PERFORMANCE OF GERBERA CULTIVARS UNDER PROTECTED CONDITION

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CERTIFICATE

This is to certify that thesis entitled, ***"PERFORMANCE OF GERBERA CULTIVARS UNDER PROTECTED CONDITION"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE****, embodies the result of a piece of bona-fide research work carried out by* ***NOOR-E-ALAM****, Registration No.* ***08-02870*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2015
Place: Dhaka, Bangladesh

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Prof. Md. Ruhul Amin
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DEDICATED

TO MY

BELOVED PARENTS

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ABSTRACT

The present investigation was carried out to study the performance of gerbera cultivars under protected condition at the Floriculture Research Field, Bangladesh Agricultural Research Institute, Gazipur from March, 2014 to May 2015. The experiment was conducted in Randomized Block Design having 8 cultivar of gerbera which were coded V_1, V_2, V_3, V_4, V_5, V_6, V_7 and V_8 (BARI Gerbera-1) treatments with three replications. Vegetative, flowering and flower characteristics varied significantly among the cultivars. Cultivar V_3 produced maximum number of leaves per plant (20.0), plant spread (15.0 cm) and number of suckers per plant (8.0). Days taken to bud visibility and full bloom varied greatly among cultivars under the study. Cultivar V_3 took least number of days, for bud visibility (69.0) and full bloom (81.0) respectively. For flower characteristics, V_3 showed the maximum number of flowers per plant (20) and possessed longest vase life (15.0 days). The largest flower diameter (10.0 cm) was found in V_3 and the smallest was in V_2 (6.5 cm). Weightiest flower stalk was produced by V_3 (25.0 g) and lightest was in V_2 (10 g). Longest flower duration was in V_3 (125 g) and shortest duration was in V_2 (105 days). Wide variation in flower colour was also observed among the cultivars. Considering the important characteristics, the cultivar V_3 is the best variety while V_6 and V_7 also exhibited acceptable quality. So, V_3, V_6 and V_7 can be cultivated under protected conditions.

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The Author

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LIST OF ABBREVIATED TERMS

ABBREVIATIONS	ELABORATIONS
%	Percent
@	At the rate of
AEZ	Agro-Ecological Zone
ANOVA	Analysis of variance
B	Boron
BARI	Bangladesh Agricultural Research Institute
CV%	Percentage of Coefficient of Variation
cv.	Cultivar (s)
$0^{O}C$	Degree Celsius
DAP	Days After Planting
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
et al.	And others
etc.	Etcetera
FYM	Farm Yard Manure
HRC	Horticulture Research Centre
Kg	Kilogram
L	Litre
m^2	Square meter
Max.	Maximum
Min.	Minimum
MoP	Muriate of Potash
MN	Micro Nutrient
NS	Non Significant
OM	Organic manure
PSB	Phosphate Solubilizing Bacteria
q	Quintal
RCB	Randomized Complete Block
RDF	Recommended Dose of Fertilizer
RDN	Recommended Dose of Nitrogen
RFR	Recommended Fertilizer Rate
RH	Relative Humidity
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
t/ha	Tons per hectare
VC	Vermicompost
Viz.	Namely

CHAPTER I
INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus) belongs to Asteraceae family is an important flower crop with long leafless stalks and daisy-like flowers. It is a popular cut flower grown throughout the world in a wide range of climatic conditions. It is also known as 'Barbeton daisy' or 'Transvaal daisy'. The genus Gerbera was named in honour of German botanist and medical doctor Traugott Gerber and the species jamesonii in honour of Captain Jameson (Das and Singh, 1989). The genus *Gerbera* L. consists of 30 species, which are of Asiatic and African origin. Among the different species, *Gerbera jamesonii* is the only species under cultivation. The development of *Gerbera jamesonii* as a floricultural crop is traced from its cultivation as a novelty in South Africa to its establishment as a commercial crop in the 1930s. Now it is grown throughout the world (Pattanashetti *et al.*, 2012) scattered from Africa to Madagascar (Khosa *et al.*, 2011) into tropical Asia and South America (Tjia and Joiner, 1984). The relative contribution of *Gerbera jamesonii* and *Gerbera viridifolia* to the modern crop is unknown but much of the cultivated germplasm can be traced back to material that passed through the Cambridge Botanic Garden, UK and La Rosarie, Antibes, France (Aswath *et al*., 1998). It is a diploid species with somatic chromosome number 2n=50. The modern gerbera arose from *Gerbera jamesonii* hybridized with *Gerbera viridifolia* and possibly other species (Leffring, 1973).

Gerbera as a cut-flower has great potential for local as well as export market. It is one among the top ten cut-flowers of the world flower trade which rank fourth in the international flower trade and a popular cut flower in Holland, Germany and USA (Chowdhary and Prasad, 2000).

