International Journal of Bio-resource and Stress Management
https://pphouse.org/ijbsm.php

IJBSM February 2023, 14(2):306-315 Print ISSN 0976-3988 Online ISSN 0976-4038
Article AR3280a

Research Article
Natural Resource Management
DOI: HTTPS://DOI.ORG/10.23910/1.2023.3280a

Evaluation of Ornamental Flowering Plants for Vertical Gardening During Summer Season

Priyanka S. Adate[1], Rajkumar V.[5], Gopalakrishnan B.[2], Labdhi Dedhia[3] and P. B. Pachankar[1]

[1]Dept. of Floriculture and Land Scaping,College of Horticulture, Mahatma Phule Krishi Vidyapeeth, Pune, Maharashtra (411 005), India
[2]School of Atmospheric Stress Management, ICAR-National Institute of Abiotic Stress Management, Baramati, Pune, Maharashtra (413 115), India
[3]Dept. ofFloriculture and Land Scaping, ICAR-Indian Institute of Horticultural Research Institute, Hessaraghatta, Bengaluru, Karnataka (560 089), India

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Corresponding priyaadt123@gmail.com

0009-0006-5317-5404

ABSTRACT

A study was carried out to evaluate the suitability of ornamental flowering plants for vertical gardening during 2019–2020 (10 months) the College of Horticulture, Pune, Maharashtra, India. Twenty (20) species of ornamental flowering plants, representing a wide spectrum of morphological variability were selected for the current investigation. The experiment was conducted in a Completely Randomized Design (CRD) with 20 treatments and 2 replications. Quantitative characters like plant height (cm), stem diameter(mm), plant area coverage (cm^2), number of leaves, number of branches, days required for flower initiation, number of flowers, size of flowers, duration of flowering, crop duration, flower colour, growth habit, leaf type, leaf shape and consumer acceptance were considered for the current study. The result showed that all 20 plant species performed well but the ornamental flowering spp viz., *Begonia* spp., *Dianthus caryophyllus*, *Torenia fournieri*, *Gomphrena globose* and *Catharanthus roseus* were found to be best suited for vertical gardening during the summer season based on their overall performance.

KEYWORDS: Ornamental, urbanization, vertical gardening, summer season

***Citation* (VANCOUVER):** Adate et al., Evaluation of Ornamental Flowering Plants for Vertical Gardening During Summer Season. *International Journal of Bio-resource and Stress Management,* 2023; 14(2), 306-315. HTTPS://DOI.ORG/10.23910/1.2023.3280a.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 04th October 2022 RECEIVED in revised form on 20th January 2023 ACCEPTED in final form on 08th February 2023 PUBLISHED on 23rd February 2023

1. INTRODUCTION

Vertical gardens are defined as gardens that cover the facade walls using various plants species (Rahman et al., 2019). They are also called green space walls, wall gardens, green wall technologies, green scaffolding, bio walls, green façades, vertical or living walls, biofacade walls, etc., across various regions around the globe (Bakar et al., 2013, Amir et al., 2014, Rahman et al., 2014, Jim, 2015, Basher et al., 2016). Globally, more people live in urban areas than in rural areas, with 54% of the world's population residing in urban areas (Zaid et al., 2018) its benefits, its carbon sequestration potential and its calculation methodologies, and its potential for urban heat island (UHI. Urban growth, including human population and buildings, is predicted to increase exponentially in the coming years (Peschardt and Stigsdotter, 2013, Price et al., 2015). Urban areas will face several new and ongoing challenges related to health, environment, economy, food, education, etc (Skelhorn et al., 2014) one strategy that has been suggested to address both adaptation and mitigation for urban areas is the increased use of greenspace. A number of studies have analysed this strategy through the use of empirical, analytical methods, or numerical methods. These tend to focus on city or regional scale changes in land use with only a broad categorisation of greenspace type. This study tests seven greenspace scenarios that might be applied at a block or neighbourhood level and the resulting microclimate changes that can be achieved through such applications for a temperate city in northwest England. Using a suburban commercial site in Manchester, UK as the case study area, the research utilises the urban microclimate model ENVI-met to compare the changes in air and surface temperatures on a warm summer day in July 2010 (approximately 4°C above the rural reference July average maximum temperature. Thus, with rapid urbanization, a need arises to allow nature to manifest in urban buildings. This rapid urbanization is hence, creating a huge potential in green space and a more quality green landscape. Urban landscaping is gaining popularity nowadays as people are becoming more conscious about a green and clean environment and are increasingly used to improve green cover in urban environment (Akbari et al., 2001, Strohbach et al., 2012, Yang et al., 2008). Urban green spaces improve the surroundings and enhance the wellbeing of urban population by positively improving the ambient conditions and noise levels thereby enhancing human health (Ghazalli et al., 2019). Apart from this, they can contribute to urban biodiversity (Lundholm, 2006, Francis and Lorimer, 2011), storm water management (Schmidt, 2003), air quality (Bruseet al., 1999, Pugh et al., 2012), temperature reduction (Santamouris, 2014) and reducing heat island effect (Alexandri and Jones, 2008, Gago et al., 2013).

