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RESEARCH PAPER

Influence of growing condition, spacing and nutrition on flower quality and post harvest life of *Heliconia* genotypes

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Abstract: *Heliconia,* a high value flower crop can assure sizable income to farmers with minimum investment and care. Suitable agro techniques help in obtaining maximum number of high quality flowers. Therefore, field trial was undertaken at the Department of Horticulture, University of Agricultural Sciences, Dharwad during 2021-22 to understand the influence of growing condition, spacing and nutrition to improve the flower quality and post harvest life of *Heliconia* genotypes. The experiment was laid out in strip plot design with three replications and sixteen treatment combinations comprised of two growing conditions as main plot (M_1:Coconut garden and M_2:Shade house) and combinations of genotypes, spacing and nutrition as eight sub plots [G_1:Orange (*H. latispatha*), G_2:Kenea Red (*H. psittacorum*), S_1:40 × 40 cm, S_2:40 × 60 cm, N_1:100% recommended dose of fertilizer (RDF) and N_2:75% RDF]. Result indicated significant difference with all flower quality parameters and post harvest life. Plants in shade house exhibited highest values for all the characters compared to plants in coconut garden. The interaction found significant for stem length (54.01 cm) which was higher under T13 ($M_2G_2S_1$N1). Treatment combination T_{11} ($M_2G_1S_2N_1$) recorded maximum stem girth (2.37 cm), spike length (19.87 cm) and spike width (21.67 cm). The same treatment combination (T11:M2G1S2N1) recorded maximum fresh weight of flowers (117.68 g), lowest physiological loss in weight (23.26%) and highest vase life of 16.60 days. and the same treatment combination can be suggested to get good quality flowers with extended vase life in *Heliconia*.

Key words: Flower quality, Genotypes, Growing condition, *Heliconia*, Nutrition, Spacing, Vase life

Introduction

India has better scope for floriculture in the future as there is a shift in trend towards tropical flowers and this can be gratefully exploited. Heliconias, birds of paradise and ornamental ginger also known as red ginger (*Alpinia purpurata*), are just a few examples of tropical floriculture species that account for a comparatively small segment of the European flower industry. In the recent decades, *Heliconia* introduced to the flower trade, recognizing itself as an ornamental variety of unusual elegance (Maria *et al*., 2014). *Heliconia* is a member of the Heliconiaceae family, consists of a single genus with about 89 species and more than 350 varieties (Malakar *et al*., 2015). They are indigenous to Central and South America, possessing chromosome number 2n (4x)=24. A herbaceous, perennial, tropical, rhizomatous plant, propagated by rhizome bits, suckers, or side shoots that emerge from the clumps and very rarely by seeds. But recently, heliconias are grown as an ornamental plant in gardens and regarded as an emerging exotic cut flower gaining popularity in all metropolitan cities of India. It is an outstanding flower for the floriculture industry as a cut flower due to its brilliant colours, distinctive inflorescence, long straight peduncles, and good post-harvest life. In India it is grown in the existing coconut gardens and in some places under protected conditions, particularly in shade houses as it requires partial shade. With little effort and expense, farmers can guarantee a significant return with this new, high-value flower crop.

Owing to its widespread use, it is vital to develop appropriate agro techniques to enhance production of high quality flowers by set of cultural and management techniques, such as a growing environment, adequate spacing, optimum fertilizer dosage, irrigation, plant protection. A proper nutrition dose and planting density will certainly help in determining the amount and period of fertilizer application for higher production and subsequent higher yield of quality flowers in *Heliconia*. There is adequate information available regarding the shade tolerance and reproductive habits of *H. latisphatha* (cv. Orange) and *H. psittacorum* (cv. Kenea Red). Therefore, it is crucial to assess how different shaded conditions affect inflorescence yield and quality in order to gather knowledge that can help with better light management in the production environment. Hence present investigation was carried out to understand the influence of growing condition, spacing and nutrition to improve the flower quality and post harvest life of *Heliconia* genotypes.