Gerbera flowers are available in various colours and form, which suit very well in different floral arrangement (Emongor, 2004). Its magnificent inflorescence with a variety of colour has also made it attractive for use in garden decorations, such as herbaceous borders, bedding, pots and for cut flowers as a long vase life (Khosa *et al.*, 2011). It is occasionally used in anniversary, birthday, friendship day, wedding etc. It is also used in preparing nail paints, lipstick shades and perfumes. Besides aesthetic and cosmetic value, the gerbera plant is used in the preparation of traditional chinese medicine: tu-er-feng, derived from whole plants of gerbera, for curing cold with cough, mouth sores and for rheumatism. It also reduces risk of cancer and acts as an anti spamodic (Bose *et al.*, 2003).

In Bangladesh, the agro- ecological conditions are very conducive for the survival and culture of gerbera. The flower growers of Bangladesh are now cultivating the traditional flower crops that do not give them high return. In Bangladesh, gerbera was introduced recently and gaining demand. The colour variation, their meaning, size of flowers, long lasting behaviour and wide adaptability for culture made gerbera a flower of choice for cultivation in Bangladesh. In Bangladesh, it is grown mainly in winter season. It cannot tolerate extreme high temperature, cold and heavy rainfall. Heavy rainfall and water logging conditions are very much harmful for gerbera. It can be grown on all types of soil but loamy soil with moist condition is better for its desired development.

Gerbera is grown in the open field as well as in the poly house condition. However, it is difficult to get good quality cut flowers of gerbera under open-field conditions. To meet the qualitative and quantitative standards, cultivars have to be grown under protected conditions (Choudhary *et al.*, 1998). Previously, in a performance study of gerbera varieties, Singh and Ramachandran (2002), Singh and Mandhar (2002) and Kandpal *et al.* (2003) grew gerbera under protected conditions and observed better growth, yield and quality characteristics under

protected. In protected conditions, gerbera grows faster and produces larger and greener leaves with high dry matter content (Kumar *et al*., 2014). As a result, the yield of the flowers increases and more side shoots will be formed. Protected conditions provide favorable environment for the growth of the plants by protecting the crop from heavy winds, pests, diseases and other climatic conditions (Khan, 1995). The market requirement for cut flowers is very specific and it can be met consistently, only when the crop is grown under protected conditions. In places where the natural weather remains considerably cooler for most parts of the year as in parts of USA, UK and Australia, the crop is being grown under fully protected climate in controlled green houses. In places near equator, with warmer sunny climate, semi protected conditions are successfully employed to cultivate the crop.

Performance of gerbera varies with the region, season and other growing conditions (Horn *et al.,* 1974). Gerbera as a cut flower has tremendous demand in domestic and international markets. Local varieties had lower yields than hybrids, some hybrids are poor in quality, some were best in both quality and quantity and some hybrids presented similar yields (Yama *et al.*, 2006). Each variety has its own significant effect on yield and yield components, and each variety has its own traits that are part and parcel as quality parameters of the crop (shape, size and color) (Hossain *et al.,* 2015). Evaluation of gerbera cultivars enables the growers to select the best performing varieties in Bangladesh. Considering the above facts the present study was undertaken with the following objectives:

i) To study growth, yield and quality of gerbera genotypes under protected conditions ; and

ii) To identify superior gerbera genotype(s) under protected condition for commercial production.

CHAPTER II
REVIEW OF LITERATURE

Gerbera (*Gerbera jamesonii* Bolus) is a herbaceous perennial flower crop with long leafless stalk and daisy like flowers. A native of South Africa, it is a popular cut flower grown thought the world in a wide range of climatic conditions. Several research works have been done all over the world by different researchers on performance of gerbera cultivars under protected condition but information is meager under climatic conditions of Bangladesh. Therefore, information available in the literature pertaining to those aspects of gerbera and other flowering crops have been reviewed briefly and presented below:

Hossain *et al.* (2015) conducted an experiment at rooftop garden, Department of Horticulture, Sher-e-Bangla Agricultural University, Bangladesh to assess growth and flowering of gerbera cultivars. Sixteen hybrid gerbera cultivars were used on the experiment by following the Completely Randomized Design with five replications. Plant height, number of leaves, number of flowers/plant, peduncle length, peduncle diameter, flower head diameter, petal thickness, petal number and petal color showed significant variation among the cultivars. Maximum number of flower/plant (11.6), peduncle length (65.0 cm), peduncle diameter (12.3 mm) and flower head diameter (10.8 cm) was found from V_8 which was followed by V_7. Maximum petal thickness (0.69 mm) was found from V_7 followed by V_{13} (0.42 mm), V_8 (0.36 mm) and V_{14} (0.36 mm). However, V_8 was the best among the cultivars concerning the yield which was followed by V_7.