The application of vertical gardening also has social and economic benefits along with environmental benefits. These systems have a therapeutic effect by promoting the mental wellbeing through exposure to vegetation, beautification of cities (Theodoridou et al., 2012), increasing the value of properties (Ichihara and Cohen, 2011) and providing heat (Sadineni et al., 2011) and noise protection (Wong et al., 2010, Renterghem et al., 2013). The demand for vertical gardens is already higher in cities but the cost and sustainability of plant species restrict the growth of vertical garden industry. The low survival and success rates of plants in green walls are due to extreme conditions such as high radiation, temperature, wind and pollution prevailing in the cities. Many enthusiastic people have started constructing vertical gardens but failed due to the lack of information on structures, suitable plant species, water and nutrient management, medium, diseases and pest management, etc. Safety concerns of supporting structures, green building ratings, innovative materials and development of various types of green modules units, community expectancy and ways and means of localizing vertical greening, reuse of construction fences, water supply and drainage system, recurring maintenance, etc., are some of the important issues that have to be addressed before proceeding with vertical gardening (Peng et al., 2015). An interdisciplinary approach involving civil and material science engineering, law discipline, architecture and urban designs is required to reduce the risks and negatives associated with vertical gardening. Since this is an upcoming area and there is very meagre research work has been carried out on this aspect with regard to India, the present investigation was carried out to find suitable ornamental flowering plants for vertical gardening during the summer season.

2. MATERIALS AND METHODS

The present study was conducted during 2019–2020 at the College of Horticulture, Pune, Maharashtra, India which is situatedat18.32°N latitude and 73.51°E longitude at an altitude of 555.74 MSL. The total annual rainfall is 1071.7 mm and the temperature ranges between 20.8°C and 37.6°C. 20 species of ornamental flowering plants, representing a wide spectrum of morphological variability were selected for the study (Table 1). An iron stand of 6×6 ft. was prepared and on each stand polypropylene vertical panel frames were fixed. One polypropylene vertical panel frame contains three cups with a pot locking system and on each stand, 11 columns and 3 rows of polypropylene vertical panel frames can be accommodated. One stand accommodates 4 treatments separated by planting border plants with 20 plant units per treatment. The experiment was conducted in a completely randomized design with 20 treatments and 2 replications.

Table 1: Ornamental flowering plants used for the study

Sl. No.	Common Name	Scientific Name	Family	Season
T_1	Snapdragon	*Antirrhinum majus*	Plantaginaceae	Perennial but grown as Annual
T_2	China Aster	*Callistephus chinensis*	Asteraceae	Annual /Biennial
T_3	Rex Begonia	*Begonia* spp.	Begoniaceae	Perennial
T_4	Pot Marigold	*Calendula officinalis*	Asteraceae	Perennial but grown as Annual
T_5	Cockscomb	*Celosia cristata*	Amaranthaceae	Annual
T_6	Garden Cosmos	*Cosmos bipinnatus*	Asteraceae	Annual
T_7	Fire Cracker Flower	*Crossandrainfundibuliformis*	Acanthaceae	Perennial/Annual
T_8	Common Zinnia	*Zinnia elegans*	Asteraceae	Annual
T_9	Carnation / Clove pink	*Dianthus caryophyllus*	Caryophyllaceae	Perennial
T_{10}	French marigold	*Tagetespatula*	Asteraceae	Annual
T_{11}	Treasure Flower	*Gazania linearis*	Asteraceae	Perennial
T_{12}	CommonLantana	*Lantana camara*	Verbenaceae	Perennial
T_{13}	Pansy	*Viola tricolorvar.hortensis*	Violaceae	Perennial but grown as Annual
T_{14}	Egyptian Starcluster	*Pentaslanceolata*	Rubiaceae	Perennial
T_{15}	Petunia	*Petunia ×atkinsiana*	Solanaceae	Perennial but grown as annual
T_{16}	Mass Rose/ common purslanes	*Portulaca grandiflora*	Portulacaceae	Annual
T_{17}	Scarlet sage	*Salvia officinalis*	Lamiaceae	Perennial
T_{18}	Periwinkle	*Catharanthusroseus*	Apocynaceae	Annual
T_{19}	Wishbone flower	*Toreniafournieri*	Linderniaceae	Annual
T_{20}	Globe amaranth	*Gomphrenaglobosa*	Amaranthaceae	Annual

2.1. Frame description

- Dimension of 1 frame (approx.): 450×150 (Length× Width) in mm
- The area covered per set/frame is 0.73 sq. (approx.)
- The frame can be stacked vertically and horizontally

2.2. Media

For raising a vertical garden, the selected media should be light weight, porous and neutral in pH with high water and nutrient holding capacity. Therefore, a mixture of coco peat, red soil and vermin compost in a 2:1:1/2 ratio was used as growing media.