Material and methods

The experiment was conducted at Hi-tech Horticulture Unit under shade house and New Orchard, Spice unit, under existing coconut garden, Department of Horticulture, College of Agriculture, Dharwad at 15° 48' North latitude and 74° 98' East longitudes during 2021-22. The experiment includes different treatments like growing condition (M1: Coconut garden and M2:Shade house), genotype [G_1:Orange (*H. latispatha*) and G_2:Kenea Red (*H. psittacorum*)], spacing (S_1:40 × 40 cm and S_2:40 × 60 cm) and nutrition (N_1:100% RDF and N_2:75% RDF). The planting materials of promising *Heliconia* genotypes *viz*., Orange (*H. latispatha*) and Kenea Red (*H. psittacorum*) were collected from Hi-tech Horticulture Unit, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Recommended dose of fertilizers for *Heliconia* (40:20:20: N, P_2O_5 and K_2O g/m^2/year) were applied as per the package of practice of University of Horticultural Sciences, Bagalkot. The experiment was carried out in strip plot design with three replications and 16 treatment combinations, growing condition being considered as main plot and combination of genotype, spacing and nutrition is considered as sub plot treatments (C_1:$G_1S_1N_1$, C_2:$G_1S_1N_2$, C_3:$G_1S_2N_1$, C_4:$G_1S_2N_2$, C_5:$G_2S_1N_1$, C_6:$G_2S_1N_2$, C_7:$G_2S_2N_1$ and C_8:$G_2S_2N_2$). The statistical analysis of the data was done by standard methods of analysis of variance as given by Panse and Sukhatme (1985). Fifty per cent shading green colour net was placed above and all sides of the structure to manage the light intensity and temperature during hot weather as one of the growing conditions for *Heliconia* and plants were grown as an intercrop (Inter row space) under the existing 40 year old coconut garden established with Arasikeri Tall variety is considered as another growing condition. Raised beds were prepared for the experiment with the size of 1 m width, 30 cm height leaving 50 cm walking space in between the beds. Fresh rhizomes were planted during March, 2021 in paired row on raised bed with specified spacing both in coconut garden and shade house condition. 50 per cent of N along with 100 per cent of P_2O_5 and K_2O were applied as basal dose and remaining 50 per cent of N was applied after two months of planting. The data was recorded on different growth and yield parameters from five tagged plants and average was statistically analyzed.

Results and discussion

Flower quality attributes

Flower quality attributes (stem length, stem girth, spike length, spike width and number of bracts spike-1) differed significantly among different treatments and data presented in Table 1.

Table 1. Flower quality of *Heliconia* genotypes as influenced by growing condition, spacing and nutrition

Treatments	Stem length (cm)	Stem girth (cm)	Spike length (cm)	Spike width (cm)	Number of bracts spike^{-1}
Main plot (M) - Growing condition					
M_1: Coconut garden	43.54	1.84	14.90	17.22	3.73
M_2: Shade house	47.35	2.13	16.35	18.85	4.05
S. Em. ±	0.43	0.04	0.17	0.21	0.06
CD @ 5%	2.63	0.27	1.01	1.27	NS
Sub plot (C) - Genotypes, spacing and nutrition					
C_1: G_1 S_1 N_1	42.83	2.02	16.70	18.73	4.09
C_2: G_1 S_1 N_2	40.66	2.13	15.19	16.22	3.76
C_3: G_1 S_2 N_1	42.82	2.25	18.44	20.78	4.57
C_4: G_1 S_2 N_2	39.16	2.22	14.57	18.50	4.03
C_5: G_2 S_1 N_1	51.18	1.90	15.42	17.99	3.65
C_6: G_2 S_1 N_2	49.42	1.66	13.24	15.88	3.61
C_7: G_2 S_2 N_1	50.25	1.96	16.93	19.32	3.90
C_8: G_2 S_2 N_2	47.23	1.71	14.52	16.86	3.52
S. Em. ±	0.81	0.13	0.92	0.69	0.19
CD @ 5%	2.46	0.40	2.80	2.08	0.57
Interactions (M×C)					
T_1: $M_1G_1S_1N_1$	39.10	1.87	16.16	18.33	3.91
T_2: $M_1G_1S_1N_2$	39.82	1.97	13.82	15.93	3.58
T_3: $M_1G_1S_2N_1$	42.01	2.13	17.02	19.90	4.33
T_4: $M_1G_1S_2N_2$	37.86	2.10	15.43	18.30	3.73
T_5: $M_1G_2S_1N_1$	48.35	1.95	14.33	17.43	3.53
T_6: $M_1G_2S_1N_2$	47.82	1.38	12.22	14.35	3.78
T_7: $M_1G_2S_2N_1$	48.31	1.89	16.00	18.32	3.60
T_8: $M_1G_2S_2N_2$	45.05	1.40	14.23	15.18	3.35
T_9: M_2 $G_1S_1N_1$	46.55	2.17	17.23	19.13	4.27
T_{10}: $M_2G_1S_1N_2$	41.50	2.30	16.57	16.50	3.93
T_{11}: $M_2G_1S_2N_1$	43.64	2.37	19.87	21.67	4.80
T_{12}: $M_2G_1S_2N_2$	40.47	2.33	13.70	18.70	4.33
T_{13}: $M_2G_2S_1N_1$	54.01	1.85	16.50	18.54	3.77
T_{14}: $M_2G_2S_1N_2$	51.02	1.93	14.27	17.40	3.44
T_{15}: $M_2G_2S_2N_1$	52.19	2.03	17.87	20.33	4.20
T_{16}: $M_2G_2S_2N_2$	49.40	2.02	14.80	18.53	3.68
S. Em. ±	0.83	0.10	0.63	0.45	0.16
CD @ 5%	2.52	0.29	1.92	1.38	NS

