Productivity and postharvest durability of Heliconiaceae grown in full sun in the Midwest region of Brazil[1]

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ABSTRACT

Flower stems of the Heliconiaceae family are gaining more and more space in the Brazilian market of ornamental plants and further knowledge about quality, productivity, and postharvest management is necessary. The objective of the present study was to evaluate heliconiaceae cultivated in full sun in the central-west region of Brazil in terms of agronomic traits and to determine the postharvest durability of floral stems submitted to cold storage. Accessions of *Heliconia bihai* cultivar Caribea, *H. bihai* cultivar Iris Red, and *H. rauliniana* were evaluated. Quantitative and qualitative morphological characteristics, the total number of flower stems produced, and number of marketable stems were obtained. Postharvest longevity was tested in a cold chamber at 16 ºC and 19 ºC and at ambient temperature of 26 ºC. Morphological characteristics such as the length, diameter and fresh mass of flower stems, inflorescence length, and postharvest durability of the inflorescences were the most affected. The most important variables were the quality of flower stems, productivity of marketable stems, and postharvest durability. The studied heliconias presented agronomic characters within the commercialization standards, highlighting *H. bihai* (Caribea) which presented the highest productivity. The best storage temperature for all accessions evaluated was 16 °C.

Keywords: tropical flowers; morphoagronomic descriptors; refrigerated storage.

INTRODUCTION

The ornamental plant sector is continuously expanding in Brazil as a result of factors such as improved market structure and increased purchasing power of producers and consumers, species diversification, and the dissemination of new production technologies (Zandonadi *et al.*, 2018).

Among the most cultivated tropical cut flowers in Brazil, the genus Heliconia (Heliconiaceae) stands out as one of the most used in the ornamental market (Lamas, 2004). Species of this genus are widely accepted by producers and consumers due to their beauty, variety of shapes and colors of the bracts, post-harvest durability, and resistance to transport over long distances (Brainer & Oliveira, 2006).

Climatic conditions such as solar radiation, temperature, and relative humidity influence the growth of heliconias (Coelho *et al.*, 2019). These plants occur throughout tropical America, in dry and humid regions with temperatures ranging from 23 to 30 °C (Brainer & Oliveira, 2006). According to Criley (1989), heliconias are commonly grown outdoors, but in regions of high luminosity, it may be necessary to use shading screens to improve the quality of floral stems that have less intense colors.

For the Brazilian Midwest region, there are no recommendations regarding the planting of heliconias under

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shade or full sun. Temperatures in the region range from 16 to 36 °C and the average annual rainfall is from 1,300 to 2,000 mm (Martins *et al.*, 2010). Maza (2004) reports the strong incidence of light provides stems with bracts of more showy color, while water in abundance and temperature can influence the quality and durability of heliconia floral stems. Postharvest durability is a prerequisite for product quality and commercialization success (Albuquerque *et al.*, 2014).

The correct handling and storage of floral stems can provide a longer shelf life of the product, due to the preservation of its physical attributes, maintaining its economic value (Folha *et al.*, 2016). Cold storage is a technique widely used in flowers and fruits to extend the shelf life of these products. At low temperatures, processes such as transpiration, ethylene production, and respiration are stopped or reduced, and the degradation of sugars and other compounds present in the flower stems is delayed (Sonego & Brackmann, 1995).

The cultivation of heliconias in Brazil lacks information about development, time to harvest, adequate planting system, harvest, and postharvest management and storage temperature, factors that affect the quality standard of the main tropical species cultivated, making the marketing (Loges *et al.*, 2008). In this sense, the objective of the present study was to evaluate heliconiaceae cultivated in full sun in the central-west region of Brazil in terms of agronomic traits and to determine the postharvest durability of floral stems submitted to cold storage.

MATERIAL AND METHODS

Plant material and study location

The inflorescences were obtained from accessions of *Heliconia bihai* cultivar Caribea, *H. bihai* cultivar Iris Red and *H. rauliniana* that belong to the germplasm bank of tropical flowers of the State University of Mato Grosso, Tangará da Serra Campus, Mato Grosso (14º39' S, 57º25' W; 321 m above sea level). The regional climate in the study area is tropical characterized by dry and rainy seasons, with an average annual rainfall of 1,300 to 2,000 mm and an average annual temperature of 16 to 36 ^{o}C (Martins *et al.,* 2010). The soil is classified as clayey, dystroferric Red Latosol, with a flat to slightly undulating relief (Santos *et al.*, 2018).