2.3. Consumer acceptance

The consumer acceptance was recorded for flowering plant species based on overall visual appearance considering the five parameters 1 Plant height; 2 Area coverage; 3 Number of flowers; 4 Size of flower; 5 Colour of flower and thus plants are categorized into excellent, very good, good and poor. Consumer acceptance is presented in Table 10.

3. RESULTS AND DISCUSSION

The flowering species selected for the study were having distinctive growth habits. The data of different quantitative parameters were recorded at 20 days intervals up to 100 DAT which showed a significant variation. Plant height is an imperative trait for the existence of vertical gardens and has always been negatively correlated. The least plant height 7.3 cm and 10.1 cm was found in *Crossandra infundibuliformis* at 20 and 40 DAT, respectively. At 60, 80 and 90 DAT the lowest plant height was found in *Begonia* spp i.e.12.9, 14.4 and 15.9, respectively. The highest plant height, 24.7 cm, 36.4 and 37.6 cm was observed in *Cosmos bipinnatus* at 20, 40 and 60 DAT, respectively. At 80 DAT, the highest plant height 31.6 cm was observed in *Salvia officinalis* and *Pentas lanceolata* and at 100 DAT maximum plant height of 36.1 cm was recorded in *Callistephus chinensis* (Table 2).

Among the treatments, wide variation was observed in plant height and it might be due to its growth habit. Based on these aspects, ornamental species like *Begonia spp.*, *Crossandra infundibuliformis*, *Tagetespatula* and *Gomphrena globose* were found to be suitable for vertical gardening in summer season. The results are in line with Srikanth (2015) who found that the use of dwarf plant species was preferable for vertical gardens. Sachs et al. (1976) and Motos and Oleveira (1998) recommended the optimum plant height of a potted plant should be 1.5 to 2 times the container height.

Like any other character, the stem diameter is also equally significant as it sustains the plants from breaking and damage. *Callistephus chinensis* showed an increasing trend throughout the experiment (6.1 to 6.7 mm) from 20 to 100 DAT. The lowest stem diameter of 3 mm, 3.3 mm, 3.6 mm, 3.6 mm and 3.8 mm was observed in *Catharanthus roseus* at 20, 40, 60, 80 and 100 DAT, respectively (Table 3).

The treatments exposed wide distinction in plant area coverage and it might be due to its growth habit, leaf length, leaf width and leaf area which are the main indicators to understand the plant area coverage. Based on the statistical observations, the highest area coverage (152.44 cm^2 and 195.2 cm^2) was observed in *Dianthus caryophyllus* whereas; the least area coverage (32.85 cm^2 and 49.49 cm^2) was recorded in *Crossandra infundibuliformis* at 20 and 40 DAT, respectively. While at 60 and 80 DAT, the highest area coverage (277.07 cm^2 and 290.16 cm^2) was observed in *Petunia×atkinsiana* and the lowest area coverage was recorded in *Lantana camara* (82.16 cm^2 and 102.69 cm^2), respectively (Table 4).

Table 2: Plant height of ornamental flowering plants (summer season) (cm)

Sl. No.	Plant height (cm)				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	13.0	19.7	24.9	29.9	32.1
T_2	8.4	15.5	24.2	30.15	36.1
T_3	7.5	10.3	12.9	14.4	15.2
T_4	12.9	16.7	19.3	21.8	24.5
T_5	12.8	16.5	17.6	0	0
T_6	24.7	36.4	37.6	0	0
T_7	7.3	10.1	14.6	17.9	19.4
T_8	16.9	20.3	22.4	0	0
T_9	20.6	24.4	27.4	30.1	32.3
T_{10}	10.6	12.6	13.8	0	0
T_{11}	14.7	16.2	17.3	19.3	20.6
T_{12}	8.6	15.2	15.8	16.3	16.9
T_{13}	10.1	15.2	19.4	23.7	25.9
T_{14}	15.6	21.2	26.3	31.6	33.8
T_{15}	15.3	21.1	26.9	27.3	27.7
T_{16}	16.5	22.6	24.9	28.9	31.9
T_{17}	16.3	22.6	29.7	31.6	33.9
T_{18}	12.6	15.6	18.6	19.8	20.3
T_{19}	14.1	16.6	19.2	21.6	23.3
T_{20}	9.8	12.1	14.3	15.2	15.9
SEm±	0.344	0.523	0.503	0.514	0.561
CD (p=0.5%)	1.017	1.543	1.485	1.518	1.657

T_1: *Antirrhinum majus;* T_2: *Callistephus chinensis;* T_3: *Begonia* spp.; T_4: *Calendula officinalis;* T_5: *Celosia cristata;* T_6: *Cosmos bipinnatus;* T_7: *Crossandra infundibuliformis;* T_8: *Zinnia elegans;* T_9: *Dianthus caryophyllus;* T_{10}: *Tagetes patula;* T_{11}: *Gazania linearis;* T_{12}: *Lantana camara;* T_{13}: *Viola tricolor var. hortensis;* T_{14}: *Pentas lanceolata;* T_{15}: *Petunia×atkinsiana;* T_{16}: *Portulaca grandiflora;* T_{17}: *Salvia officinalis;* T_{18}: *Catharanthus roseus;* T_{19}: *Torenia fournieri;* T_{20}: *Gomphrena globosa*

Based on the results, ornamental species like *Dianthus caryophyllus, Petunia atkinsiana, Portulaca grandiflora* and *Pentas lanceolata* were found to be suitable for vertical gardening in summer season. The results are in line with Srikanth (2015) and Alex (2012). The sustainability and greenery of vertical gardens depend on the number of leaves and leaf area. The number of leaves differs from species to species and it depends on the number of branches and leaf type. The results are in line with Srikanth (2015).