Genotype (G)	Spacing (S)	Nutrition (N)
G_1: Orange (*H. latispatha*)	S_1: 40 × 40 cm	N_1:100% RDF
G_2: Kenea Red (*H. psittacorum*)	S_2: 40 × 60 cm	N_2:75% RDF

Heliconia under shade house recorded significantly greater stem length (47.35 cm) compared to plants in coconut garden (43.54 cm) (fig 1). Among subplot treatments, C_5:$G_2S_1N_1$ *i.e.* Kenea Red at 40 × 40 cm spacing with 100 per cent RDF recorded the lengthiest stem (51.18 cm), which was on par with C_7:$G_2S_2N_1$ and C_6:$G_2S_1N_2$ (50.25 cm and 49.42 cm, respectively). However, C_4:$G_1S_2N_2$ recorded minimum stem length (39.16 cm). The interaction data reveals that, maximum stem length (54.01 cm) was recorded in treatment T_{13}:$M_2G_2S_1N_1$ (Kenea Red under shade house at 40 × 40 cm with 100 per cent RDF) which was superior over other treatments. The next superior treatments were T15:M2G2S2N1 (52.19 cm) and T_{14}:$M_2G_2S_1N_2$ (51.02 cm). Flower of T_4:$M_1G_1S_2N_2$ had short stem length (37.86 cm).

Maximum stem girth was registered in plants under shade house (2.13 cm) compared to plants in coconut garden (1.84 cm). Stem girth of cut flower varied significantly among subplot treatments. It was maximum (2.25 cm) in Orange at 40 × 60 cm with 100 per cent RDF (C_3:$G_1S_2N_1$), which was on par with C_4:$G_1S_2N_2$ (2.22 cm) and two other treatments and minimum girth (1.66 cm) was witnessed by C_6:$G_2S_1N_2$. Among interactions, Orange planted at wider spacing under shade house with 100 per cent RDF (T_{11}:$M_2G_1S^2N_1$) recorded maximum stem girth (2.37 cm), which was on par with T_{12}:$M_2G_1S_2N_2$ (2.33 cm), T10:M2G1S1N2 (2.30 cm) and two other treatments. Whereas, minimum girth was recorded by T_6:$M_1G_2S_1N_2$ (1.38 cm) and T_8:$M_1G_2S_2N_2$ (1.40 cm).