Ajish and Karuppaiah (2015) carried out an experiment on gerbera and found among the different treatment combinations, shade level of 75 per cent and growing media with coir pith + coconut husk envisaged maximum plant height, plant spread, number of flowers per plant, flower stalk length, spathe length and spathe breadth. The number of days taken for flower bud appearance was also earlier in this treatment.

Palanisamy *et al.* (2015) conducted an experiment at Horticultural Research Station, Yercaud to assess the fertigation levels on cut gerbera cv. Palm Beach along with micro nutrients and humic acid as foliar spray under in Shevaroy hills. The experiment was laid out in Randomized Block Design (RBD) with two replications. The treatments consisted of three levels of fertigation regimes (125, 100 and 75% of recommended dose of fertilizer), foliar spray of micronutrient mixture (0.004%) and humic acid (0.2 %). The results revealed that the morphological parameters namely, plant height, number of leaves, leaf area, plant spread, sucker number and plant density had progressive increase at different stages of plant growth at 100% RDF+0.004% MN Mixture + 0.2% humic acid (T_{11}) while, the treatment T_{12} (75% RDF + 0.004% MN Mixture + 0.2% humic acid) had induced the first flowering. The treatment T_{11} (100% RDF+0.004% MN Mixture + 0.2% humic acid) recorded the highest flower yield, longest flower stalk length, flower stalk girth and largest flower diameter. Hence this treat mental combination could be recommended for commercial cultivation of cut gerbera.

Kankana *et al.* (2015) carried out an investigation to study the performance of twelve cultivars of gerbera (*Gerbera jamesonii* Bolus) under open field conditions in Assam. Vegetative, flowering and flower characters varied significantly among the cultivars. Mean performance of the cultivars revealed that cv. Pride of Sikkim was the tallest (61.80 cm) and produced longest stalk length (49.51cm). Cultivar 'Red Gem' produced maximum number of leaves per plant (46.55), plant spread (54.10 cm) and number of suckers per plant (24.04). Days taken to bud visibility and full bloom varied greatly among cultivars under the study. Cultivar 'Pink Melody' took least number of days, 63.78 and 76.00 for bud visibility and full bloom, respectively. With respect to flower characters, cv. Red Gem recorded the maximum number of flowers per plant (53.17) and possessed longest self-life (19.96 days) and vase life (9.81 days). Largest flower diameter was found in cv. Orange Gleam (11.20 cm) which was followed by cv. Classic Beauty (10.95 cm).

Heaviest flowers were produced by the cv. Classic Beauty (16.71 g). Duration of flowering was longest in cv. Red Gem (130 days). Wide variation in flower colour was also observed among the cultivars. Cultivar Red Gem expressed best performance on various growth and flower characters followed by other cultivars, viz. Orange Gleam, Classic Beauty and Pink Melody.

Shaukat (2015) evaluated the performance of six cultivars of gerbera under polyhouse at experimental farm, faculty of agriculture under the climatic conditions of Rawalakot, Pakistan for their adaptability and performance. Results on vegetative characteristics showed that cultivars V_2 and V_3 took less number of days for sprouting. Cultivar V_2 produced more plants per sucker and maximum plant height. Results on floral characteristics showed that cultivar V_3 were earlier for flower bud visibility. Maximum flower number and longest stalk length were produced by V_2. On the basis of overall performance, cultivar V_2 and V_3 were found superior under ployhouse condition.

Kumar *et al.* (2014) conducted a study on the growth and flowering of different varieties of gerbera under shade net at Akshaya farm, India. The data revealed that amongst 05 varieties under study, Salvador had significantly more plant height, plant spread, suckers, leaf, vase life, maximum stalk diameter and number of flowers per plant and required minimum days for development of flower recorded. Intense had significantly more number of leaves per plant. Winter queen had significantly more stalk length and neck diameter of a flower. Goliath required significantly less period for sucker production. Overall performance of Salvador, Intense and Winter queen varieties was found better.

Tapas (2014) conducted a study to evaluate seven varieties of gerbera (Dune, Goliath, Cacharelle, Forza, Danaellen, Lan- caster and Malibu) for growth and flowering under polyhouse at Mondouri Horticulture Research Station of Bidhan Chandra Krishi Viswavidylaya under subtropical plains. The experiment was laid

out in Randomized Block Design (RBD) with three replications having ten plants each in raised beds under polyhouse. Among the varieties studied, there were highly significant variations observed for growth, yield and quality parameters. The data revealed that among all the seven varieties under study, Dune had significantly highest plant height (54.70 cm) followed by Cacharelle (51.27 cm) and Malibu (46.13 cm).The same cultivar also required minimum days (40.23) for visibility of flower bud, maximum flower size (13.40 cm), flower number (9.37) and stalk length (80.13 cm). With respect to vegetative parameters like number of leaves per plant was recorded highest in variety Lancastar (42.20) followed by Cacharelle (33.30). Highest number of suckers per plant was found in variety Malibu (4.43) followed by Forza (4.10). On the basis of overall performance, varieties Dune, Goliath, Cacharelle, Malibu were found superior with respect to growth and flowering characteristics under polyhouse in West Bengal condition

