Scientific Article

Heliconia cv. Golden Torch cultivated under different irrigation depths in protected environment [1]

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ABSTRACT

The genus *Heliconia* is commercially detached by the exotic appearance of the inflorescences but is susceptible to lack of moisture in the soil, being necessary the irrigation management. In this sense, the objective was to evaluate the effect of different irrigation levels on the plant growth and productive characters of *Heliconia psittacorum* cv. Golden Torch cultivated in vase. The experiment was conducted from March to October 2014, in a randomized blocks design. Five treatments corresponding to the different irrigation levels were used [50, 75, 100, 125 and 150% of the evaporation measured in Class A (ECA)] with four replicates and two plants per replicate. The following evaluations were carried out: number of days for the emergence of the first tiller, number of days for the emergence of the first inflorescence, number of days for the inflorescence harvest, crop cycle, diameter of the flower stem, length of the flower stem, inflorescence length, plant high, number of tillers and productivity of flower stems. Chlorophyll and leaf area measurements were performed. The irrigation levels tested significantly influenced the number of days for the first inflorescence harvest, length of the flower stem and inflorescence length. The irrigation level of 150% ECA provided better results for the length of the flower stem, inflorescence length and for leaf area but without differences from 75%, 100% and 125% ECA. Thus, for the cultivation of the heliconia cv. Golden Torch in pot can be recommended the level corresponding from 75% to 150% ECA.

Keywords: *Heliconia psittacorum*, water demand, productivity, tropical floriculture.

RESUMO

Helicônia cv. Golden Torch cultivada sob diferentes lâminas de irrigação em ambiente protegido

O gênero *Heliconia* se destaca comercialmente pela aparência exótica de suas inflorescências. São plantas sensíveis à falta de umidade no solo, sendo necessário manejo adequado da irrigação. Nesse sentido, objetivou-se avaliar o efeito de diferentes lâminas de irrigação sobre os caracteres fitotécnicos e produtivos de *Heliconia psittacorum* cultivar Golden Torch cultivadas em vaso. O experimento foi conduzido no período de março a outubro de 2014, em blocos casualizados. Foram utilizados cinco tratamentos correspondentes as diferentes lâminas de irrigação [50 (L50), 75 (L75), 100 (L100), 125 (L125) e 150% (L150) da evaporação de água do tanque Classe A (ECA)] com quatro repetições e duas plantas por repetição. Foram realizadas as seguintes avaliações: número de dias para emissão do primeiro perfilho, número de dias para emissão da primeira inflorescência, número de dias para a colheita da inflorescência, ciclo da planta, diâmetro da haste floral, comprimento da haste floral, comprimento da inflorescência, altura de planta, número de perfilhos e produtividade de hastes florais. Foram realizadas leituras de clorofila e medições de área foliar. As lâminas de irrigação testadas influenciaram significativamente o número de dias para colheita da primeira inflorescência, comprimento da haste floral e comprimento da inflorescência. A lâmina de irrigação de 150% da ECA proporcionou melhores resultados para o comprimento da haste floral, comprimento da inflorescência e para área foliar, mas sem diferir das lâminas de 75%, 100% e 125% da ECA. Assim, para o cultivo da helicônia cv. Golden Torch em vaso recomenda-se as lâminas correspondentes de 75% a 150% da ECA.

Palavras-chave: *Heliconia psittacorum*, demanda hídrica, produtividade, floricultura tropical

1. INTRODUCTION

Floriculture plays an important role for Brazilian agribusiness, presenting high yield per cultivated area, high value aggregated and short cycle, which allows a fast financial return (FELISBERTO et al., 2015). The group of ornamental plants that has highlighted out in the Northeast region are the tropical flowers due to the beauty, rusticity and high post-harvest durability (SOSA RODRÍGUEZ, 2013; SOUZA et al., 2016).

The genus *Heliconia* has Neotropical origin and is among the most important products of tropical floriculture

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due to its exotic appearance, being used as a cut flower and in landscaping (SHEELA, 2008). In this context, the cultivar Golden Torch (*Heliconia psittacorum* x *H. spathocircinata*) has shown both good acceptance in the consumer market and a growing increase in its demand (ALBUQUERQUE, 2014; JUNQUEIRA and PEETZ, 2014).

The edaphoclimatic conditions of Brazil, especially in North and Northeast regions, are favorable for heliconia cultivation with quality (JUNQUEIRA and PEETZ, 2014). The heliconia is a demanding crop in water and for its full development water supplementation is necessary, especially in regions that present deficits (GERVÁSIO et al., 2017). In this sense, knowing the crop evapotranspiration is fundamental for irrigation management.