Table 3: Stem diameter of ornamental flowering plants (mm) (summer season)

Sl. No.	Stem diameter (mm)				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	4.3	4.5	4.7	4.9	5.0
T_2	6.1	6.3	6.5	6.6	6.7
T_3	5.3	5.6	5.7	6	6.1
T_4	5.4	5.4	5.5	5.8	5.9
T_5	6.3	6.6	6.9	0	0
T_6	6.3	6.5	6.8	0	0
T_7	3.6	3.8	4.0	4.2	4.3
T_8	3.9	4.2	4.4	0	0
T_9	4.0	4.5	5.1	5.2	5.4
T_{10}	5.3	5.6	5.7	0	0
T_{11}	3.5	3.7	3.9	4.1	4.2
T_{12}	3.3	3.4	3.8	4.0	4.2
T_{13}	5.6	5.7	5.9	6.0	6.0
T_{14}	4.2	4.5	4.9	5.5	6.1
T_{15}	5.0	5.3	5.7	6.0	6.1
T_{16}	4.5	4.8	5.1	5.4	5.7
T_{17}	5.2	5.4	5.5	5.6	5.8
T_{18}	3.0	3.3	3.6	3.6	3.8
T_{19}	4.6	4.9	5.1	5.2	5.4
T_{20}	4.o	4.2	4.3	4.3	4.4
SEm±	0.140	0.135	0.149	0.148	0.149
CD (p=0.5%)	0.415	0.398	0.441	0.438	0.440

Table 4: Area coverage of ornamental flowering plants (cm^2) (summer season)

Sl. No.	Area coverage (cm^2)				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	91.00	171.39	236.55	296.01	340.26
T_2	34.44	86.80	164.56	238.185	296.02
T_3	44.25	78.28	114.81	155.52	183.92
T_4	56.76	76.82	96.50	115.54	142.10
T_5	52.48	84.15	95.04	0	0
T_6	71.63	123.76	169.20	0	0
T_7	32.85	49.49	83.22	127.09	161.02
T_8	87.88	136.01	181.44	0	0
T_9	152.44	195.20	238.38	279.93	323
T_{10}	75.26	109.62	126.96	0	0
T_{11}	91.14	119.88	141.86	173.7	208.06
T_{12}	33.54	66.88	82.16	102.69	119.99
T_{13}	62.62	115.52	168.78	225.15	274.54
T_{14}	95.16	167.48	244.59	328.64	378.56
T_{15}	96.39	170.91	277.07	313.95	335.17
T_{16}	80.85	205.66	239.04	300.56	363.66
T_{17}	99.43	178.54	252.45	278.08	315.27
T_{18}	52.92	84.24	113.46	132.66	190.82
T_{19}	105.75	146.08	201.60	250.56	281.93
T_{20}	44.10	75.02	105.82	135.28	176.49
SEm±	2.286	4.313	5.780	6.122	7.858
CD (p=0.5%)	6.744	12.725	17.052	18.062	23.182

The highest number of leaves was recorded in *Portulaca grandiflora* (136, 215, 258, 300 and 334) at 20, 40, 60, 80 and 100 DAT, respectively (Table 5). Among 20 plant species, only *Antirrhinum majus* showed the maximum number of branches (9) for summer season. At 40, 60, 80 and 100 DAT, the maximum number of branches were recorded in *Portulaca grandiflora* (20, 33, 33 and 34) during summer season (Table 6). Significant difference with respect to the number of flowers among the 20 plant species was observed. Among them, *Pentas lanceolata* showed the highest number of flowers (30, 26, 40 and 37) at 40, 60, 80 and 100 DAT, respectively. Flower size is also an important character to be considered as it determines the compactness and appearance of the plant. *Celosia cristata* had the highest flower size (6.1 cm and 6.1 cm) at 40 and 60 DAT, respectively, while *Petunia×atkinsiana* showed the highest flower size (5.3 cm and 5.4 cm) at 80 and 100 DAT, respectively (Table 7). The lowest flower size (1.3, 1.3, 1.4 and 1.6 cm) was observed in *Gomphrena globosa* at 40, 60, 80 and 100 DAT, respectively (Table 8). During the course of its growing period, momentous differences were observed among the 20 species in the days required for flower initiation. In the present study, it was observed that *Tagetes patula* required the least number of days for flower initiation *i.e.* 19.2 days. While the highest number of days was recorded in *Portulaca grandiflora* (51.5 days) (Table 9). Species with early flower initiation are desired for the maintenance of aesthetic beauty of vertical garden. Early initiation of flower may be due to genetic factors and prevailing climatic conditions of the area. Significant differences were observed among the 20 species for days required for flowering. Species with the maximum duration of flowering are the most desirable flowering plants for vertical gardens. In the present study, *Begonia* spp (72.5 days) recorded the highest flowering duration,