Magar and Siwakoti (2014) carried out a study to assess varietal characteristics of gerbera grown in Kathmandu, Nepal under plastic shed condition. The experiment was conducted at Sasita's Agri Farm, Bhaktapur, Nepal. The data revealed that among ten gerbera varieties under study, Pirineo had significantly more number of flowers per plant and more number of leaves per plant. Maximum flower diameter was recorded in varieties Aqua, Pompei and Bayadere. Highest plant survival rate (about 95%) was found in Pirineo at the age of 10 months after transplantation. Considering the more number of flowers per plant and least mortality rate, Pirineo variety was found promising.

Five carnation cultivars ('Grand Salam', 'Nelson', 'Kaly', 'Cinderella' and 'Tempo') were evaluated with respect to growth, yield and quality characteristics under lath house conditions by Mehmood *et al.* (2013) at Kala Shah Kaku Research Station, Directorate of Floriculture, Lahore. Among the cultivars studied, maximum plant height was recorded in carnation cultivar 'Grand Salam' (78.66

cm) closely followed by ‘Kaly’ (78.23 cm) and ‘Cinderella’ (77.96 cm). Number of shoots was highest in cultivars ‘Tempo’ (6.3) and ‘Nelson’ (6.2). Maximum stem thickness was observed in ‘Nelson’ (6.21 mm) and minimum in ‘Grand Salam’ (3.63 mm). Maximum number of internodes per stem were found in ‘Nelson’ (12.66) followed by ‘Kely’ (11.33) and ‘Grand Salam’ (11.00). Highest flower yield per plant was recorded in cultivars ‘Tempo’ (6.4) and ‘Nelson’ (6.33). Maximum number of flowers per square meter were recorded in cultivar ‘Nelson’ (198.3) followed by ‘Tempo’ (189.6). Hence it can be concluded that cultivars ‘Nelson’ and ‘Tempo’ were found superior with respect to growth and flower yield characteristics under lath house conditions.

Singh *et al.* (2014) conducted an experiment on evaluation of gerbera (*Gerbera jamesonii*) cultivars under shade net house condition at Floriculture unit, Department of Horticulture, Allahabad. The experiment was laid out in a Randomized Block Design having 14 treatments with three replication. The treatments comprised of 14 different cultivar of Gerbera. The results revealed that cultivar Danaellen was found best for obtaining maximum plant height (47.33 cm), flower diameter (11.91 cm), vase life (14.20 days) and longevity of flower (23.53 days). While, plant spread (50.97 cm) and fresh weight of flower (30.65 g) found maximum in cultivar Rosalin. The maximum number of suckers (6.33) and minimum number of days (51.45) for flower bud initiation as found in cultivar prime rose. The highest number of leaves (25.47) as found in cultivar Sangria and maximum stalk length (71.67 cm) was found in cultivar Intense. Maximum number of flower (10.22), flowers per plot (204.47) and flower yield per hectare (681333) and gross return, net return and benefit cost ratio (2043999.00 Rs./ha, 590999 Rs./ha and 1.41, respectively) in Malibu.

Roni (2014) conducted a pot experiment to find out the morpho-physiological characteristics of anthurium under shade condition at Sher-e-Bangla Agricultural University, Dhaka. Five anthurium varieties viz. V_1 (Pink anthurium), V_2 (White pink anthurium), V_3 (White anthurium,) V_4 (Light anthurium) and V_5 (Green red anthurium) were grown under three light intensities (L_0, Control or full sun, L_1 40% reduced light, L_2 60% reduced light). The highest plant height (34.4 cm) and flower stalk length (29.1 cm) were found from V_1, whereas the lowest was from V_5. Maximum spathe length (9.6 cm), spathe breadth (8.3 cm), number of flowers/plant (6.4) and highest vase life (26.7 days) were also found from V_3, while minimum results for these characters were obtained in V_5. Among the light intensities, maximum result of all attributes were recorded from L_2 (60% reduced light) whereas minimum in L_0. Results also revealed that leaf area and chlorophyll percentage were positive relation with anthurium flower yield. Maximum number of flowers (8.3) was obtained from V_3 (White anthurium) which is the best variety for flowering and 60% reduced light was the most suitable shade condition for its cultivation.

Saleem *et al.* (2013) evaluated five potential exotic cultivars of gerbera, 'Essence', 'Loveniness', 'Dune', 'Diana' and 'Sunway' to determine the cultivar effects on yield and quality, to compare their relative performance and recommend their suitability for commercial production under protected condition. Among the tested cultivars, 'Diana' performed best for early flowering, greater number of leaves/plant, number of flower/plant, stalk length and vase life.