The study of different irrigation levels is a very practical way to determine the water requirements of a species in a certain region (AZEVEDO and BEZERRA, 2008) and several studies have been carried out with horticultural crops due to lack of information (SOARES et al., 2016; FREITAS et al. al., 2017; OLIVEIRA et al., 2017).

However, information related to the management of heliconia irrigation are scarce and limited to field cultivation conditions. The recommendations often do not take into account the local water demand, affecting the development of the plant and its production. In this sense, the objective of this study was to evaluate the effect of different irrigation depths on the production of *Heliconia psittacorum* cv. Golden Torch grown in pot and in protected environment.

2. MATERIAL AND METHODS

The experiment was developed from March to October 2014, at the geographic coordinates 9º04'28'' S, 44º21'31'' W and 277 m altitude and classified as dry sub-humid climate (ANDRADE JÚNIOR et al., 2004).

The experimental was a randomized complete block design with five treatments corresponding to the different irrigation levels based on the evaporation measured in Class A (ECA): 50, 75, 100, 125 and 150% ECA, with four replicates and two plants per replicate.

The species used was *H. psittacorum* (L.) cv. Golden Torch grown in pots and in protected environment totally covered with polypropylene (50% shading), installed in the East-West direction. Eight plant lines, each with five pots (20 L capacity) spaced 0.9 m between pots and 2.0 m between rows, were placed inside the environment. Every two lines of pots there was a box of water with a capacity of 310 L, totaling four boxes. Each line had individual water registers to control the water levels corresponding to the treatments studied.

The plants were propagated by vegetative method, through the division of rhizomes which was 10 to 12.5 cm in length and with one to two buds per rhizome. Initially, the seedlings were cultivated in a protected environment (50% shading) in black polyethylene bags (volume 3.0 L) with substrate composed of washed fine sand and bovine manure (1:1, v v^{-1}) containing 0.1% N, 0.2% P, 0.16% K, 0.49% Ca, 0.09% Mg, 0.22% S, 17 mg kg^{-1} Cu, 1.90 mg kg^{-1} Fe, 73 mg kg^{-1} Mn and 60 mg kg^{-1} Zn.

Sixty days after the preparation and with 50 cm in high, the seedlings were transplanted to the pots with 20 L capacity. The substrate was the same used for the seedlings phase. The amount of phosphorus (45 g pot^{-1}) was applied totally in transplanting. The doses of N (120 g pot^{-1}) and K (120 g pot^{-1}) were divided into three equal applications, according to Beckmann-Cavalcante et al. (2015). Urea (45% of N), Simple Superphosphate (18% of P_2O^5) and Potassium Chloride (58% of K_2O) were used as the fertilization source.

During the experiment the climate conditions were recorded daily, using digital thermo-hygrometer (Quimis®) and digital luxmeter (Instrutherm®). The maximum and minimum temperature recorded were, respectively, 32.3 ºC and 27.2 ºC, the air moisture values varied between 34 and 68% and the luminous intensity between 3.42 and 6.09 μmol.m^2.s.

Before planting, the substrate was raised to field capacity and irrigated with 100% of the evaporation measured in Class A tank (ECA) for 10 days. After this period the application of the irrigation levels were started. The calculation of the applied water depth in each treatment was performed based on the reference evapotranspiration (ET_0) data obtained by reading the evaporated water depth from the Class A tank adjusted by the tank coefficient (K_t), according to the recommendations of Volpe and Churata-Masca (1988) (Eq. 1).

$$\mathrm{ETo} = \mathrm{E.Kt}\mathrm{ETo} = \mathrm{E.Kt} \quad (1)$$

Where: ET_0 – reference evapotranspiration (mm dia^1); E – evaporation of the Class A tank (mm dia^{-1}); K_t - cefficient of the tank.

The crop evapotranspiration (ET_c) was calculated by multiplying the ET_0 by crop coefficient (K_c) according to Doorenbos and Kassan (1994) (Eq. 2). The K_c values were differentiated according to the stages of development of the culture, as initial, vegetative and reproductive phases, using 0.41, 0.78 and 1.29, respectively (GOMES et al., 2006).

$$\mathrm{ETc} = \mathrm{ETo.Kc} \quad \mathrm{ETc} = \mathrm{ETo.Kc} \quad (2)$$

Where: ET_c – crop evapotranspiration (mm dia^{-1}); ET_0 – reference evapotranspiration (mm dia^{-1}) (mm dia^{-1}); K_c – crop coefficient.