Table 5: Number of leaves of ornamental flowering plants

Sl. No.	Number of leaves				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	43.8	54.7	64.6	68.9	69.6
T_2	13.3	18.4	22.4	23.1	26.35
T_3	12.3	21.5	27.3	32.4	37.6
T_4	8.3	16.8	18.3	19.4	19.9
T_5	10.9	14.3	16.3	0	0
T_6	11.2	14.7	15.15	0	0
T_7	11.3	16	17.6	19.3	20.4
T_8	26.9	34.5	41.4	0	0
T_9	25.0	31.9	34.4	35.0	35.9
T_{10}	16.3	23.2	27.2	0	0
T_{11}	16.1	22.4	26.6	25.4	28.5
T_{12}	16.5	20.6	24.5	26.7	29.15
T_{13}	15.0	20.2	25.8	26.5	27.0
T_{14}	14.5	15.5	16.4	18.4	23.1
T_{15}	22.8	27.7	34.75	35.6	36.5
T_{16}	136.0	215.3	257.8	300.2	334.5
T_{17}	19.2	22.75	24.2	14.0	27.8
T_{18}	17.3	23.7	25.4	28.8	30.2
T_{19}	50.7	69.7	83.7	85.4	88.1
T_{20}	17.0	22.5	26.6	28.3	29.6
SEm±	0.485	0.983	1.224	1.296	1.326
CD (*p*=0.5%)	1.433	2.902	3.612	3.824	3.913

Table 6: Number of branches of ornamental flowering plants (summer season)

Sl. No.	Number of branches				
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
T_1	8.5	16.1	17.2	17.8	18.1
T_2	0	0	0	0	0
T_3	3.6	6.6	7.0	7.1	7.8
T_4	0	0	0	0	0
T_5	0	0	0	0	0
T_6	0	0	0	0	0
T_7	1.7	2.2	2.7	2.8	2.9
T_8	1.6	3.3	3.7	0	0
T_9	3.4	6.5	7.8	7.9	7.9
T_{10}	3.5	5.4	5.7	0	0
T_{11}	0	0	0	0	0
T_{12}	2.1	2.9	3.1	3.3	3.4
T_{13}	2.5	4.6	4.7	4.8	5.4
T_{14}	1.1	2.9	3.0	3.3	3.7
T_{15}	3.7	7.9	8.3	8.9	9.6
T_{16}	8.0	19.7	33	33.2	34.4
T_{17}	0	0	0	0	0
T_{18}	1.5	4.2	5.6	5.8	6.0
T_{19}	3.6	8.2	8.5	9.2	9.4
T_{20}	1.3	2.5	2.9	3.2	3.3
SEm±	0.093	0.159	0.220	0.238	0.236
CD (*p*=0.5%)	0.275	0.471	0.651	0.704	0.696

which was found at par with *Catharanthus roseus* (72.0 days), *Antirrhinum majus* (70.5 days) and *Gomphrena globosa* (68 days). The lowest flowering duration was observed in *Cosmos bipinnatus* (27.5 days) (Table 9). The most important aspect of vertical garden is the degree of time in which the plants appears healthy and attractive. Thus, the plants with longer durations are the most preferred for vertical gardens.

In the present study, significant differences were observed among the 20 species for total cropping duration out of which, *Antirrhinum majus* recorded the highest crop duration of 130.5 days which was found at par with *Gazania linearis* (121 days) and *Pentas lanceolata* (120 days). The lowest crop duration was observed in *Celosia cristata* (75 days) (Table 9). Significant differences were observed among the 20 species for its establishment percentage.

The present investigation witnessed a 100% faster establishment in 12 species under study. The highest establishment percent was observed in *Antirrhinum majus, Begonia spp, Calendula officinalis*, *Crossandra infundibuliformis, Dianthus caryophyllus, Lantana camara, Pentas lanceolata, Portulaca grandiflora, Salvia officinalis, Catharanthus roseus, Torenia fournieri* and *Gomphrena globosa*. While the species *Cosmos bipinnatus,* and *Petunia ×atkinsiana* showed minimum survival percentage (Table 9). This is due to its capacity to withstand adverse conditions like increase in temperature, wind velocity and its potential to tolerate drought conditions which is a prime expectation in any vertical garden plant selection. The findings are in line with Srikanth (2015).

3.1. Qualitative characters

Flower colour, growth habit, leaf type and leaf shape were taken as qualitative characteristics as they helped to relate to the aesthetic value of the plants. All the qualitative characters were presented in Table 11.

