The Pharma Innovation Journal 2022; 11(7): 2268-2273

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 2268-2273

www.thepharmajournal.com
Received: 01-05-2022
Accepted: 08-06-2022

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Physiological and Biochemical characteristics of *Heliconia* genotypes grown in shadenet condition

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Abstract
The present investigation was carried out at Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore District during 2021-22. The experiment was laid out in Completely Randomized Design, with 12 genotypes and three replications. As the physiological and biochemical characteristics play a vital role in the crop health status, the present study was carried out in different *Heliconia* genotypes. The treated *Heliconia* rhizomes were planted under shadenet (25% light intensity) and observed for physiological and biochemical characters. Among different genotypes studied, leaf area (380.49 cm^2), SPAD (SCMR) value for chlorophyll content (59.33), stomatal conductance (5.80 $molm^{-2}s^{-1}$), photosynthetic rate (21.53 µmol m^{-2} s^{-1}), transpiration rate (5.84 mmol $m^{-2}s^{-1}$), total sugar content (28.79 mg/100ml) and total phenol content (8.03mg/10ml) were recorded the highest in G_1 (*H. psittacorum* cv. Golden Torch). Maximum leaf temperature (40.13˚C) was observed in G_{11} (*H. psittacorum* cv. Red Devil), while the genotype G_3 (*H. psittacorum* cv. Tropics) recorded the maximum leaf intercellular CO_2 (571.90µmol m^{-2} s^{-1}).

Keywords: *Heliconia*, shadenet, genotypes, observation

1. Introduction
Heliconia which is a perennial flowering herb belongs to the family Heliconiaceae and order Zingiberales is diploid in nature with 2n=24 chromosomes though triploid cultivars 2n=3x=36 also exist. It is one of most attractive tropical flower and the genus *Heliconia* consists of about 89 species and more than 350 varieties. It is native to South and Central America, the Carribean Islands and some of the South Pacific Islands. It is popularly known as lobster claw, wild plantain or false bird of paradise and in Tropical America it is often called as wild bananas. Its flowers are attractive with beautiful multi-coloured bracts viz., red, orange, yellow, pink and green with combination of different size and shapes. The annual production of this crop in India accounts for less than one percent of the total production of the country where West Godavari District of Andhra Pradesh gives the fifty percent production. The popularity of *Heliconia* as a popular ornamental plant distributes among Kerala, parts of Tamil Nadu, Karnataka, Maharashtra, West Bengal, North-Eastern region states. It is well adapted to all major agro climatic zones of the country and its cultivation can be done up to the height of 3000-4000 feet above mean sea level. The tropical, humid and heavy rainfall region of South Gujarat and medium black soils are conducive for cultivation of *Heliconia.*
Heliconia has been categorized as 'Speciality flower' due to its exotic unusual inflorescence and has its uses as cut flowers and for landscaping purpose. It has been featured as an outstanding cut flower for florist because of long, straight peduncles, brilliant colours and excellent postharvest characteristics, tolerance to biotic and abiotic stresses and reasonable prices. Tropical flowers are a modest part of the global cut flower business, accounting for about 4% of all cut flowers traded (Laws, 1998) [11]. Roughly, 1% of all cut flowers shipped into the United States, one of the world's major markets, are tropicals (Echeverri *et al*., 1997) [6]. Due to its exotic form and vivid colours, Heliconias are regarded as best plant in landscaping and as a potential as cut flower in floral arrangements.
Heliconia has significant potential to become more competitive in the floriculture sector and as an exporter of flowers because of the longer flowering season, vibrant colours, larger blossom size, and superior quality (Loges *et al*., 2010) [13]. *Heliconia* leaves are used in flower decorations and as background material throughout the Caribbean and Mexico, as well as for thatching and food wrapping. In Brazil, several components of this plant, such as the roots and seeds, are utilised for medicinal purposes. *H. psittacorum, H. hirsuta, H. rostrata, H. caribea, H. latispatha*, and other *Heliconia* species are commercially valuable.