Agronomic characterization and experimental design

Characterization was performed based on 22 morphological descriptors, including 15 quantitative and 7 qualitative descriptors, adapted from Castro (1993). Evaluations were carried out in the second year of planting. Ten flower stems from 10 clumps were evaluated per species, totaling 100 flower stems.

The stems were harvested 5 cm from the ground when they had two to four open bracts, between 7:00 and 8:00 am. After harvest, the flower stems were placed in buckets of water and transported to the postharvest laboratory for evaluation.

Qualitative descriptors

Heliconias were evaluated according to the following qualitative descriptors: type of inflorescence: erect or pendant; bract and flower color according to Munsell Tissue Color Book (2012); waxy and hairy: presence or absence in inflorescence, floral stem, leaf, and petiole; bract and rachis firmness: resistant or non-resistant; and bract arrangement: flat or twisted.

Quantitative descriptors

The following quantitative descriptors were evaluated: flower stem length (FSL), number of leaves per flower stem (NLFS), flower stem diameter (FSD), leaf width (LW), leaf length (LL), inflorescence width (IW), inflorescence length (IL), number of bracts per inflorescence (NBI), bract length (BL), bract depth (BD), number of flowers per bract (NFB), flower stem fresh mass (FSFM), the total number of flower stem (TNFS), number of marketable flower stem (NMFS) (Figure 1), and postharvest durability (PD).

Productivity and postharvest durability

The weekly production of flower stems was divided into marketable flower stems and non-marketable flower stems. Heliconiaceae flower stems with the following characteristics were classified as marketable according to Loges *et al.* (2005) and Castro *et al.* (2006): absence of deterioration or dehydration; good coloring; FSL > 80 cm; FSD < 3.0 cm; IL between 10 and 30 cm; FSFM between 100 and 200 g, and PD of more than 7 days (Figure 2). Flower stems without these characteristics or that exhibited some deteriorations were classified as non-marketable (Figure 2).

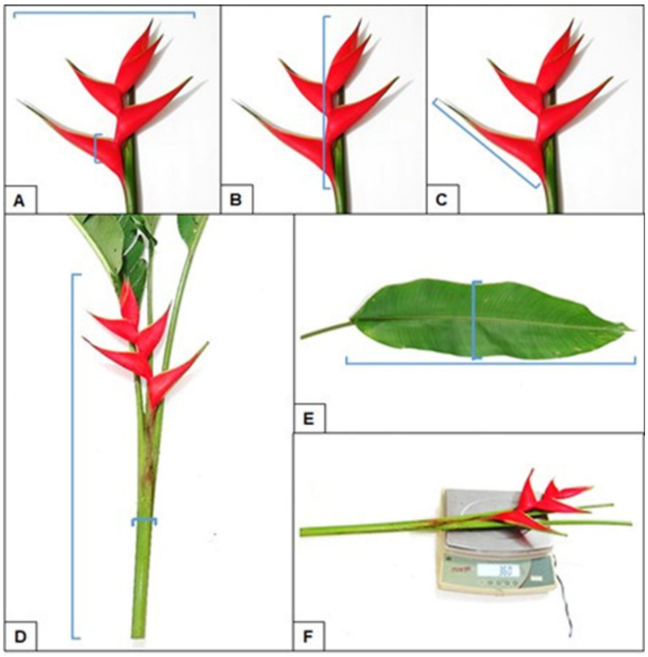

Figure 1: Morphometry of Heliconiaceae. (A) Inflorescence width and bract depth, (B) inflorescence length, (C) bract length, (D) flowering stem length and diameter, (E) leaf length and width, and (F) fresh mass of the flowering stem.

Figure 2: Criteria used for the classification of marketable and non-marketable flowering stems of Heliconia. (A) Non-marketable stem: did not reach the minimum size, (B) presence of deterioration, (C) damage caused by insects. (D) Marketable stem: appropriate size for sale, absence of deterioration, and good coloring. Active germplasm bank of UNEMAT, Tangará da Serra – MT (adapted from Costa *et al*., 2007).