Mahmood *et al.* (2013) evaluated ten gerbera cultivars ('Labinel', 'Lilla', 'Alp', 'Alberino', 'Bonnie', 'Avemaria', 'Mammut', 'Lexus', 'Terramixa ' & 'Sarolta') for their growth, yield and quality characteristics under protected conditions. Among the cultivars studied, there were highly significant variations observed for growth, yield and quality parameters. Longest stalk length (60.3 cm) was exhibited

by the cultivar ‘Alberino’ followed by ‘Lexus’ (59.0) and ‘Mammut’ (54.0 cm). The same cultivar also produced flowers with maximum diameter. With respect to vegetative parameters like number of leaves per plant and plant spread were also more in the same cultivar. Maximum number of flowers 135 per square meters was recorded in cv. ‘Avemaria’ (135) followed by ‘Alberino’ (125). Maximum vase life was recorded in cultivars ‘Alberino’ and ‘Lexus’ (6.6) followed by ‘Mammut’ (5.6) and ‘Sarolta’ (5.6). Excellent quality flowers were observed in cultivar ‘Alberino’ (4.8) followed by ‘Lexus’ (4.4). Cultivar ‘Alberino’ and ‘Lexus’ were found superior with respect to growth, yield and vase-life characteristics under protected conditions.

Kumar and Yadav (2013) carried out an investigation to evaluate the performance of seven genotypes under polyhouse conditions in sub-tropical mid hills of Meghalaya. Significant differences were observed for all the characters. The results revealed that genotype Monarch recorded maximum leaf length (38.75 cm), number of leaves/plant (23.22) and delayed bud burst (123.00 days) and first flower opening (130.00 days). Maximum stalk length (62.85 cm) and disc diameter (2.97 cm) was recorded in genotype Piton. Genotype Sangria recorded maximum leaf breadth (11.25 cm), number of suckers/plant (4.13) and number of ray florets/flower head (69.65 cm). Maximum plant spread (46.51 cm), stalk diameter (0.83 cm), flower diameter (12.98 cm) and vase life (11.65 days) was recorded in genotype Pink Elegance. However, genotype ‘Sazou’ recorded maximum number of flowers/plant (37.65 cm) followed by ‘Piton’ (37.25) and ‘Sangria’ (36.62). On the basis of overall performance, genotypes ‘Pink Elegance’, ‘Piton’ and ‘Sangria’ were found promising for cut flower production under polyhouse in Meghalaya conditions.

Sudhagar (2013) conducted a study on production of cut flower gerbera in protected condition. He reported that, floriculture has emerged as a lucrative profession with much higher potential in gerbera for returns compared to other agri-horticultural crops.

Singh *et al.* (2013) carried out an experiment to evaluate carnation varieties under naturally ventilated greenhouse in midhills of Kumaon Himalaya. Among eight Carnation varieties viz. Diana, Aurturo, White Dona, Pink Dona, Soto, Red King, Tuareg and Dona., evaluated under naturally ventilated greenhouse and subjected to uniform treatment and cultural package of practices, the variety Red King was found best with respect to number of branches (8.0), number of flowers/plant (35.6), fresh weight of flower (8.38 g), dry weight of flower (2.66 g), flower diameter (7.83 cm) and vase life an important post-harvest quality parameter was observed to be the superior in variety Red King (29.3 days) followed by cv Tuareg (24 days) and Pink Dona (21.3 days). On the basis of present experiment, it was concluded that cultivar Red King were found to be promising with respect to yield as well as flower quality parameters and found suitable for commercial cultivation under naturally ventilated green house in mid hills of Kumaon Himalayas.

Karthikeyan *et al.* (2013) carried out a study to observe the performance of four cultivars of carnation namely ‘Gaudina’, ‘Dona’, ‘Bizet’ and ‘Malaga’ were tried under two different environments *viz.*, wooden frame structure and steel frame structure at Ooty, The Nilgiris. The performance of the cultivars under two different growing structures were compared based on the vegetative, yield and quality parameters of the crop. Among the cultivars, Gaudina under naturally ventilated aerodynamic steel frame structure polyhouse showed better performance when compared with wooden frame structure. The longevity and performance of crop inside the steel frame structure proved better.

Shruti and Gajbhiye *et al*. (2013) studied 5 varieties of anthurium, viz. 'Caesar', 'Aymara', 'Ivory', 'Jewel', and 'Triticaca' under polyhouse. Significant differences among varieties were noted for all attributes evaluated. Variety 'Titicaca' had maximum stalk length and diameter, spathe length and breadth, spadix length, vase life and flowers per plant. Through present analysis it was noticed that, variety 'Titicaca' was exceedingly preferred because of its attractive flowers, excellent flower size, yield potentiality and long shelf life.