For the recommendations as individual varieties of this crop, research is required in various categories such as growth, climatic conditions, nutrient requirements, soil conditions, light conditions, and so on. This study was carried out as a basic study for evaluating and analysing the growth of *Heliconia* in shade house condition in the Coimbatore region. The findings of this study will be useful in growing *Heliconias* in this region and as a source of information about the crop's behaviour.

2. Materials and Methods

This study was carried out during the year 2021-2022 at the Department of Floriculture and Landscape Architechure, Tamil Nadu Agricultural University, Coimbatore district, India. This study was carried out with 12 genotypes of Heliconia, of which 9 genotypes were collected from Thrissur, Kerala and remaining 3 genotypes from Hosur and Yercaud of Tamil Nadu. The species of collections included *H. psittacorum* (cultivars such as Golden Torch, Lady Di, Golden Torch Andrian, Sherbert, Sassy Pink, Rubra Red, Kenea Red, Red devil, Petranova, Tropics, St.Vincent Red) and *H.densiflora* cv. Fire Flash. The experiment was laid out in Completely Randomized Block Design (CRD) with three replications in a shadenet (25%) house using growbags. The medium used for filling the grow bags were the mixture of soil (Red loamy), vermicompost and cocopeat perlite mixture (1:1), FYM in the ratio of 2:1:1. The bags were arranged with the spacing of 45×45 cm in the shadenet. The weight of suckers differed from 38-45 grams. Suckers were drenched with Bavistin 8g/l of water is done before planting. Light watering was done immediately after planting and it upto 50 days for initial establishment. NPK @ 4g plant^{-1} was given after the establishment of the suckers. Later NPK @ 6g plant^{-1} were given at monthly intervals before and after flower emergence. Foliar spray with micronutrients was also given for enhanced nutrient uptake by the medium. Irrigation to the plants were given at twice a week based on the requirement of the plants.

Leaf readings to determine chlorophyll content were taken with a Minolta chlorophyll meter (model SPAD 502) by averaging the 5-10 reading per plant. The photosynthetic rate (µmol m^{-2} s^{-1}), transpiration rate (mmol m^{-2}s^{-1}), stomatal conductance (mol m^{-2} s^{-1}), Leaf intercellular CO_2 (µmol m^{-2} s^{-1}), leaf temperature(˚C) was taken by Licor-6400 Leaf Gas Exchange instrument, viz., Infra-red gas analyzer (IRGA) during different growth stages. The leaf area was measured using Leaf area meter (Licor-3100). The biochemical analysis like total sugars estimation was done by following the anthrone reagent method (Yemm, E. W and Willis, A. 1954) [20] and the total phenol content estimation was done by following the method (Bray and Thorpe, 1954) [2]. The data recorded on various observations were analysed using Fisher's method of analysis of variance and the level of significance employed in F tests was (P = 0.05).

3. Results and Discussion

i) Leaf area (cm^2)

The data on leaf area was found to be significantly different among the different genotypes and presented in Table 1. Highest leaf area (380.49 cm^2) was recorded in G_1 (*H. psittacorum* cv. Golden Torch) which was on par with G_4 (*H. densiflora* cv. Fire Flash) (335.29 cm^2) and G_{11} (*H. psittacorum* cv. Red Devil) (323.38 cm^2) and the minimum leaf area was recorded in G_8 (*H. psittacorum* cv. Rubra Red) (206.78 cm^2). The increase in leaf area might be due to increased leaf length and petiole length and width of the individual leaves. The variation among the different genotypes may be due to the genetic makeup of the cultivars coupled with different climatic conditions. Optimum leaf area contributes to photosynthesis and dry matter production. This finding was supported by (Pragya *et al*., 2010) [16] in gladiolus cultivars. Optimum rate of photosynthesis will take care of the energy requirement by the plants which ultimately contributes to the proper growth of the plant and flower production. This finding was supported by Dilipkumar Naik *et al*. (2019) in Heliconia wherein maximum leaf area may lead to more dry matter accumulation, resulting in the accumulation of maximum photosynthates that contributed to produce bigger sized flower or more number of flowers.

ii) Leaf temperature (˚C)