Then, the gross irrigation water requirement of the crop was calculated (Eq. 3):

$$\mathrm{GIWR} = \frac{\mathrm{ETc}}{\mathrm{Ei}} \qquad \mathrm{GIWR} = \frac{\mathrm{ETc}}{\mathrm{Ei}} \quad (3)$$

Where: GIWR – gross irrigation water requirement (mm d^{-1}); ET_c – crop evapotranspiration (mm dia^{-1}); E_i - irrigation efficiency (90%).

The following evaluations were carried out: 1) Number of days for the emergence of the first tiller (NDET, days); 2) number of days for the emergence of the first inflorescence (NDEI, days) from the formation of the tiller; 3) number of days for the inflorescence harvest (NDIH, days) from the emission until when the inflorescence had two opened bracts and one terminal bract closed; 4) crop cycle (CC, days), defined as the number of days from the emergence of the till until the date of the inflorescence harvest (NDET + NDEI + NDHI); 5) diameter of the flower stem (DFS, mm) were measured 20 cm below the inflorescence; 6) inflorescence length (IL, cm) from the colored part of the peduncle (region of insertion of the bracts) to the apex of the inflorescence; 7) length of the flower stem (LFS, cm) from the base of the false stem to the apex of the inflorescence; and, 8) productivity of flower stems (PFS) registered as number of stems m^{-2}.

For evaluations realized in function of the time (at 30, 60, 90, 120, 150, 180 and 210 days after transplantation - DAT), there were observed: 1) plant high (PH, cm) measured from the upper level of the pot to the apex of plant; 2) number of tillers emitted (NT); 3) chlorophyll index of leaves (CIL) evaluated using an electronic chlorophyll meter (ClorofiLOG - Falker®), which uses the Falker chlorophyll index (fci) as the unit of measurement, following the recommendations of El-Hendawy and Schimidhalter (2005); 4) leaf area (LA, cm^{-2}) obtained from non-destructive measurements.

For the monthly evaluations the analysis of variance was performed in subdivided plots, with the irrigation levels in the plots (50, 75, 100, 125 and 150% ECA) and the evaluation dates in the subplots (30, 60, 90, 120, 150, 180 and 210 DAT). For the other evaluations, the data were submitted to analysis of variance, using the statistical program ASSISTAT, version 7.7 beta. The means were compared by the Tukey test at 5% probability (BANZATTO and KRONKA, 2006).

3. RESULTS AND DISCUSSION

From the analysis of variance (Table 1) it can be observed that the treatments corresponding to the irrigation levels influenced only the variables NDIH, LFS and IL. Although there were no significant differences between the treatments on NDET, NDEI, CC, DFS and PFS, the mean values obtained were 35.65 days for tiller emission; 43 days for inflorescence emission from the tiller formation; 53 days for crop cycle; 5.6 mm for stem diameter and 47.2 floral stems m^{-2}.

Table 1. Analysis of variance for the number of days for the emergence of the first tiller (NDET), number of days for the emergence of the first inflorescence (NDEI), number of days for the inflorescence harvest (NDIH), crop cycle (CC), diameter of the flower stem (DFS), length of the flower stem (LFS), inflorescence length (IL) and productivity of flower stems (PFS) of *H. psittacorum* cv. Golden Torch cultivated in pot under different irrigation levels of ECA.

Source of variation	NDET	NDEI	NDIH	CC	DFS	LFS	IL	PFS
	------------------- days --------------------				- mm -	--------- cm ---------		stems m^{-2}
Irrigation levels (% ECA)	0.98 ns	1.76 ns	3.32*	0.87 ns	2.30 ns	3.56*	3.74*	0.53 ns
50	24.00 a	53.00 a	8.75 b	61.75 a	4.40 a	31.07 b	12.05 b	45.77 a
75	36.50 a	47.00 a	13.25 ab	60.25 a	6.02 a	46.07 ab	16.15 ab	38.77 a
100	47.25 a	29.00 a	15.00 a	44.25 a	6.17 a	54.82 ab	16.85 ab	52.80 a
125	29.50 a	47.00 a	11.25 ab	58.00 a	5.17 a	46.17 ab	15.27 ab	52.82 a
150	41.00 a	39.00 a	13.25 ab	52.25 a	6.22 a	56.45 a	19.10 a	45.80 a
CV (%)	52.05	31.36	21.30	27.71	18.67	22.72	16.71	33.98

* = Significant at 5% probability (F value); ns = non-significant; C.V. = coefficient of variation. Means followed by the same letter in the column do not differ by Tukey test ($p < 0,05$)

The lowest value obtained for NDIH was with the use of 50% ECA (8.75 days), allowing to predict that the water deficit caused by the smallest irrigation level accelerated the harvesting point, a desirable effect to obtain flowers in a shorter time; but, on the other hand, causes losses in variables that may compromise the aesthetics of inflorescences. Some plants, when subjected to low water supply conditions, may develop mechanisms to minimize the effects of stress, including escape. In the escape, plants complete their phenological cycle more quickly, so that the condition of low water availability does not cause severe damage (VERSLUES et al., 2006). In the present study there was a reduction of approximately 41% in NDIH, comparing the result of 50% with 100% ECA (15 days), but for the productive cycle the treatments were statistically the same between all the irrigation levels, showing that despite the reduced NDIH the heliconia probably did not develop the mechanism of escape through the irrigation levels studied.