Productivity was evaluated weekly and the total production of each accession was calculated as stems ha^{-1} year^{-1} using the following equation: P = 10,000 × [(TNFS/90)/2], where TNFS is the total number of harvested flower stems.

The yield (% of marketable flower stems) of flower stems was calculated using the following formula: NMFS × 100/TNFS, where NMFS is the number of marketable flower stems and TNFS is the total number of harvested flowers stems.

The marketable flower stems were submitted to three storage treatments: two treatments in a cold chamber at temperatures of 16 and 19 ºC and relative humidity of 80%, and a control treatment under laboratory conditions at a mean temperature of 26 ºC and relative humidity of 50 to 55%. The inflorescences were inspected visually every day and were discarded when the inflorescences had lost natural brightness, or when they exhibited dark spots or slightly stained bracts (Figure 3).

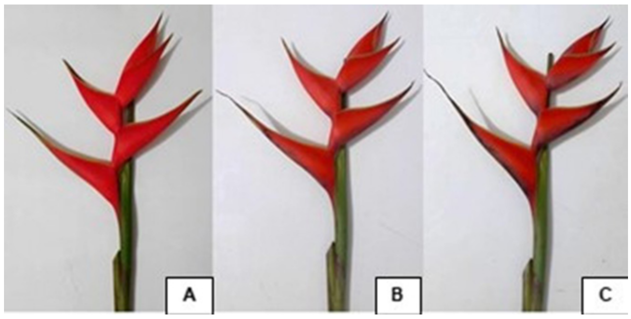

Figure 3: Senescence process of flowering stems of *Heliconia bihai*. (A) newly harvested flower stem, absence of browning in the bracts; (B) floral stem with bracts starting to darken at the edges and apical region; (C) floral stem senescent, unsuitable for commercialization, with the presence of browning in all bracts.

Data analysis

The data were submitted to analysis of variance and means were compared by the Scott-Knott test at 5% probability in a 3×3 factorial scheme [accessions x temperatures (16, 19 and 26 ºC)]. All analyses were performed using the SISVAR statistical program (Ferreira, 2011).

RESULTS

Qualitative descriptors

The qualitative characteristics of the inflorescences, bracts, flower stem, leaf, petiole, rachis, and flowers produced from 2015 to 2017 are presented in Table 1. All accessions of the *H. bihai* group exhibited erect inflorescences whose color varied across shades of red, as well as the absence of hairiness and waxiness in stem, leaves, and petiole. The rachis was resistant and the color of the flowers ranged from white to green and yellow. There were resistant bracts with a flat arrangement, except for *H. rauliniana* which showed a twisted arrangement of the bracts.

Quantitative descriptors

The bihai group exhibited the usual values for characteristics such as FSL and FSD, BD, NFD, and IW. FSL ranged from 83.2 to 121.9 cm. The FSL of *H. rauliniana* was about 38.7 cm longer, with the difference being significant compared to the FSL of *H. bihai* (Iris Red) (Table 2).

Heliconia rauliniana had a significantly greater mean IW than *H. bihai* (Iris Red) and *H. bihai* (Caribea) (Table 2). No significant difference in IL was observed between cultivars (Table 1). *Heliconia rauliniana* and *H. bihai* (Caribea) had significantly greater mean LW than *H. bihai* (Iris Red) (Table 2).

There was no significant difference in LL (Table 2). However, the FSFM and the NLFS differed significantly between cultivars. The NBI could be divided into two classes, in which *H. bihai* (Caribea) and *H. rauliniana* with lower mean values than *H. bihai* (Iris Red) were assigned to the same class (Table 2). BL was significantly greater in *H. bihai* (Caribea) compared to the other cultivars (Table 2).

Table 1: Qualitative characteristics of the three *Heliconia* spp. accessions in the active germplasm bank of UNEMAT/Tangará, 2015-2017

	Inflorescence			Bract			Flowering stem
Accession	Type	*Color	Hairiness	Waxiness	Firmness	Arrangement	Hairiness
H. bihai (Iris Red)	Erect	Red (5 R 4/6)	Absent	Absent	Resistant	Plane	Absent
H. bihai (Caribea)	Erect	Red (5 R 4/4)	Absent	Absent	Resistant	Plane	Absent
H. rauliniana	Erect	Red (5 R 4/4)	Absent	Absent	Resistant	Twisted	Absent

	Flowering stem	Leaf		Petiole		Rachis	Flower
Accession	Waxiness	Waxiness	Hairiness	Waxiness	Hairiness	Firmness	Color
H. bihai (Iris Red)	Absent	Absent	Absent	Absent	Absent	Resistant	(2.5 G 7/8)
H. bihai (Caribea)	Absent	Absent	Absent	Absent	Absent	Resistant	(5 GY 4/8)
H. rauliniana	Absent	Absent	Absent	Absent	Absent	Resistant	(5 Y 8/4)

*Color numbers in parentheses, according to Munsell Plant Tissue Color Book (2012).