The maximum leaf temperature was observed in G_{11} (*H. psittacorum* cv. Red Devil) (40.13˚C) which was on par with G_8 (*H. psittacorum* cv. Rubra Red) (40.06˚C) and G_9 (*H. psittacorum* cv. Petranova) (40.03˚C) and the minimum leaf temperature was observed in G_1 (*H. psittacorum* cv. Golden Torch) (37.40˚C) (Table 1). The maximum leaf temperature might be due to the leaf thickness in G_{11} (*H. psittacorum* cv. Red Devil) where thick leaves store more heat than thin leaves and consequently, have typically higher leaf temperatures (Lewis and Nobel, 1977). The leaf temperature not only affects the physiological and energy changes of the plants, which decides upon the health status of plants, but also reflects the water status of crops, which can guide crop irrigation and drought resistant genotype selection (Lu Yu *et al*., 2016). Water deficit by closing stomata, causes increased leaf temperature, which is considered as the major determinant of leaf temperature and rate of evaporation or transpiration from the leaf (Jones *et al*., 2009). Related findings for leaf temperature have been reported in chrysanthemum and dieffenbachia grown in glasshouse condition where at the time of peak irradiance with air conditioning and no shading, leaf temperature in chrysanthemum was about 1℃ above air temperature while in dieffenbachia 5℃ above air temperature. At shading condition, they observed the reduced leaf temperature in chrysanthemum by 3-4℃ and in dieffenbachia by 4-5℃. (Langton *et al*., 2000).

iii) Stomatal conductance (mol m^{-2} s^{-1})

Leaf stomatal conductance plays a key role in water and carbon flux by regulating gas exchanges between plants and atmosphere (Engineer *et al*., 2016). From the present investigation, it was found that the genotype G_1 (*H. psittacorum* cv. Golden Torch) (5.80mol m^{-2} s^{-1}) had the maximum stomatal conductance which was on par with G_8 (*H. psittacorum* cv. Rubra Red) (5.33mol m^{-2} s^{-1}), G_2 (*H. psittacorum* cv. Sassy pink) (4.33mol m^{-2} s^{-1}) and G_{11} (*H. psittacorum* cv. Red Devil) (4.13mol m^{-2} s^{-1}) and the minimum stomatal conductance was found in G_4 (*H. densiflora* cv. Fire Flash) (0.13mol m^{-2} s^{-1}). (Table 1). The increased stomatal conductance might be due to the higher gas exchange capacity that occurred in the

genotype G_1 as reported by Rho *et al*. (2012). Stomatal conductance control leaf water potential in a plant through balancing water supply from the roots with transpirational demand, as well as carbon gain (Korner 1994), since stomata control the diffusion of carbon dioxide (CO_2) which is used in the process of photosynthesis. Similar findings were reported in *Bougainvillea glabra* which grown under different conditions. They reported that during negative effect was observed by high shading (75%) on plant morphology. There occurred the reduction in stomatal conductance by increasing shading to maintain the physiological coherence. (Saiffudin *et al*., 2010).

iv) Leaf intercellular CO_2 (µmol m^{-2} s^{-1})

Among 12 genotypes studied, G_3 (*H. psittacorum* cv. Tropics) (571.90µmol m^{-2} s^{-1}) had the maximum leaf intercellular CO_2 which was on par with G_8 (*H. psittacorum* cv. Rubra Red) (559.67µmol m^{-2} s^{-1}), G_9 (*H. psittacorum* cv. Petranova) (528.41µmol m^{-2} s^{-1}) and G_{11} (*H. psittacorum* cv. Red Devil) (514.60µmol m^{-2} s^{-1}). The minimum leaf intercellular CO2 was found in the genotype G_1 (*H. psittacorum* cv. Golden Torch) (215.88µmol m^{-2} s^{-1}) and the data corresponding to this physiological character is presented in Table 1. The vital role of the highest leaf intercellular CO_2 concentration of leaves in enhancing the photosynthesis process was mentioned in earlier studies by Kokkanti Rekha Rani *et al*. (2019). The reason for the change in the leaf intercellular CO_2 in the *Heliconia* genotypes might be due to the microclimatic conditions that prevail in the shadenet (Dilipkumar Naik *et al*., 2019). Similar results were previously observed by Pires *et al*., (2014) who recorded higher values of leaf intercellular CO2 in *Passiflora* 'Aniha' (0.52 + 0.29 mmol (H_2O) m^{-2} s^{-1}), *Passiflora* 'Priscilla' (0.74 + 0.81 mmol (H_2O) m^{-2} s^{-1}) and in *Passiflora palmeri* var. *sublanceolata* (0.74 + 0.01 mmol (H_2O) m^{-2} s^{-1}) among 13 ornamental passion flowers.