Maximum spike length was noticed in plants grown under shade house condition (16.35 cm) over *Heliconia* in coconut garden (14.90 cm). Among subplot treatments, maximum spike length (18.44 cm) was recorded in Orange at 40 × 60 cm spacing with 100 per cent RDF (C_3:$G_1S_2N_1$), which was on par with C_7:$G_2S_2N_1$ (16.93 cm) and C_1:$G_1S_1N_1$ (16.70 cm). Spike length found minimum in C_6:$G_2S_1N_2$ (13.24 cm). Interaction data revealed that, maximum spike length (19.87 cm) was recorded in Orange at wider spacing under shade house with 100 per cent RDF (T_{11}:$M_2G_1S_2N_1$) followed by T_{15}:$M_2G_2S_2N_1$ (17.87 cm) and T_9:$M_2G_1S_1N_1$ (17.23 cm) whereas, minimum was observed in T_6:$M_1G_2S_1N_2$ (12.22 cm).

Between two growing conditions, plants grown under shade house had shown superior performance with respect to spike width (18.85 cm) compared to plants in coconut garden (17.22 cm). Subplot treatment C_3:$G_1S_2N_1$ (Orange at wider spacing with 100 per cent RDF produced significantly widest spike (20.78 cm), which was on par with C_7:$G_2S_2N_1$ (19.32 cm), while C_6:$G_2S_1N_2$ produced spike with least width (15.88 cm). Interaction of main and sub plot treatments had significant influence on spike width. The maximum spike width (21.67 cm) was registered by Orange planted at 40 × 60 cm spacing under shade house with 100 per cent RDF (T_{11}:$M_2G_1S_2N_1$) which was on par with T_{15}:$M_2G_2S_2N_1$ (20.33 cm) and followed by T_3:$M_1G_1S_2N_1$ (19.90 cm). Whereas, minimum spike width was observed in T_6:$M_1G_2S_1N_2$ (14.35 cm).

The data presented in Table 1 revealed that, there was no significant difference with respect to number of bracts per spike among two growing conditions. Significantly maximum number of bracts per spike was recorded C_3:$G_1S_2N_1$ (4.57), which was on par with C_1:$G_1S_1N_1$ (4.09) and C_4:$G_1S_2N_2$ (4.03). Lesser number of bracts per spike was found in the treatment C_8:$G_2S_2N_2$ (3.52). However, no significant difference was observed for number of bracts per spike in response to interaction effects.

Basically, heliconias in their natural habitat perform well under partial shade compared to full sunlight. This might be due to exploitation of genetic potential with low light intensity and high relative humidity under shade net situation (Babu *et al*., 2019). The flower quality attributes of *Heliconia viz*., stem length, stem girth, spike length, spike width and number of bracts per spike are most desirable to claim it as an ideal cut flower with strong and sturdy stem. Increased vegetative growth under shade house resulted in higher bio-mass production and partitioning of photosynthates hence increased stem length and girth and finally length and width of spike. Sudhakar and Kumar (2012), Albuquerque *et al*. (2014) and De-Souza *et al*. (2016) also concluded that, the environments with shading favored the occurrence of inflorescences with the greatest length and girth. The increase in stem length is evident from the enhanced plant height at closer spacing. The positive effect of wider spacing and higher nutrition dose on stem girth, length and width of spike might be due to less competition for nutrients and availability of more photosynthates which ultimately support better development of the sink (flowers). Further the variation in flower quality attributes might be due to hereditary factor of genotypes as it is an important criterion for grading of *Heliconia* spikes and genotype description. These findings also find support from reports of Chourasia *et al*. (2015), Aklade *et al*. (2016) and Dalvi *et al*. (2022).

Post harvest life of flower

The data on post harvest life of flowers (fresh weight of flowers, physiological loss in weight, water uptake and vase life) of different treatments differed significantly and presented in Table 2 (Fig. 1).