Table 2: Mean values of flowering stem length (SL), number of leaves per stem (NLS), stem diameter (SD), leaf width (LW), leaf length (LL), inflorescence width (IW), inflorescence length (IL), number of bracts per inflorescence (NBI), bract length (BL), bract depth (BD), number of flowers per bract (NFB), stem fresh mass (SFM), total number of stems (TNS), and number of marketable stems (NMS). UNEMAT, Tangará da Serra - MT, 2015-2017

Accession	Characteristic													
	SL (cm)	NLS (un)	SD (cm)	LW (cm)	LL (cm)	IW (cm)	IL (cm)	NBI (un)	BL (cm)	BD (cm)	NFB (un)	SFM (g)	TNS (stems ha^{-1} $year^{-1}$)	NMS (stems ha^{-1} $year^{-1}$)
H. bihai (Iris Red)	83.2B	4.6B	2.22A	19.4B	75.6A	27.5B	32.5A	3.0A	17.5B	4.7A	15.1A	223.7B	2,214.28A	1,928.57A
H. bihai (Caribea)	88.6B	3.6C	2.32A	20.8A	79.2A	29.7B	32.0A	2.5B	20.1A	4.5A	14.6A	267.2A	2,666.66A	2,000.00A
H. rauliniana	121.9A	5.1A	1.83B	21.9A	70.5A	35.0A	33.2A	2.5B	18.0B	2.9B	10.4B	151.3C	2,071.42A	2,000.01A

[1] Means in the same column followed by the same lowercase letter do not differ from one another by the Scott-Knott test at 5% probability. [2] Means in the same column followed by the same uppercase letter do not differ from one another by the Scott-Knott test at 5% probability.

Productivity and postharvest durability

All Heliconia cultivars evaluated in the study area achieved the highest production in the months with the highest rainfall, between October 2016 and March 2017 (Figure 4). Peak production of the three cultivars was observed between November and January (Figure 5). The *H. bihai* (Iris Red) cultivar obtained a percent yield of 87.8% of the 19,111.11 flower stems produced ha^{-1} year^{-1} (Figure 5), followed by *H. bihai* (Caribea) with a yield of 77.13% of the 27,444.44 flower stems produced ha^{-1} year^{-1} (Figure 5). The lowest yield was recorded for the *H. rauliniana* cultivar in which 11,611.11 of the 16,055.56 flower stems produced ha^{-1} year^{-1} were considered to be marketable, corresponding to a yield of 72.32% (Figure 5).

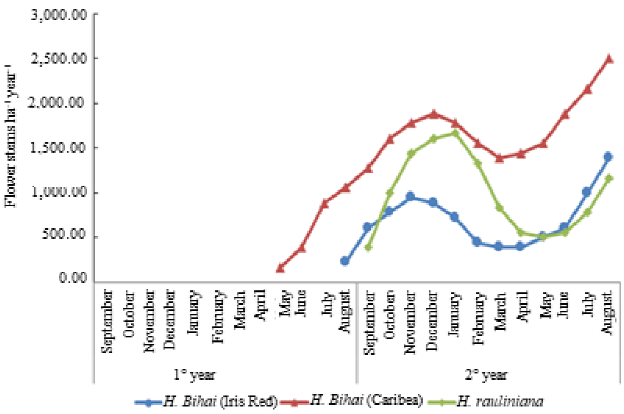

Figure 4: Monthly productivity in stems ha^{-1} year^{-1} of accessions of *Heliconia bihai* (Caribea), *Heliconia bihai* (Iris Red), and *Heliconia rauliniana* cultivated in the germplasm bank of tropical ornamental plants from 2015 to 2017, Tangará da Serra – MT.