v) Chlorophyll content (SCMR values)

Chlorophyll is a pigment necessary for plant photosynthesis and has a direct correlation with crop productivity. For purpose of assessing the plant health or identifying/ estimating plants tolerance to drought stress, analysis of chlorophyll content is essential (Darika *et al*. 2018). Among the different genotypes studied, the highest chlorophyll content was recorded in G_1 (*H. psittacorum* cv. Golden Torch) (59.33) which was on par with G_{11} (58.30), G_{10} (*H. psittacorum* cv. Kenea Red) (58.16) and G_9 (*H. psittacorum* cv. Petranova) (56.83) and the lowest value was noticed in G_2 (*H. psittacorum* cv. Sassy Pink) (37.10) (Table 2). Assessment of chlorophyll content using SPAD chlorophyll meter, could provide an indirect assessment of yield status (Gholizadeh *et al*. 2011). The difference in the value among the different genotypes might be due to the varied genetic makeup of the genotypes (Marenco *et al*. 2009). Chlorophyll content serve as an essential measure for assessing a plant's general health state, nitrogen and protein content, and potential for photosynthetic activity (Ling *et al*. 2011). Carbohydrates serve as energy source for growing buds, flower opening and longevity. Under low irradiance, chlorophyll content tends to increase in a shade-tolerant species (Beneragama and Goto 2011), whereas the contrary happens under light stress (Hebbar *et a*l. 2016). Ma *et al*. (2015) reported that improved growth of *Camptotheca acuminata* was attributed to increased photosynthesis and the healthy status of chloroplast and stomatal structures. The current finding is supported by Saleem *et al*. (2013) in gladiolus and Roni *et al*. (2014) in carnation, indicating varied chlorophyll content in different cultivars.

vi) Photosynthetic rate (µmol m-2 s-1)

The maximum photosynthetic rate was obtained in the genotype G_1 (*H. psittacorum* cv. Golden Torch) (21.53µmol m-2 s-1) which was on par with G_{11} (*H. psittacorum* cv. Red Devil) (20.12 µmol m-2 s-1) and G_{10} (*H. psittacorum* cv. Kenea Red) (18.25) and the minimum photosynthetic rate was noticed in the genotype G4 (*H. densiflora* cv. Fire Flash) (3.93 µmol m-2 s-1). These data were statistically analysed and presented in Table 2. The increased leaf area of *Heliconia* species in shadenet conditions show that plants extend their photosynthetic surface for efficient absorption of light radiation as reported by Dilipkumar Naik *et al*., (2019). The variation in photosynthetic rate among the genotypes of Heliconia might be due to the genetic makeup and differences in growth of the plants. The number of suckers determines the number of leaves in a plant and effectiveness of photosynthesis for greater growth and productivity. Photosynthetic processes in respect to shade conditions, they are very sensitive and plants change their photosynthetic characteristics to acclimate to various light environments. Yet another finding related to this study, where three species of Paeonia species were grown under shade conditions (30%) and the results of the study showed that the photosynthetic efficiency improved under shade conditions and varied among the species.

vii) Transpiration rate (mmol m-2s-1)