Results obtained by Souza et al. (2016) showed that the heliconia cv. Golden Torch, cultivated in an environment with 50% shading and in pots with daily irrigation to the point of reaching pot capacity, presented flowering at 87 days from tiller formation, higher than the means observed in the present study, with NDEI ranging from 29 to 53 days. While Beckmann-Cavalcante et al. (2015), for the same cultivar, in full sun and directly in the soil, obtained 123.8 days for NDEI and more 14.5 days for NDIH. The divergences in the results indicate that these variables are influenced by several factors, from the form of cultivation to the climatic conditions that are determinant in the flowering of the heliconia. According to Costa et al. (2009) to cv. Golden Torch has a short cycle, less than 150 days; however the averages obtained in the present study were lower ranging between 52.25 and 61.75 days.

The irrigation with a level of 150% ECA provided the best evaluation for LFS (56.45 cm) but without statically difference from 75, 100 and 125% ECA (Table 1). According to Costa et al. (2009) corresponded to medium stems, in the range between 50.1 and 150.0 cm. Albuquerque et al. (2010) studying the influence of organic fertilizers produced stems with a length varying between 83.3 and 107.7 cm. Beckmann-Cavalcante et al. (2015) when comparing different potassic fertilizations obtained 76.6 cm for the lowest stem length, values higher than the present study. The consumer market prefers stems larger than 70 cm (FARIAS et al., 2013), thus, even the best result obtained was below the minimum desirable. The diameter and length of flower stems in addition to the aesthetic value are related to the resistance of the flower to the strong winds when cultivated in the field, during transport and in the durability of the flowers at the post-harvest period (ALBUQUERQUE et al., 2010; FARIAS et al., 2013; ALBUQUERQUE et al., 2014).

The irrigation level which provided the best result for IL was 150% ECA, with a mean of 19.10 cm and similar to 75, 100 and 125% ECA (Table 1). This variable is important, since larger inflorescences are more attractive and vigorous, important characteristics from a commercial point of view. Costa et al. (2009) observed similar values of inflorescences lengths, up to 18.55 cm, classified as medium inflorescences, ranging between 10.1 and 30 cm.

For the variables evaluated in time (Table 2), it can be observed that for CIL and LA there was a significant effect isolated as a function of the irrigation levels and evaluation days, whereas NT was influenced only by the evaluation days. There was significant interaction between irrigation levels and days for plant high (PH).

Table 2. Analysis of variance for the plant high (PH), number of tillers (NT), chlorophyll index of leaves (CIL) and leaf area (LA) of *H. psittacorum* cv. Golden Torch cultivated in pot under different irrigation levels of ECA at 30, 60, 90, 120, 150, 180 and 210 days after transplantation (DAT)

Source of variation	PH	NT	CIL	LA
	-------- cm ---------	----	---- fci ---	---- cm^2 ---
Irrigation levels	2.43^{ns}	0.98^{ns}	5.67**	3.07**
DAT (F)	159.57**	198.91**	3.22**	49.05**
Irrigation levels x DAT	3.86**	1.30^{ns}	1.29^{ns}	1.48^{ns}

** and * = significant at 1% and 5% probability (F value), respectively; ns = non-significant.

When analyzing the CIL as a function of the irrigation levels it was verified that there was an increase in the index of chlorophyll in the leaves as the water depth was increased, but with no significant difference between 75, 100, 125 and 150% ECA (Table 3). A similar result occurs with LA, where the irrigation level of 150% ECA provided the higher value but without significant difference from 75, 100 and 125%. In relation to 50% ECA have an increase of 18.4% (Table 3). According to Bergamaschi et al. (2006), the water deficit interferes in the leaf area and can decrease the growth and accelerates the senescence process of the leaves.