Heliconia flowers obtained from shade house recorded maximum fresh weight (83.76 g) over flowers from coconut garden (63.34 g). Significantly maximum fresh weight of flowers (106.25 g) was registered in Orange planted at wider spacing with 100 per cent RDF (C_3:$G_1S_2N_1$) followed by C_1:$G_1S_1N_1$ (94.10 g), C_4:$G_1S_2N_2$ (74.10 g) and C_2:$G_1S_1N_2$ (73.75 g). Whereas, minimum fresh weight found in C_8:$G_2S_2N_2$ (51.13 g). Among the interaction effects, maximum fresh weight of flowers (117.68 g) was registered in T_{11}:$M_2G_1S_2N_1$ (Orange planted at 40 × 60 cm spacing under shade house condition with 100 per cent of RDF) followed by T_9:$M_2G_1S_1N_1$ (110.97 g), T_3:$M_1G_1S_2N_1$ (94.82 g) and T_{10}:$M_2G_1S_1N_2$ (93.20 g). On contrast, the lesser weight was recorded in T_6:$M_1G_2S_1N_2$ (45.20 g).

Flowers obtained from shade house recorded maximum physiological loss in weight (29.93%) compared to *Heliconia* as intercropping in coconut garden (24.94%). Kenea Red planted at wider spacing with 75 per cent RDF (C_8:$G_2S_2N_2$) recorded maximum physiological loss in weight of flowers (32.25%), which was on par with C_2:$G_1S_1N_2$ (29.92%) and C_5:$G_2S_1N_1$ (29.43%). While the lowest physiological loss in weight of flowers was registered in C_3:G_1S2N^1 (23.43%).

Table 2. Post harvest life of *Heliconia* genotypes as influenced by growing condition, spacing and nutrition

Treatments	Fresh weight of flowers (g)	Physiological loss in weight (%)	Water uptake (ml)	Vase life (Days)
Main plot (M) - Growing condition				
M_1: Coconut garden	63.34	29.93	40.16	11.34
M_2: Shade house	83.76	24.94	49.30	14.91
S. Em. ±	0.88	0.42	0.65	0.15
CD @ 5%	5.34	2.57	3.94	0.91
Sub plot (C) - Genotypes, spacing and nutrition				
C_1: G_1 S_1 N_1	94.10	27.54	42.91	13.32
C_2: G_1 S_1 N_2	73.75	29.92	36.94	12.62
C_3: G_1 S_2 N_1	106.25	23.43	55.70	14.45
C_4: G_1 S_2 N_2	74.10	27.56	45.26	13.48
C_5: G_2 S_1 N_1	63.47	29.43	48.80	12.45
C_6: G_2 S_1 N_2	52.72	24.46	37.65	12.05
C_7: G_2 S_2 N_1	72.88	24.89	54.53	13.67
C_8: G_2 S_2 N_2	51.13	32.25	36.03	12.97
S. Em. ±	2.16	0.94	1.49	0.28
CD @ 5%	6.56	2.84	4.52	0.84
Interactions (M×C)				
T_1: $M_1G_1S_1N_1$	77.23	31.42	35.42	10.83
T_2: $M_1G_1S_1N_2$	54.30	33.69	35.30	10.67
T_3: $M_1G_1S_2N_1$	94.82	23.60	54.67	12.30
T_4: $M_1G_1S_2N_2$	63.10	29.00	40.13	12.23
T_5: $M_1G_2S_1N_1$	55.03	33.16	43.37	10.73
T_6: $M_1G_2S_1N_2$	45.20	24.78	30.50	10.63
T_7: $M_1G_2S_2N_1$	68.92	23.60	48.42	12.33
T_8: $M_1G_2S_2N_2$	48.11	40.15	33.47	11.00
T_9: $M_2G_1S_1N_1$	110.97	23.65	50.39	15.80
T_{10}: $M_2G_1S_1N_2$	93.20	26.14	38.58	14.57
T_{11}: $M_2G_1S_2N_1$	117.68	23.26	56.73	16.60
T_{12}: $M_2G_1S_2N_2$	85.10	26.12	50.39	14.73
T_{13}: $M_2G_2S_1N_1$	71.92	25.69	54.23	14.17
T_{14}: $M_2G_2S_1N_2$	60.23	24.14	44.80	13.47
T_{15}: $M_2G_2S_2N_1$	76.85	26.18	60.63	15.00
T_{16}: $M_2G_2S_2N_2$	54.14	24.36	38.60	14.93
S. Em. ±	2.50	1.38	1.47	0.37
CD @ 5%	7.59	4.18	4.45	1.11
Genotype (G)	Spacing (S)		Nutrition (N)	
G_1: Orange (*H. latispatha*)	S_1: 40 × 40 cm		N_1:100% RDF	
G_2: Kenea Red (*H. psittacorum*)	S_2: 40 × 60 cm		N_2:75% RDF	