Transpiration rate plays an important role in maintaining water balance of the plant. Among the different genotypes studied, the transpiration rate was higher for the genotype G_9 (*H. psittacorum* cv. Petranova) (5.83 mmol m-2s-1) and G_2 (*H. psittacorum* cv. Sassy pink) (5.55mmol m-2s-1) and the lowest transpiration rate was obtained in G_1 (*H. psittacorum* cv. Golden Torch) (3.10mmol m-2s-1) and G_3 (*H. psittacorum* cv. Tropics) (3.19mmol m-2s-1). The data of transpiration rate for *Heliconia* genotypes were statistically analysed and represented in Table 2. The transpiration rate was found to be inversely proportional to the shade level as it is directly dependent on temperature, light intensity, relative humidity and transmittance. The present findings are supported by similar type of research in lily plants grown in shade conditions that the transpiration rate was lower in shaded condition than the sunlight condition (Sorrentino et al., 1997) [19]. Similar findings were reported in banana where the transpiration rate was reduced by 38% by shading along with other physiological characteristics (Eckstein *et al*., 2015) [7]. Likewise in Petunia hybrid, compared to high light intensity, low and moderate light intensity recorded the lowest transpiration rates.

viii) Total sugars (mg/100 ml)

Among the different genotypes studied, the maximum sugar content was observed in G_1 (*H. psittacorum* cv. Golden Torch) (28.79 mg/100ml) which was on par with G_{11} (*H. psittacorum* cv. Red Devil) (28.46 mg/100ml) and G_9 (*H. psittacorum* cv. Petranova) (26.10 mg/100ml). The minimum amount of sugar content was obtained in G_8 (*H. psittacorum* cv. Rubra Red) (19.86 mg/100 ml) (Fig 1). Plant growth and development are controlled by environmental conditions that influence the availability of photosynthetic carbon in the form of sucrose. Sugars provide energy required for the synthesis of new cell and for cell division and elongation, thus produce the positive effect on growth of plant. The higher carbohydrate content contributed to the proper development of the plants for their growth and development. If the adequate amount of the sugars were available to the crop to meet its nutrient demand, the vegetative and yield characters will improve accordingly. Heliconia genotypes with higher sugar content resulted in the healthy growth of the plant and the improved flower qualities than other genotypes grown in shadenet. Similar findings were reported by Nihad *et al*., 2019 [15] in Heliconia stricta, where the soluble sugar content decreased with increasing light intensities and increased in lower light intensities.

ix) Total phenols (mg/10 ml)

Phenolic content in plants contribute to the defense mechanism of resistance against diseases. Hence if the plant shows higher phenolic content, the defense mechanism will be more to both biotic and abiotic stresses. Among the different genotypes studied, the highest phenolic content was noticed in the genotype G_1 (*H. psittacorum* cv. Golden Torch) (8.03mg/10ml) which was on par with G_7 (*H. psittacorum* cv. Lady Di) (7.53mg/10ml) and G11 (*H. psittacorum* cv. Red Devil) (6.60mg/10ml). The lowest phenolic content was noticed in the genotype G_8 (*H. psittacorum* cv. Rubra Red) (4.10 mg/10ml) (Fig 2). The phenolic compounds are involved in plant responses to environmental stresses including wounding, pathogen attack, mineral deficiencies, and temperature stress. The direct involvement of phenols to plant stress regulation was reported in banana where the phenolic content and lignin content played an important role in the defence mechanism against Radopholus similis (Dhakshinamoorthy *et al*., 2014) [5]. Heliconia genotypes grown in partial shade condition accumulate more phenols than those grown in sunlight. This statement was supported in ornamental conifers where Taxus needles grown in shade had the more phenolic content than in sunny conditions (Brzezinska *et al*., 2008) [3].

4. Conclusion

From the present study, it may be concluded that, *Heliconia psittacorum* cv. Golden torch (G1) proved to be the best among the other *Heliconia* genotypes in terms of physiological and biochemical parameters which might contribute to the healthy growth of the plants and improvement in yield characters. Assessment of physiological and biochemical traits play an important role in the crop health status and it might contribute to the changes to be made in improving the crop production. Hence the genotype *Heliconia psittacorum* cv. Golden torch (G1) can be recommended for growing in Coimbatore condition for better crop production.