Kumar *et al.* (2012) carried out a study to evaluate the performance of gerbera varieties growing in naturally ventilated polyhouse in Lucknow. Seven varieties, viz. Salvadore, 'Silvester', 'Goliath', 'Zingaro', 'Sunway', 'Dana Ellen' and 'Rosaline' were grown on same type of growing media comprising soil and sand : FYM : rice husk (2 : 1 : 1) ratio. Planting was done in beds (26.0 × 0.75 × 0.60 m) in two rows (0.30 × 0.30 m) at a distance of 0.30 m between plants. Plant growth parameters and flower characteristics were evaluated. The results revealed that the variety Rosaline recorded maximum plant height (33.67 cm), number of leaves/plant (31.33), leaf length (21.67 cm), leaf breadth (10.33cm) and number of suckers/plant (11.00) followed by 'Dana Ellen' and 'Silvester'. Rosaline recorded minimum days (45.00 days) for bud initiation and days taken to first flower initiation (52.67 days) followed by 'Dana Ellen' (50.85 days). Highest values for stalk length (61.00cm), flower stalk diameter (1.99 cm) and flower diameter (11.63 cm) were recorded in Rosaline.

Bhosale *et al.* (2012) undertaken an experiment on keeping in view the importance of planting density and varietal performance on growth and quality of flowers in India on different planting densities, viz. 30 × 30 cm, 30 × 37.5 cm, 30 × 45 cm, 37.5 × 37.5 cm and 45 × 45 cm with 3 varieties Diana, Diablo and Pink Shiva. Plants grown at 30 × 30 cm produced maximum flowers/m^2/year (317.00) followed by 37.5 × 37.5 cm (304.17). The average stalk length, top diameter of

flower and number of flowers/plant/year were significantly superior in 30x 30 cm. Among the varieties cultivar Diablo proved to be the vigorous and yielded 335.63 flowers/m^2/year.

Singh and Singh (2012) conducted studies on advancing early flowering in two single petalled tuberose cultivars namely; Shringar and Mexican Single due to the bulbs planted under three different growing conditions, viz. under low plastic tunnel (planted on 2nd December, 2005), under open field conditions (planted on 2nd December, 2005) and under open field conditions on recommended planting time (planted on 2nd March, 2006). The results obtained showed that the tuberose bulbs planted under low plastic tunnel started flowering during last week of May (26th), which was 44 day earlier to the bulbs planted without tunnel and 38 day earlier to the normal recommended planting time (March) under Delhi conditions in cv. Shringar. The flower quality in terms of spike length (66.88 to 68.67 cm) and number of florets per spike (43.13 to 44.63) was not affected significantly under low plastic tunnel grown crop. The early plantings with plastic tunnels had a non-significant effect on plant height and spike length in cv. Shringar and a significant effect in cv. Mexican Single except for other growth and flowering parameters studied. However, the advanced off-season flowering in tuberose will offer higher returns to the farmers owing to an overall increase in total flowering period of the crop.

Patil *et al.* (2011) evaluated five cultivars (white, yellow, red, orange and violet) of gerbera in India. Minimum days were taken by yellow cultivar followed by white cultivar to reach full bloom. Longest stalk length was produced by white cultivar which was followed by yellow, while shortest for orange and violet. Flower number varied from 20-30. Maximum flower was produced in white cultivar followed by yellow. Maximum vase life was obtained in yellow cultivar. Cultivar white and yellow were found superior with respect to flowering, vase life and yield under polyhouse conditions.

Islam and Haque (2011) conducted a study with a view to observing the performance of two gladiolus genotypes during the rainy season under poly tunnel production system. The genotype 'GL-027' produced taller plants (73.8 cm) with longer spike (97.2 cm) and longer rachis (51.7 cm) compared to the genotype 'GL-023'. In respect of spike length (97.0 cm), rachis length (54.4 cm), weight of corm per plant (16.0 g) and weight of cormel per plant (30.3 g), 1st July planting was better than in 1st May planting. Plants grown under poly tunnel produced flower earlier (82.5 days) compared to plants grown without poly tunnel (84.6 days). Although difference of only two days in flower initiation is of no significance, but plants grown under poly tunnel performed better in respect of number of florets per spike (12.8), number of cormels per plant (8.2), weight of corm per plant (16.0 g) and weight of cormels per plant (30.6 g) than the plants grown without poly tunnel.