Table 7: Number of flowers of ornamental flowering plants (summer season)

Sl. No.	Number of flowers			
	40 DAT	60 DAT	80 DAT	100 DAT
T_1	6.0	1.5	3.9	2.3
T_2	1.0	2.5	4.2	4.1
T_3	11.8	8.1	8.8	9.5
T_4	1.4	1.5	1.0	1.1
T_5	2.8	2.9	0	0
T_6	2.7	3.1	0	0
T_7	8.5	9.9	9.9	7.9
T_8	10.0	7.1	0	0
T_9	10.6	5.6	9.1	5.1
T_{10}	3.2	1.8	0	0
T_{11}	0	1.0	1.0	1.0
T_{12}	2.4	1.3	1.9	2.2
T_{13}	0	1.1	1.8	1.7
T_{14}	29.7	25.7	39.5	36.6
T_{15}	0	2.4	2.5	2.5
T_{16}	0	1.1	1.0	1.1
T_{17}	0	10.3	11.3	14.0
T_{18}	4.0	4.1	4.4	5.2
T_{19}	17.4	19.1	14.4	9.6
T_{20}	4.6	15.3	17.1	18.3
SEm±	0.128	0.21	0.230	0.214
CD (p=0.5%)	0.38	0.621	0.679	0.631

Table 8: Size of flowers of ornamental flowering plant (summer season)

Sl. No.	Size of flowers			
	40 DAT	60 DAT	80 DAT	100 DAT
T_1	2.8	2.4	3.2	2.9
T_2	2.3	2.5	2.7	2.6
T_3	3.1	3.2	2.9	3.1
T_4	4.0	4.1	3.3	3.6
T_5	6.1	6.1	0	0
T_6	3.3	3.4	0	0
T_7	2.4	2.2	2.3	2.4
T_8	4.0	4.6	0	0
T_9	3.0	3.1	3.3	3.2
T_{10}	3.3	3.5	0	0
T_{11}	0	5.2	4.4	4.8
T_{12}	2.3	2.6	2.5	2.6
T_{13}	0	5.4	5.1	5.2
T_{14}	5.2	4.7	4.7	4.3
T_{15}	0	5.75	5.34	5.4
T_{16}	0	2.2	3.0	2.0
T_{17}	0	2.1	2.6	2.2
T_{18}	3.5	3.4	3.9	3.6
T_{19}	1.5	1.8	1.9	1.9
T_{20}	1.3	1.3	1.4	1.6
SEm±	0.073	0.117	0.093	0.109
CD (p=0.5%)	0.216	0.346	0.276	0.324

3.2. Flower colour

Flower colour is one of the factors to enhance the attractiveness of plants. The flower colour was recorded by comparing the colour of the flower with the Royal Horticulture Society colour chart (5th edition). Appearance and attractiveness are important factors in the study of flowering plants. The attractiveness depends on the colour of flower plants. Among these 20 species, significant difference was observed.

3.3. Growth habit

Among the 20 plant species, significant difference was observed in the growth habit. *Antirrhinum majus, Zinnia elegans, Lantana camara, Pentas lanceolata, Catharanthus roseus* were having erect and branching types. *Celosia cristata, Cosmos bipinnatusand Salvia officinalis* were having erect and non-branching types. *Begonia spp, Dianthus caryophyllus, Tagetespatula, Viola tricolor var. hortensis, Petunia×atkinsiana, Torenia fournieri and Gomphrenag lobosa* were of spreading and branching types. *Callistephus chinensis, Calendula officinalis, Crossandra infundibuliformis* and *Gazania linearis* were of spreading and non-branching types.

3.4. Leaf type

Among these 20 plant species, only *Tagetes patula* is odd pinnately compound and other remaining 19 species were recorded as simple type of leaf.

3.5. Leaf shape

Among the 20 plant species, difference was observed in the leaf shape. *Begonia spp*, *Calendula officinalis*, *Zinnia elegans*, *Lantana camara*, *Viola tricolorvar. hortensis* and *Catharanthus roseus* has ovate leaf shape. *Antirrhinum majus*, *Dianthus caryophyllus*, *Tagetes patula*, *Torenia fournieri*, *Gomphrena globosa*, *Pentas lanceolata* were observed to have oblong leaf shapes. *Gazania linearis*, *Petunia×atkinsiana*, was found

Table 9: Flower initiation (days), Flower duration (days), Crop duration (days), Establishment (survival %) of ornamental flowering plants (summer season)