Table 1: Physiological traits for different genotypes of *Heliconia* under shadenet condition

Genotypes	Leaf area plant^{-1} (cm^2)	Leaf temperature ($^\circ$C)	Stomatal conductance (mol m^{-2} s^{-1})	Leaf intercellular CO_2 (µmol m^{-2} s^{-1})
G_1 -*H. psittacorum* cv. Golden Torch	380.49	37.40	5.80	215.88
G_2 - *H. psittacorum* cv. Sassy Pink	234.53	38.23	4.33	234.86
G_3 - *H. psittacorum* cv. Tropics	262.83	38.16	0.37	571.90
G_4 -*H. densiflora* cv. Fire Flash	335.29	39.63	0.13	360.20
G_5 - *H. psittacorum* cv. Golden Torch Andrian	261.59	37.53	0.45	373.71
G_6 - *H. psittacorum* cv. Sherbert	217.01	39.03	0.20	342.66
G_7 -*H. psittacorum* cv. Lady Di	212.95	40.03	5.53	425.06
G_8 - *H. psittacorum* cv. Rubra Red	206.78	40.06	4.31	559.67
G_9 - *H. psittacorum* cv. Petranova	242.26	39.83	0.53	528.41
G_{10} -*H. psittacorum cv.* Kenea Red	275.36	38.06	0.30	418.35
G_{11} - *H. psittacorum* cv. Red Devil	323.38	40.13	4.13	514.60
G_{12} – *H. psittacorum* cv. St. Vincent Red	230.45	39.55	2.20	405.21
SEd	21.11	0.31	0.13	30.06
CD (P = 0.05)	43.58	0.65	0.28	62.04

Table 2: Physiological and biochemical traits of different *Heliconia* genotypes under shadenet condition

Genotypes	Chlorophyll content (SCMR)	Photosynthetic rate (µmol m^{-2} s^{-1})	Transpiration rate (mmol m^{-2}s^{-1})
G_1 -*H. psittacorum* cv. Golden Torch	59.33	21.53	3.10
G_2 - *H. psittacorum* cv. Sassy Pink	37.10	5.52	5.55
G_3 -*H. psittacorum* cv. Tropics	49.14	10.12	3.19
G_4 -*H. densiflora* cv. Fire Flash	52.13	3.93	5.40
G_5 - *H. psittacorum* cv. Golden Torch Andrian	46.20	7.77	4.17
G_6 - *H. psittacorum* cv. Sherbert	38.83	13.93	5.05
G_7 - *H. psittacorum* cv. Lady Di	55.26	12.33	5.02
G_8 - *H. psittacorum* cv. Rubra Red	43.03	10.4	3.89

G_9 - *H. pittacorum* cv. Petranova	56.43	12.55	5.83
G_{10} -*H. psittacorum cv.* Kenea Red	58.16	18.25	5.16
G_{11} -*H. psittacorum*cv. Red Devil	58.30	20.12	3.98
G_{12} – *H. psittacorum* cv. St.Vincent Red	38.10	11.21	4.10
SEd	2.52	0.99	0.31
CD (P=0.05)	5.20	2.06	0.64