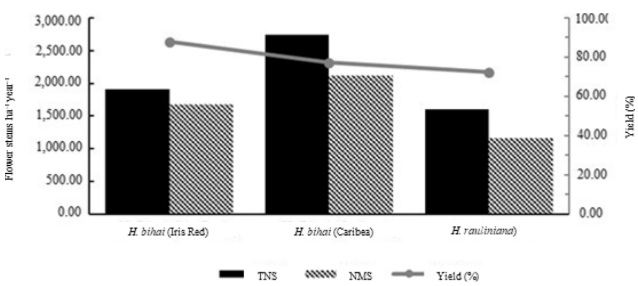

Figure 5: Total number of produced stems (TNS), number of marketable stems (NMS), and percent yield of flowering stems over the two years of cultivation in the active germplasm bank of tropical ornamental plants.

The mean durability of the three cultivars exceeded 15 days at a temperature of 16 °C. The mean durability of *Heliconia bihai* (Iris Red) was 20.9 days, three days more than *H. bihai* (Caribea) and *H. rauliniana* (Table 3). No significant difference between the *Heliconia* cultivars was observed at a temperature of 19 °C, with mean durability of 15.2 days (Table 3).

Flower stems kept at the control temperature of 26 °C achieved a mean durability of 8 days, a reduction of 133.7% when compared to the temperature of 16 °C. The longest mean durability was observed for the *H. bihai* (Caribea) accession (10 days) (Table 3). There was no significant difference between *H. bihai* (Iris Red) and *H. rauliniana*.

Table 3: Postharvest durability (days) of the flowering stem of Heliconia spp. at temperatures of 16, 19 and 26 °C. UNEMAT, Tangará da Serra - MT, 2015-2017

	Temperature		
	16 °C	**19 °C**	**26 °C (control)**
H. bihai (Iris Red)	20.91Aa	15.32Ba	7.70Cb
H. bihai (Caribea)	17.85Ab	14.81Ba	10.04Ca
H. rauliniana	17.37Ab	15.61Ba	6.54Cb

Means in the same row followed by the same uppercase letter (between temperatures) and in the same column followed by the same lowercase letter (between accessions) do not differ from one another by the Scott-Knott test at 5% probability.

DISCUSSION

The heliconias presented qualitative and quantitative characteristics within the standards required for commercialization. Erect inflorescences in a single plane and with firm bracts facilitate harvest, handling, and rapid preparation, in addition to enabling packaging in bundles or boxes, and are therefore not associated with transportation problems. Some quantitative characteristics found, such as stem length, stem diameter, stem fresh mass, the durability of the flowering stem, and inflorescence length, which are of greater commercial interest when the aim is to select accessions with ornamental potential (Castro *et al.*, 2006).

The *Heliconia bihai* and *H. rauliniana* cultivars were classified as medium in terms of stem length. Similarly, Rocha (2009) and Costa *et al.* (2007), evaluating *H. psittacorum* cultivars and hybrids in Pernambuco, obtained lengths of the flowering stem between 84 and 107.6 cm after 1.5 year of cultivation.

According to Loges *et al.* (2005), the size of the flowering stem is one of the quality standards observed when commercializing *Heliconia*. Very short stems limit their use in arrangements, with a minimum stem length of 80 cm being required. On the other hand, large stems, with a length greater than 1.51 m, require careful handling to avoid tip-over or unwanted breakage. In addition, very long stems are more susceptible to lodging caused by wind and other environmental factors (Castro *et al.*, 2006).

The diameter of the flowering stem is an important feature by providing support to the plant. Damage can occur during handling and transport, for example, breakage of very thin stems. The diameter is also related to the lodging of flowering stems, with very thin stems being less resistant to wind and rain, causing production losses (Castro et al., 2006). The largest stem diameters were observed for *H. bihai* accessions, ranging from 2.22 to 2.32 cm. This diameter is desirable since the inflorescences are large and require resistant stems with a large diameter to support the weight of the inflorescences.

In the case of cut flowers, the carbon reserve in the stem is generally used to extend the potential longevity of the flowers; the greater the length and diameter of the stem, the longer the postharvest durability (Hermans *et al.*, 2006; Castro *et al.*, 2007a).