Mohanty *et al.* (2011) carried out an investigation on the comparative performance of rose varieties, *viz*. 'Gladiator', 'Minuparle' and 'Montezuma' under four growing environments *viz*., open field, 50 per cent and 75 per cent shade net and polyhouse condition. Montezuma performed very well with respect to several growth characters which recorded maximum plant height (60.94 cm), highest number of second order laterals (6.69) and maximum plant spread N-S (53.72 cm) and E-W (35.60 cm) direction. Gladiator performed better with respect to various floral characters like stem length of flower (30.61 cm), largest flower bud (3.54 cm) and maximum bud diameter (3.52 cm) and number of petals per plant (44.37). It also took minimum time for bud appearance after pruning and maximum flower diameter (7.26 cm). Hence, it was judged as the most ideal variety for using as cut flower.

Gharge *et al*. (2011) undertaken an investigation on evaluation of ten cultivars of carnation *(Dianthus caryophyllus* L.) with respect to vegetative and yield parameters of carnation cut flowers was under naturally ventilated poly house

condition at Hi-tech Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, 'Dharwad'. Varieties 'Yellow Firato', 'Firato', 'Diana' and 'Gaudina' were superior with respect to growth parameters like plant height, stem girth, number of shoots, length of shoots, number of leaves and length of leaves. Plant height was maximum (134.0 cm) in variety 'Yellow Firato'. The shortest (99.14 cm) plant height was observed in variety Viking. Number of shoot was maximum in variety 'Yellow Firato' (7.64). Length of shoot was maximum in variety 'Yellow Firato' measuring 107.4 cm and was superior to rest of the varieties, however minimum shoot length was recorded in variety Alibaba (81.34 cm). Varieties 'Pink Shiva', 'Alibaba' and 'Diana' had thicker and stronger stems, while variety 'Firato', 'Viking', 'Buemonde' had weaker stems. Variety 'Yellow Firato' (22.80) produced maximum number of internodes per branch, where it was recorded minimum variety Dali (15.47). Inter nodal length was maximum in variety Aicardi (7.52) and minimum in Viking (4.37 cm). Number of leaves was maximum in variety 'Yellow Firato' (214.4) and minimum in variety Alibaba (172.8). Leaf length was maximum in variety 'Buemonde' (12.48 cm). Based on the present findings it can be concluded that the varieties 'Yellow Firato', 'Diana Firato', 'Aicardi', and 'Pink Shiva' performed best with respect to growth, earliness in flowering, flower yield and quality.

Vasudevan and Rao (2010) carried out an experiment to evaluate the performance of 13 genotypes of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) under polyhouse conditions in the mid hill conditions of Garhwal Himalaya. Significant differences were studied for all the characters. The results revealed that Fiction attained the maximum plant height (48.40 cm) and plant spread (49.43 cm). Maximum number of suckers per plant (3.46) was found in 'Red Explosion'. Sunglow produced maximum number of leaves (26.33), longest leaf (47.40 cm), broader leaf (14.43 cm), longest stalk (70.04 cm), flower diameter (11.45 cm), heaviest weight of flower with stalk (26.39 g) and longest ray floret (5.36 cm).

Leaf area was maximum in 'Loveliness' (150.39 cm^2). Sunglow took minimum duration (51.24 days) for first bud appearance. Minimum duration (22.28 days) required for achieving marketable stage of flowers was found in Excellence and Entourage (23.58 days), maximum number of cut flowers per plant (14.44) was produced by genotype Loveliness. Maximum vase life (16.13 days) in water and (21.31 days) in holding solution was recorded by 'Essence' and 'Red Explosion', respectively. Essence was obtained maximum aggregate sensory scores (18.00).

Budiarto and Marwoto (2009) conducted a research in Indonesian Ornamental Plant Research Institute, Segunung, Cianjur, West Java. Twelve commercial chrysanthemum varieties, i.e. 'Sakuntala', 'Larasati', 'Kartini', 'NyiAgeng Serang', 'Dewi Ratih', 'Dewi Sartika', 'Cut Nyak Dien', 'Saraswati', 'Chandra' 'Kirana', 'Cut Nyak' 'Meutia' 'Cat Eye', and 'Town Talk' were planted as mother stocks for cutting production under two sets of environmental conditions, i.e. under plastic house and open conditions. A randomized completely block design with three replications was used in each environmental condition. The results showed that varietal differences were found significant among the varieties tested in terms of plant productivity and cutting quality in both environmental conditions. To all varieties tested, better plant productivity and cutting quality were produced by the mother plants grown under plastic house than those under open conditions. However, insignificant differences in cutting quality and average number of cuttings produced per plant were found by well adapted 'Cut Nyak' 'Dien' variety at both planting conditions.