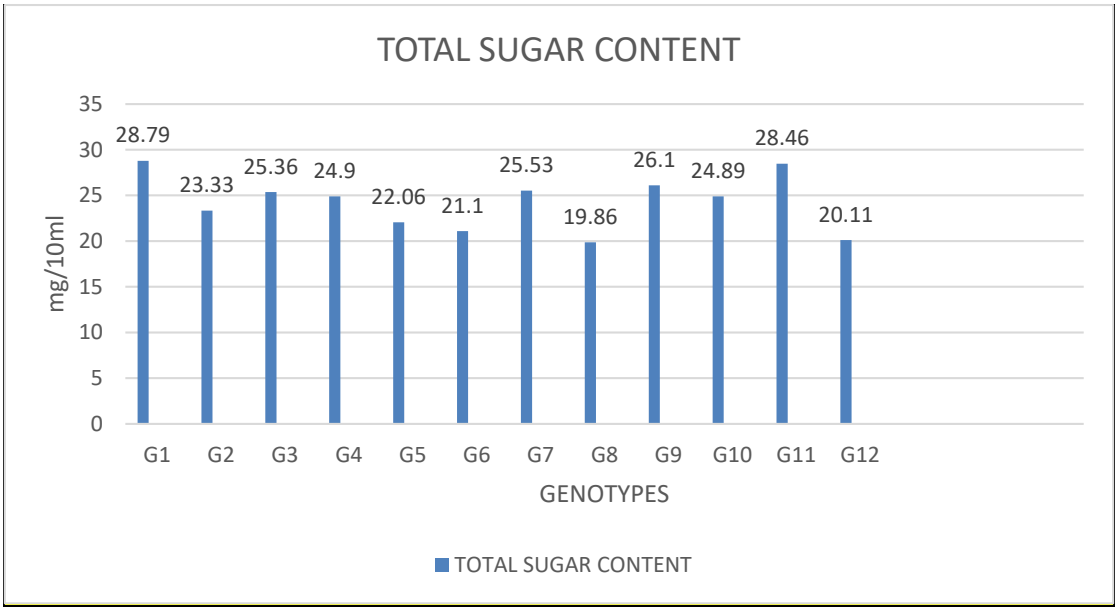

Fig 1: Total sugar content for different genotypes of *Heliconia* under shadenet condition

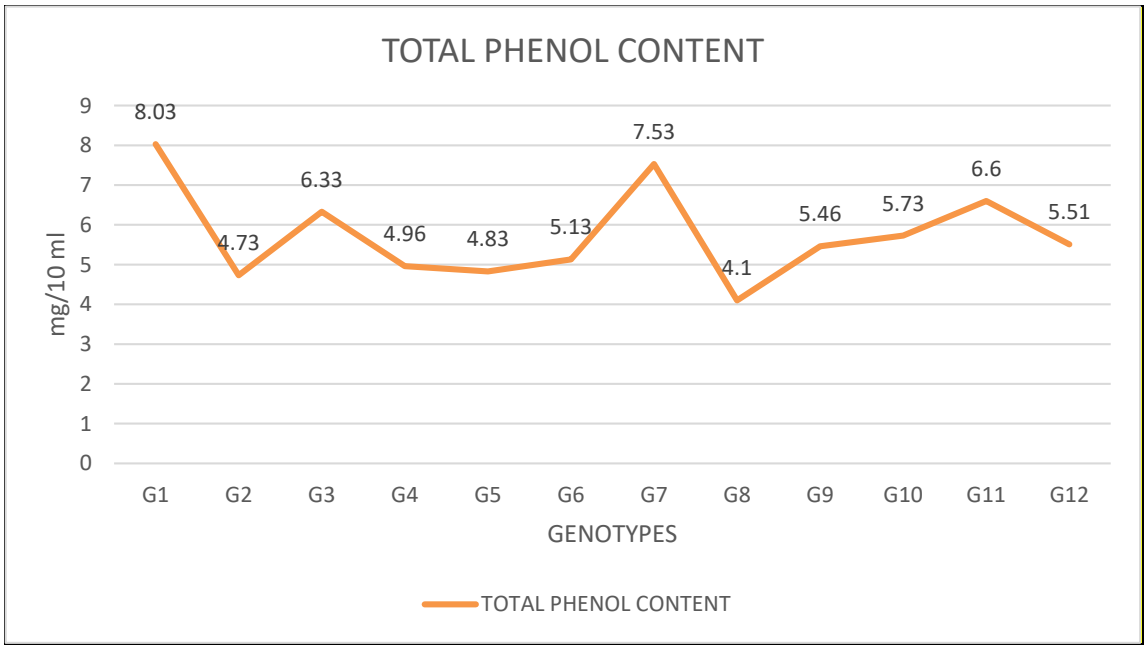

Fig 2: Total phenol content for different genotypes of *Heliconia* under shadenet condition

5. Acknowledgment
The authors thankfully acknowledge the Department of Plant Biochemistry and Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore, India for providing laboratory facilities and instruments for carrying out the research work.

6. References

1. Beneragama C, Goto K. Chlorophyll a: b ratio increases under low-light in 'shade-tolerant' Euglena gracilis. Trop Agric Res. 2011;22(1):12-25.
2. Bray HG, Thorpe W. Analysis of phenolic compounds of interest in metabolism. Methods of biochemical analysis, 1954, 27-52.
3. Brzezinska E, Kozlowska M. Effect of sunlight on phenolic compounds accumulation in coniferous plants. Dendrobiology. 2008;59:3-7.
4. Korner C. Leaf diffusive conductances in the major vegetation types of the globe. In: Schulze E-D, Caldwell MM (eds) Ecophysiology of photosynthesis. Ecological studies. Springer, Berlin Heidelberg New York. 1994;100:463-490.