Heavy flowering stems, such as those of the *bihai* group, can make transport difficult and increase the cost of transportation, which is a factor limiting the export of tropical flowering plants such as *Heliconia* and others. These flowers are usually transported by air cargo and the costs vary according to distance, volume, and transported weight (Pizano, 2005). On the other hand, stem mass is directly related to the longevity of the inflorescence since flowering stems with a greater mass contain a higher amount of carbohydrates and, consequently, exhibit longer postharvest durability (Castro *et al.*, 2007b).

The fresh mass of the flowering stem varies widely among cut flowers. In *Alpinia*, the mean weight was 167 g for stems with a standardized length of 60 cm (Dias-Tagliacozzo *et al.*, 2003). Studies on torch ginger have reported wide variation in fresh mass, ranging from 166.5 to 480.9 g for stems measuring 80 cm in length (Gonçalves *et al.*, 2014).

Peak production of *Heliconia* is related to higher water availability, i.e., peak flowering occurs during the wettest months of the year. Heliconiaceae are water-dependent plants, with their natural habitats being riverbanks, clearings in humid tropical forests or marsh areas (Castro *et al.*, 2011). Thus, water availability is a limiting factor in the cultivation of these plants and an irrigation system becomes necessary to meet the water requirement during the driest months of the year. According to Castro (1995), abundant irrigation is recommended, especially after leaf emergence in order to maintain a high soil moisture content.

The longevity of the flower stem is determined by various pre and postharvest factors and is also related to the genetic and anatomical characteristics of each species and cultivar (Lima & Ferraz., 2008). Temperature is one of the main factors that influence the postharvest quality of cut flowers. Refrigeration is the most economical method for long-term storage (Castro, 1984). For example, the postharvest durability of *H. bihai* (Iris Red) at 16 ºC obtained in the present study was double the durability of the same cultivar at 15 ºC in Fortaleza–CE (Guimarães, 2008). Damage caused by cold storage has been reported for *H. bihai* inflorescences stored at 12 ºC (Costa *et al.*, 2011).

A low storage temperature is an important factor in delaying deterioration since it reduces metabolic processes (transpiration and respiration) and the growth of pathogens, maintaining quality for a longer period of time and prolonging the postharvest life of plants and flowers (Lima & Ferraz, 2008). Temperate climate plants can be stored at 0 to 2 ºC for long periods without significant loss of quality, while tropical plants are more sensitive to cold and must therefore be stored at temperatures above 13 ºC to prevent the occurrence of injuries (Reid, 2001).

During the transport and storage of flowers, inappropriate temperatures are largely responsible for the loss of quality and the reduction in the vase life of cut flowers. During storage, refrigeration is essential to the maintenance of the final quality of the product. Long stems can reach more distant markets due to the extension of stem life and maintenance of commercial quality (Castro *et al.*, 2006).

CONCLUSIONS

The heliconiaceae *H. bihai* cultivar Caribea, *H. bihai* cultivar Iris red, and *H. rauliniana* cultivated in full sun in the Brazilian Midwest region presented agronomic characteristics according to the standards required for commercialization. The *H. bihai* cultivar Caribea stood out among the others for being the most productive.

Refrigerated storage at a temperature of 16 °C is the most recommended to prolong the post-harvest durability of the flower stems.

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REFERENCES

Albuquerque AW, Santos JM & Farias AP (2014) Produtividade e qualidade pós-colheita de Helicônia Golden Torch submetida a fontes e doses de silício. Revista Brasileira de Engenharia Agrícola e Ambiental, 18:173-179.

Brainer MSCP & Oliveira AAP (2006) Perfil da Floricultura no Nordeste brasileiro. In: XLIV Congresso da Sober, Fortaleza. Proceedings, AgEcon Search. p.01-22.

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

Castro CEF (1984) Tratamentos químicos pós-colheita e critérios de avaliação da qualidade de cravos (*Dianthus caryophyllus* L.) cv. Scania Red Sim. Master Dissertation. Escola Superior de Agricultura 'Luiz de Queiroz', Piracicaba. 139p.

Castro CEF (1993) Heliconias como flores de corte: adequação de espécies e tecnologia pós-colheita. Doctoral Thesis. Escola Superior de Agricultura 'Luiz de Queiroz', Piracicaba. 191p.