Sl. No.	Plant species	Flower initiation (Days)	Flower duration (Days)	Crop duration (Days)	Establishment (Survival %)
T_1	*Antirrhinum majus*	45.0	70.5	130.5	100
T_2	*Callistephus chinensis*	50.5	52.5	115	90.0
T_3	*Begonia* spp	25.0	72.5	117	100
T_4	*Calendula officinalis*	40.0	40.0	106	100
T_5	*Celosia cristata*	25.0	40.5	75.0	40.0
T_6	*Cosmos bipinnatus*	30.4	27.5	78.0	25.5
T_7	*Crossandra infundibuliformis*	23.0	65.0	108	100
T_8	*Zinnia elegans*	24.5	52.0	79.0	59.0
T_9	*Dianthus caryophyllus*	30.0	49.4	92.0	100
T_{10}	*Tagetespatula*	19.2	42.0	76.5	40.0
T_{11}	*Gazania linearis*	51.0	58.0	121	97.5
T_{12}	*Lantana camara*	20.0	55.2	95.2	100
T_{13}	*Viola tricolor var. hortensis*	46.5	38.0	99.5	59.5
T_{14}	*Pentaslanceolata*	35.0	60.0	120	100
T_{15}	*Petunia×atkinsiana*	49.0	30.0	97.0	32.5
T_{16}	*Portulaca grandiflora*	51.5	32.5	104	100
T_{17}	*Salvia officinalis*	47.0	40.0	110	100
T_{18}	*Catharanthus roseus*	28.0	72.0	118	100
T_{19}	*Torenia fournieri*	27.0	49.0	96.0	100
T_{20}	*Gomphrena globosa*	30.0	68.0	105	100
SEm±		1.078	1.592	3.783	5.968
CD (p=0.5%)		3.180	4.696	11.161	17.607

Table 10: Consumer acceptance

Sl. No.	Class	Plant species (Summer Season)
1.	Excellent	*Begonia* spp., *Dianthus caryophyllus, Torenia fournieri, Gomphrena globosa, Catharanthus roseus.*
2.	Very good	*Salvia officinalis, Viola tricolor var. hortensis, Gazania linearis, Pentas lanceolata, Antirrhinum majus*
3.	Good	*Petunia ×atkinsiana, Portulaca grandiflora, Crossandra infundibuliformis, Zinnia elegans, Calendula officinalis.*
4.	Poor	*Callistephus chinensis, Tagetes patula,Cosmos bipinnatus, Celosia cristata, Lantana camara*

Table 11: Qualitative leaf characters of flowering plants selected for the study

Sl. No	Plant Species	Flower colour	Growth habit	Leaf shape	Leaf type
T_1	*Antirrhinum majus*	Peony Purple (729)	Erect and Branching	Simple	Oblong
T_2	*Callistephus chinensis*	Spinel Pink (0625/3), Spectrum Violet (735)	Spreading and Non-Branching	Simple	Spatulate
T_3	*Begonia* spp.	NeyronRose (623/1), NeyronRose (623),	Spreading and Branching	Simple	Ovate

Table 11: Continue...

Sl. No.	Plant Species	Flower colour	Growth habit	Leaf shape	Leaf type
T_4	*Calendula officinalis*	Buttercup Yellow (5)	Spreading and Non-Branching	Simple	Ovate
T_5	*Celosia cristata*	Signal Red (719), Shrimp Red (616)	Erect and Non-Branching	Simple	Saggitate
T_6	*Cosmos bipinnatus*	Lemon Yellow (4)	Erect and Non-Branching	Simple	Variable
T_7	*Crossandra infundibuliformis*	Shrimp Red (616)	Spreading and Non-Branching	Simple	Ovate to lanceolate
T_8	*Zinnia elegans*	Persimmon orange (710/1), Rose Bengal (25)	Erect and Branching	Simple	Ovate
T_9	*Dianthus caryophyllus*	Cyclamen Purple (30), Orchid Purple (31)	Spreading and Branching	Simple	Oblong
T_{10}	*Tagetespatula*	Orange (12)	Spreading and Branching	Odd pinnately compound	Oblong
T_{11}	*Gazania linearis*	Aueolin (3/1)	Spreading and Non-Branching	Simple	Linear
T_{12}	*Lantana camara*	Indian Yellow (6)	Erect and Branching	Simple	Ovate
T_{13}	*Viola tricolor var. hortensis*	Spectrum Violet (735)	Spreading and Branching	Simple	Ovate
T_{14}	*Pentaslanceolata*	Peony purple (729/2)	Erect and Branching	Simple	Oblong
T_{15}	*Petunia×atkinsiana*	Spectrum Violet (735)	Spreading and Branching	Simple	Linear
T_{16}	*Portulaca grandiflora*	NeyronRose (623/2)	Spreading and Sub shoots	Simple	Ovate to lanceolate
T_{17}	*Salvia officinalis*	Blood Red (820/1)	Erect and Non-Branching	Simple	Elliptic
T_{18}	*Catharanthus roseus*	Peony purple (729/1)	Erect and Branching	Simple	Ovate
T_{19}	*Torenia fournieri*	Doge purple (732), Victoria Violet (738)	Spreading and Branching	Simple	Oblong
T_{20}	*Gomphrena globosa*	Orchid Purple (31)	Spreading and Branching	Simple	Oblong

to have linear type of leaf shape. *Callistephus chinensis* was observed to have spatulate type of leaf shape. *Celosia cristata* was recorded as saggitate type of leaf shape and *Cosmos bipinnatus* was found to have variable type of leaf shape and *Crossandra infundibuliformis* and *Portulaca grandiflora* as ovate to lanceolate type of leaf shape.