5. Dhakshinamoorthy, Suganthagunthalam, et al. Phenols and lignin are involved in the defence response of banana (Musa) plants to Radopholussimilis infection. Nematology, 2014, 565-576.
6. Echeverri LG, Robbins J, González C. Informe General sobre el Mercado de Flores Tropicales en los EstadosUnidos. PROEXPORT Colombia, 1997, 62pp.
7. Eckstein K, Robinson JC, Fraser C. Physiological responses of banana (Musa AAA; Cavendish sub-group) in the subtropics. VII. Effects of windbreak shading on phenology, physiology and yield. Journal of Horticultural Science. 1997;72(3):389-396.
8. Engineer CB, Hashimoto-Sugimoto M, Negi J, Israelsson-Nordström M, Azoulay-Shemer T, Rappel WJ, et al. CO2 sensing and CO2 regulation of stomatal conductance: advances and open questions. Trends in Plant Science. 2016;21(1):16-30.
9. Hebbar KB, Subramanian P, Sheena TL, Shwetha K, Sugatha P, Arivalagan M, et al. Chlorophyll and nitrogen determination in coconut using a non-destructive method. J Plant Nutr. 2016;39:1610-1619.
10. Langton FA, Horridge JS, Hamer PJC. Effects of the glasshouse environment on leaf temperature of pot chrysanthemum and dieffenbachia. In International Conference and British-Israeli Workshop on Greenhouse Techniques towards the 3rd Millennium 2000;534:75-84.
11. Laws N. Tropical flowers from grower to market. Flora Culture International, 1998 May, 16-22.
12. Lewis DA, Nobel PS. Thermal energy exchange model and water loss of a barrel cactus, Ferocactusacanthodes. Plant Physiology. 1977;60(4):609-616.
13. Loges V, de Castro CEF, Guimarães WNR, Costa AS, de A Lima TL, Leite KP. Agronomic traits of Heliconia for cut flowers use and molecular markers. In XXVIII International Horticultural Congress on Science and Horticulture for People (IHC2010): International Symposium on 2010;937:535-543.
14. Naik MD, Naik MR, Kadiri L, Arunodhayam K, Reddy YS. Flowering, physiological and biochemical responses of Heliconia genotypes under shade house conditions. Current Agriculture Research Journal. 2019;7(3):368.
15. Nihad K, Berwal MK, Hebbar KB, Bhat R, Haris AA, Ramesh SV. Photochemical and biochemical responses of heliconia (Heliconiastricta 'Iris') to different light intensities in a humid coastal environment. Horticulture, Environment, and Biotechnology. 2019;60(6):799-808.
16. Pragya R, Bhat KV, Misra RL, Singh SK, Ranjan JK. Genetic relationships of gladiolus cultivars inferred from fluorescence based AFLP markers. Scientia Hort. 2010;123:562-567.
17. Rho H, Yu JD, Kim SJ, Lee JH. Limitation factors for photosynthesis in 'Bluecrop' highbush blueberry (Vacciniumcorymbosum) leaves in response to moderate water stress. Journal of Plant Biology. 2012;55:450-457.
18. Saifuddin M, Hossain AMBS, Normaniza O. Impacts of shading on flower formation and longevity, leaf chlorophyll and growth of Bougainvillea glabra. Asian Journal of Plant Sciences. 2010;9(1):20.
19. Sorrentino G, Cerio L, Alvino A. Effect of shading and air temperature on leaf photosynthesis, fluorescence and growth in lily plants. Scientiahorticulturae. 1997;69(3-4):259-273.
20. Yemm EW, Willis A. The estimation of carbohydrates in plant extracts by anthrone. Biochemical Journal. 1954;57(3):508.
21. Yu L, Wang W, Zhang X, Zheng W. A review on leaf temperature sensor: Measurement methods and application. In International conference on computer and computing technologies in agriculture. Springer, Cham. 2015, 216-230pp.