Castro CEF (1995) Helicônia para exportação: aspectos técnicos da produção. Brasília, Embrapa/SPI. 43p.

Castro CEF, Gonçalves C, Moreira SR & Faria OA (2011) Helicônias brasileiras: características, ocorrência e usos. Ornamental Horticulture, 17:05-24.

Castro CEF, May A & Gonçalves C (2006) Espécies de helicônia como flores de corte. Ornamental Horticulture, 12:87-96.

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

Coelho JPA, Gervásio ES, Sá TS, Cavalcante MZB & Souza SG (2019) Management of tillering in the production of flower stems of heliconia cultivated in pots. Comunicata Scientiae, 10:353-363.

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

Costa AS, Nogueira LC, Santos VF, Camara TR, Loges V & Willadino L (2011) Storage of cut *Heliconia bihai* (L.) cv. Lobster Claw flowers at low temperatures. Revista Brasileira de Engenharia Agrícola e Ambiental, 15:966-972.

Criley RA (1989) Development of Heliconia and Alpinia in Hawaii: cultivar selection and culture. Acta Horticulturae, 246:247-258.

Dias-Tagliacozzo GM, Zullo MA & Castro CEF (2003) Caracterização física e conservação pós-colheita de alpínia. Ornamental Horticulture, 9:17-23.

Ferreira DF (2011) Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia, 35:1039-1042.

Folha WR, Souza RR, Amaral GC, Silva AA, Carvalho JN & Cavalcante MZB (2016) Heliconia 'Golden Torch' postharvest: stem ends cutting and renewing vase water benefits. Ornamental Horticulture, 22:180-185.

Gonçalves C, Colombo CA & Castro CEF (2014) Genetic divergence of *Etlingera elatior* based on agro-morphological features for cut flowers. Ornamental Horticulture, 20:93-102.

Hermans C, Hammond JP, White PJ & Verbruggen N (2006) How do plants respond to nutrient shortage by biomass allocation?. Trends in Plant Science, 11:610-617.

Lamas AM (2004) Flores: produção, pós-colheita e mercado. Fortaleza, Instituto Frutal. 109p.

Lima JD & Ferraz MV (2008) Cuidados na colheita e na pós-colheita das flores tropicais. Revista Brasileira de Horticultura Ornamental, 14:29-34.

Loges V, Castro ACR, Guimarães WN, Costa AS & Teixeira M (2008) Caracterização de hastes de flores tropicais da emissão até a colheita. Ornamental Horticulture, 14:91-97.

Loges V, Teixeira MCF, Castro ACR & Costa AS (2005) Colheita e embalagem de flores tropicais em Pernambuco. Horticultura Brasileira, 23:699-702.

Martins JA, Dallacort R, Inoue MH, Santi A, Kolling EM & Coletti AJ (2010) Probabilidade de precipitação para a microregião de Tangará da Serra, Estado do Mato Grosso. Pesquisa Agropecuária Tropical, 40:291-296.

Maza BV (2004) Cultivo, cosecha y pos cosecha de heliconias y flores tropicales. Medellín, Ediciones Gráficas Ltda. 195p.

Munsell Color Chips (2012) Munsell Plant Tissue Color Book. Baltimore, Munsell. 17p.

Pizano M (2005) International Market Trends - Tropical flowers. Acta Horticulturae, 683:79-86.

Reid MS (2001) Advances in shipping and handling of ornamentals. Acta Horticulturae, 543:277-284.

Rocha FHA (2009) Caracterização agronômica, variabilidade, correlações e repetibilidade em cultivares de *Heliconia psittacorum* e híbridos interespecíficos. Master Dissertation. Universidade Federal de Pernambuco, Recife. 58p.

Santos HG, Jacomine PKT, Anjos LHC, Oliveira VA, Lumbreras JF, Coelho MR, Almeida JA, Araújo Filho JC, Oliveira JB & Cunha TJF (2018) Sistema Brasileiro de Classificação de Solos. 5ª ed. Brasília, Embrapa. 356p.

Sonego G & Brackmann A (1995) Conservação pós-colheita de flores. Ciência Rural, 25:475-479.

Zandonadi AS, Maia C, Barbosa JG, Finger FL & Grossi JA (2018) Influence of long days on the production of cut chrysanthemum cultivars. Horticultura Brasileira, 36:33-39.