Interactions of main and subplot treatments had significant variation with respect to physiological loss in weight of flowers and Kenea Red planted at wider spacing in coconut garden with application of 75 per cent RDF (T_8:$M_1G_2S_2N_2$) had highest physiological loss in weight (40.15%). Whereas, the lowest physiological loss in weight was recorded in T_{11}:$M_2G_1S_2N_1$ (23.26%).

Significantly more uptake of water was recorded in the flower stems harvested from shade house condition (49.30 ml) compared to intercropping in coconut (40.16 ml). Significant variation observed among sub plot treatments with respect to water uptake of cut flowers and maximum value was registered by C_3:$G_1S^2N_1$ (55.70 ml) which was on par with C_7:$G_2S_2N_1$ (54.53 ml). Sub plot treatments C_8:$G_2S_2N_2$ and C_2:$G_1S_1N^2$ recorded minimum water uptake (36.03 and 36.94 ml, respectively). Among interactions maximum water uptake of 60.63 ml was noticed in Kenea Red planted at 40 × 60 cm spacing under shade house condition with 100 per cent RDF (T_{15}:$M_2G_2S_2N_1$) which was on par with T_{11}:$M_2G_1S_2N_1$ (56.73 ml). Whereas, the minimum water uptake was registered in treatment T_6:$M_1G_2S_1N_2$ (30.50 ml).

Vase life of cut flower is an important quality parameter for consideration in identifying plant species suitable for use in the floriculture industry. *Heliconia* cut flowers differed significantly for this trait.

The maximum vase life of 14.91 days noticed in flowers obtained from shade house condition compared to intercropping in coconut (11.34 days). In response to sub plot treatments, Orange planted at 40 × 60 cm spacing with 100 per cent of RDF (C_3:G_1S_2N1) recorded vase life of 14.45 days, which was statistically on par with C_7:$G_2S_2N_1$ (13.67 days). Whereas, C_6:$G_2S_1N_2$ recorded minimum shelf life of 12.05 days. Among interaction effects, Orange planted at 40 × 60 cm spacing under shade house condition with 100 per cent RDF (T_{11}:$M_2G_1S_2N_1$)

