effect of spacing and size rhizome on the flower production of Heliconia (*Heliconia psittacorum* L.). **Journal of the Agricultural Science Society of North East India 13**: 48-51.

Loges V, Teixeira MCF, Castro ACR and Costa AS (2005) Colheita e pós-colheita de flores tropicais no estado de Pernambuco. **Revista de Horticultura Brasileira 23**: 699-672.

Nowak J and Rudnicki RM (1990) **Postharvest handling and storage of cut flowers, florist greens and potted plants**. Timber Press, Portland, 210p.

Pizano M (2005) International market trends – tropical flowers. **Acta Horticulturae 8l**: 79 - 86.

Vencovsky R and Barriga P (1992) **Genética biométrica no fitomelhoramento**. Revista Brasileira de Genética, Ribeirão Preto, 496p.