Table 3. Chlorophyll index of leaves (CIL) and leaf area (LA) of *H. psittacorum* cv. Golden Torch cultivated in pot under different irrigation levels of ECA at 30, 60, 90, 120, 150, 180 and 210 days after transplantation (DAT)

Irrigation levels (% ECA)	CIL (fci)	LA (cm^2)
50	51.07 b	230.82 b
75	57.75 ab	247.21 ab
100	62.08 a	267.50 ab
125	60.84 a	265.34 ab
150	61.34 a	282.91 a
CV (%)	17.18	23.43
DAT		
30	60.57 ab	221.14 d
60	57.84 ab	223.55 d
90	56.70 ab	243.99 c
120	61.76 ab	271.78 b
150	54.87 b	292.36 a
180	63.78 a	283.40 ab
210	54.81 b	275.08 ab
CV (%)	14.84	7.16

C.V. = coefficient of variation. Averages followed by the same letter in the column do not differ by Tukey test ($p < 0,05$)

Regarding the evaluations in time it was observed for CIL the occurrence of oscillation during the evaluated period, with the highest values recorded at 180 DAT of evaluation. The variation may be associated to the fact that during the development, the plant presented a period of high demand with the emission of the tillers, causing the reduction. Soon after, an increased occurred, reducing again when the leaves began the senescence process (Table 3). In relation to LA, increased up to 150 DAT, and after this decreased until the last two evaluations, but without significant differences between 150, 180 and 210 DAT (Table 3). These results among other factors are possibly associated to the senescence of the plants causing natural reduction in the leaf area at the end of the evaluation period.

The NT (data not shown) emitted over time presented increases with significant difference until 150 DAT (6.3 tillers) which was statistically similar to 180 DAT (7.1 tillers) and 210 DAT (7.7 tillers). During this phase the clump occupied practically the whole area of the pot, which certainly contributed to the restriction of leaf expansion. Souza et al. (2016) studying cv. Golden Torch, after seven months of potting, observed the emission of 11.4 tillers. Assis et al. (2009) reported that a greater number of tillers can provide greater production of flowers per clump and, consequently, the increase of productivity per area. But the cultivation in pots restricts the growth and consequently can reduce the production.

The effect of the interaction between irrigation levels and DAT for PH (Table 4) showed that until 90 DAT there was no significant influence for the irrigation levels. However, from 120 to 210 DAT it was observed that the levels of 75%, 100%, 125% and 150% ECA were superior to the level of 50% ECA, promoting higher plants.

Tabela 4. Effect of interaction for plant high of *H. psittacorum* cv. Golden Torch cultivated in pot under different irrigation levels of ECA at 30, 60, 90, 120, 150, 180 and 210 days after transplantation (DAT).

Irrigation levels (% ECA)	**DAT**						
	30	60	90	120	150	180	210
50	60.50 aD	67.12 aCD	69.62 aABCD	68.37 bBCD	77.00 bABC	81.25 bAB	82.37 bA
75	54.12 aC	65.75 aC	66.50 aC	79.75 abB	92.70 abAB	95.50 abA	95.12 abA
100	55.25 aD	67.00 aCD	74.37 aC	87.75 abB	106.25 aA	110.87 aA	112.62 aA
125	53.50 aD	67.75 aC	71.62 aBC	84.37 abB	99.87 aA	101.87 abA	104.62 aA
150	56.87 aD	70.87 aC	78.12 aC	91.50 aB	104.50 aAB	105.37 aA	107.25 aA

Averages followed by the same lowercase letter in the column and uppercase in the line do not differ by Tukey test ($p < 0.05$)

Evaluating each irrigation level between the dates (Table 4), it was observed that, from 150 DAT up to 210 DAT, there was no difference between the dates for each depth. Probably up to 150 DAT there was no space restriction which allowed growth in height. From this time, due to the fact of the space restriction, both it prevented the emission of tillers and the growth in height. The mean height at the end of the seven months was 100.4 cm. These results are similar to those obtained by Souza et al. (2016) that obtained the average height of the plants of cv. Golden Torch also potted, around 94.2 cm at 210 DAT.

4. CONCLUSIONS

The results of the present study indicated that the irrigation level of 50% ECA is not recommended for the production of heliconia cv. Golden Torch. The irrigation levels from 75 to 150% ECA can be indicated for the production of heliconia cv. Golden Torch grown in pot and in protected environment.

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AUTHORS CONTRIBUTIONS

A.A.S.: Conduction of the experiment, data analysis and manuscript writing. **M.Z.B.C.**: Experimental planning, monitoring the activities and assistance in interpreting the results. **E.M.S.**: Supervision and assistance in the irrigation system. **B.E.P.**: Assistance in the statistical analysis. **J.T.L.**: Assistance in writing**. M.L.N.S.**: Assistance in writing.

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