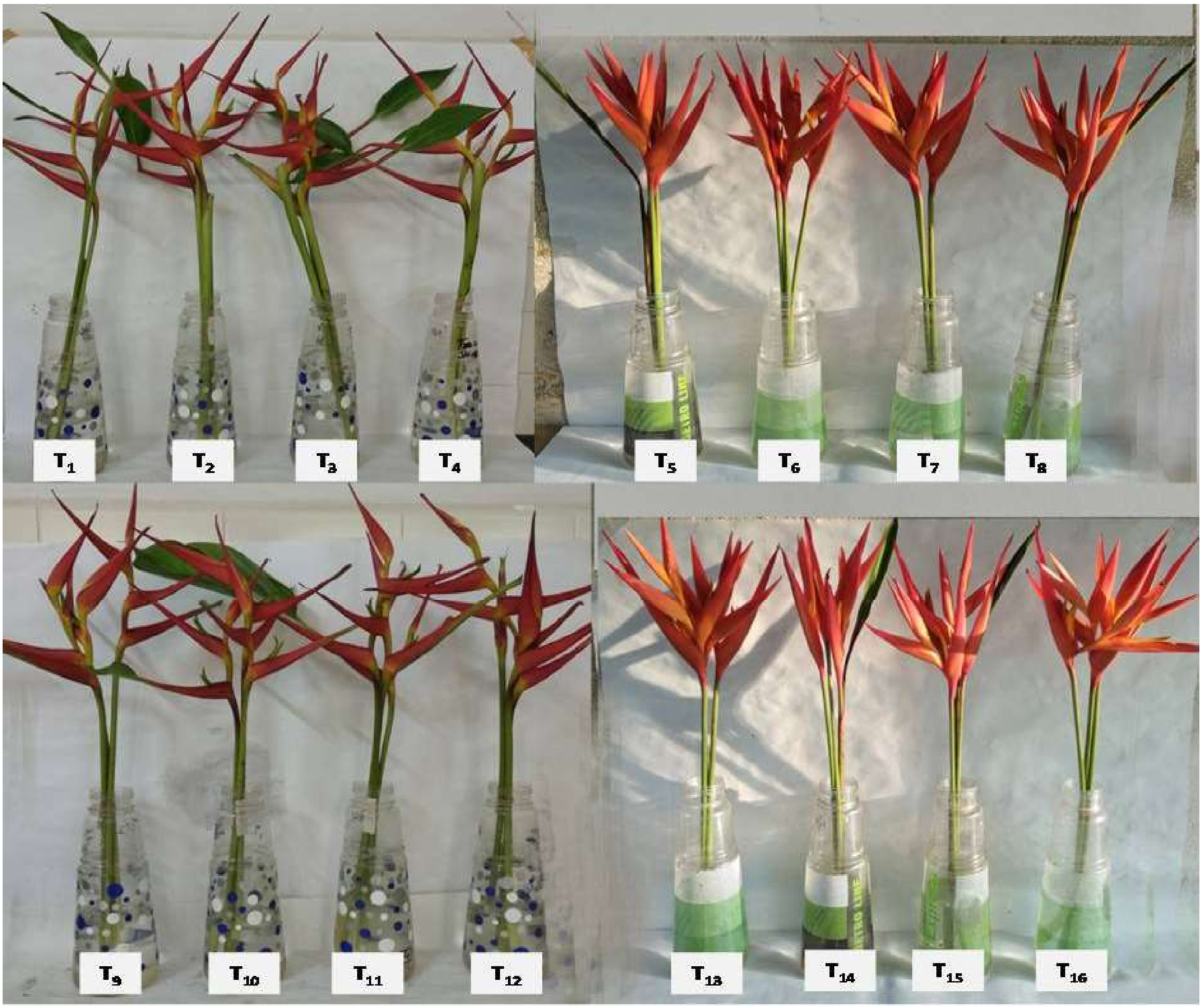

Fig.1 Vase life studies in *Heliconia* genotypes as influenced by growing condition, spacing and nutrition

recorded significantly maximum vase life (16.60 days), which was statistically on par with T_9:$M_2G_1S_1N_1$ (15.80 days) and followed by T_{15}:$M_2G_2S_2N_1$ and T_{16}:$M_2G_2S_2N_2$ (15.00 and 14.93 days respectively). On contrary, the minimum vase life of 10.63 days was noticed in T_6:$M_1G_2S_1N_2$.

The quantity and quality of *Heliconia* flowers greatly influenced by spacing, nutrient supply and light intensity among the species. Hence flowers from wider spaced plants exhibited maximum fresh weight due to efficient utilization of diffused light, humidity and air temperature under shaded environment and higher dose of nutrients make it possible to achieve superior vegetative growth and accumulation of maximum carbon reserve in flowering stems. Fresh weight retention depends on maintenance of carbohydrate level and water uptake. Increase in fresh weight of stems in wider spacing nourished with higher dose of nutrient might be due to enhanced food reserve by efficient utilization of light, water and nutrients. This carbon reserve found in the stem of cut flowers is utilized to extend their longevity and larger the length and girth of the stem, the longer their postharvest life. Earlier studies by Sudhakar and Kumar (2012), Nihad *et al*. (2013), Naik (2015), Aklade *et al*. (2016), De-Souza *et al*. (2016) and Dalvi *et al*. (2022) concluded that different agronomic practices like spacing, nutrients and growing condition have effect on post harvest life of cut flower.

Conclusion

From the present study it can be concluded that shade house as growing condition, 40 × 60 cm spacing and 100 per cent recommended dose of fertilizer is optimum for obtaining good quality flower with enhanced vase life in both *Heliconia* genotypes.

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