4. CONCLUSION

The study of evaluation of 20 flowering plant species in the summer season concluded that the ornamental flowering plant *viz*., *Begonia* spp., *Dianthus caryophyllus, Torenia fournieri, Gomphrena globosa* and *Catharanthus roseus* were found to be excellent for the summer season.

5. REFERENCES

Akbari, H., Pomerantz, M., Taha, H., 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Solar Energy 70(3), 295–310.

Alex, R., 2012. Evaluation of foliage plants for interior plantscaping.Ph. D. (Hort) Thesis. Kerala Agricultural University, Vellanikkara, Thrissur.

Alexandri, E., Jones, P., 2008. Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates. Building and Environment 43, 480–493.

Amir, A.F., Yeok, F.S., Rahman, A.M., 2014. Estimation of annual carbon sequestration in psophocarpustetragonobulus used as biofacade in tropical environment. In: Proceedings of International Conference on Architecture and Civil Engineering (ICAACE'14), Dubai.

Bakar, N.I.A., Mansor, M., Harun, N.Z., 2013. Approaching vertical greenery as public art: a review on potentials in urban Malaysia. Journal of Architecture & Environment 12(1), 1–26.

Basher, H.S., Sheikh Ahmad, S., Rahman, A., Malek, A., Qamaruz Zaman, N., 2016.The use of edible vertical greenery system to improve thermal performance in a tropical climate. Journal of Mechanical Engineering 13(1), 58–66.

Bruse, M., Thonnessen, M., Radke, U., 1999. Practical and theoretical investigation of the influence of facade greening on the distribution of heavy metals in urban streets. http://www.envi- met.com/documents/papers/facade1999.pdf Accessed on 17th January 2012.

Francis, R., Lorimer, J., 2011. Urban reconciliation ecology: The potential of living roofs and walls. Journal of Environmental Management 92, 1429–1437.

Gago, E.J., Roldan, R., Pacheco-Torres, R., Ordóñez, J., 2013. The city and urban heat islands: A review of strategies to mitigate adverse effects. Renewable and Sustainable Energy Reviews 25, 749–58.

Ghazalli, A.J., Brack, C., Bai, X., Said, I., 2019. Physical and Non-Physical Benefits of Vertical Greenery Systems: A Review. Journal of Urban Technology 26(4), 53–78.

Ichihara, K., Cohen, J., 2011. New York City property values: what is the impact of green roofs on rental pricing?. Letters in Spatial and Resource Sciences 4, 21–30.

Jim, C.Y., 2015. Greenwall classification and critical design-management assessments. Ecological Engineering 77, 348–362.

Lundholm, J., 2006. Green roofs and facades: a habitat template approach. Urban Habitats 4, 87–101.

Motos, J., Oliveira, M.J.G., 1998. Producao de crisantemosemvaso.Holambra, Flortec 34.

Peng, K.H., Kuo, Y.C., Lin, H.Y., 2015. The use of vertical greening in urban rehabilitation to improve sustainability of the environment in Taiwan. International Review for Spatial Planning and Sustainable Development 3(1), 5–16.

Peschardt, K.K., Stigsdotter, U.K., 2013. Associations between Park Characteristics and Perceived Restorativeness of Small Public Urban Green Spaces. Landscape and Urban Planning 112(1), 26–39.

Price, A., Jones, E.C., Jefferson, F., 2015. Vertical greenery systems as a strategy in urban heat island mitigation. Water, Air, and Soil Pollution 226(8), 246–256.

Pugh, T., MacKenzie, A., Whyatt, J., Hewitt, C., 2012. Effectiveness of green infrastructures for improvement of air quality in urban street canyons. Environmental Science and Technology 46, 7692–7699.

Rahman, A., Wang, C, Mohd Rahim, A., Loo., S.C., Miswan, N., 2014. Vertical Greenery Systems (Vgs) In Urban Tropics. Open House International 39(4), 42–52.

Rahman, M.H., Khan, T.Z., Raju, R.A., Huq, M.J., 2019. Urban eco-sustainability and disaster risk reduction by implementing vertical garden in dhaka city eco-system services and urban disaster risk management. In: Proceedings on International Conference on Disaster Risk Management 206–213.

Skelhorn, C., Lindley, S., Levermore, G., 2014. The impact of vegetation types on air and surface temperatures in a temperate city: A fine scale assessment in Manchester, UK. Landscape and Urban Planning 121, 129–140.

Zaid, S.M., Perisamy, E., Hussein, H., Myeda, N.E., Zainon, N., 2018. Vertical greenery system in urban tropical climate and its carbon sequestration potential: A review. Ecological Indicators 91, 57–70.

Yang, J., Yu, Q., Gong, P., 2008. Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment 42, 7266–7273.

Zaid, S.M., Perisamy, E., Hussein, H., Myeda, N.E., Zainon, N., 2018. Vertical greenery system in urban tropical climate and its carbon sequestration potential: A review. Ecological Indicators 91, 57–70.