Singh *et al.* (2009) carried out at the Greenhouse Complex of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, to standardize the potting media and varietal performance of anthurium (*Anthurium andreanum* L.) grown under protected conditions. The pot experiment was conducted in Completely Randomized Design with three replications. These treatments were prepared by volumetric ratios of basic medias viz. rice husk (2), saw dust (2), coco

peat (2), compost (2), soil (1), sand (1), FYM (1), brick pieces (1) and wooden charcoal (1) in three cultivars. Results indicate that the combinations of growing media significantly influenced the vegetative growth, flowering pattern and flower production of all varieties of anthurium. The maximum number of leaves per plant (7.40), highest number of suckers per plant (5.00) and longest inflorescence longevity (63.53 days) were recorded in treatment combination involving saw dust + wooden charcoal + soil + sand + FYM (T_6) in the ratio of 2:1:1:1:1.

Protected cultivation of chrysanthemum is beneficial for better yield and quality of flowers. Therefore Palai (2009) conducted an experiment to evaluate twelve spray type chrysanthemum for their performance under open and poly-house conditions. The experiment was laid out in factorial RBD under two conditions such as open and naturally ventilated poly house in the premises of Regional Plant Resource Centre, Bhubaneswar, India. Eleven spray type new chrysanthemums cultivars developed by different All India Co-ordinated Floriculture Improvement Project centres were chosen as the experiment material. It included ‘Arka Ravi’, ‘Yellow Gold’, ‘Ravi Kiran’, ‘Kirti’, ‘Chandrika’, ‘Neelima’ (from IIHR, Bangalore); ‘Maghi White’, ‘Mother Teresa’ (from NBRI, Lucknow) and ‘Punjab Gold’, ‘Ratlam Selection’, ‘Punjab Anuradha’ (from PAU, Ludhiana). A popular spray type cultivar, 'Flirt' was used as check. Well established rooted cuttings of the above cultivars were planted at a spacing of 30 cm × 30 cm (P × R). Adequate FYM and fertilizer @ 50:100:100 kg of NPK was applied to raise the crop successfully. The recommended cultural practices were followed, in both the crops grown in open and the poly house conditions. Observations were recorded on growth, development and flowering parameters. The best quality flowers with respect to the all floral trials were obtained in ‘Yellow Gold’, ‘Mother Teresa’ and ‘Neelima’.

Pragya *et al.* (2008) evaluated the performance of seven gerbera under protected condition at the experimental farm of Mukteshwar, India. Alberino gave maximum plant height while Lexus was found earliest for flower bud visibility. The longest stalk was recorded in Lexus. Cultivar Alberino recorded maximum number of flowers per plant. Lexus bloomed earlier than all other cultivars. Among all cultivars Alberino and Lexus performed better under protected condition.

Dhadu *et al.* (2007) conducted an experiment to investigate the feasibility of using GA_3 to increase growth and flower production in anthurium cultivars. The experiment was carried out under the Hi-tech greenhouse at ASPEE College of Horticulture and Forestry, Navsari. Climate of this place is typically tropical and humid, having annual rainfall around 1500 mm and temperature ranges from 230 to 3f 70 C in summer and 100 to 230 C in winter. Five cultivars of anthurium, viz Pumissilo, Coralis, Rosario, Condor and Patino, having good demand in cut flower trade were used for this study. Hardened tissue culture plants of one year age were procured and maintained under greenhouse. The potting medium contained rice husk: coco peat: sand: soil in 1:1:1:1 ratio. The experiment was laid out in a completely randomized design with factorial concept having five cultivars and four levels of GA_3 (300, 400, 500 ppm and 0 ppm i.e., control) and replicated thrice. Gibberellic acid solution was sprayed twice at monthly intervals starting from second month after planting. Teepol was added as surfactant and water spray was taken as control. Observations were recorded after eight months on various growth and flowering parameters. The variety Coralis and Condor were found superior with respect to growth, flowering, yield and vase life characteristics under protected condition.

Rashmi (2006) evaluated 10 elite gladiolus hybrids (Dharwad-1 to Dharwad-10) and one check variety (American Beauty) of gladiolus at the Saidapur farm of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Plant height ranged from 42.7-73.7 cm, number of leaves from 4.9-9.2

plant. Days taken for spike initiation ranged from 50.5-76.3, for first floret to show color from 65.4-86.6, for first floret to open from 69.4-90.3. The range of the spike length was recorded from73.7 cm -102.4 cm, spike girth from 0.6 cm -1.2 cm, rachis length from 44.1cm - 66.7 cm, average weight of spike from 36.8 g - 58.5 g. Number of florets ranged between 14.1-16.7/spike, length of floret 7.0-9.8, diameter of floret from 6.6 cm - 9.1 cm. Corm weight ranged from 14.6 g- 35.7 g, corm diameter from 3.1 cm -5.2 cm.

Dalal *et al.* (2006) evaluated 3 cultivars of gladiolus American Beauty, Her Majesty and Jester in Maharashtra, India under protected condition, viz. Significantly earliest 50% flowering (84.1 days) was observed in Her Majesty, followed by Jester (85.0) and last in American Beauty (91.1 days). Spike length (87.4 cm) and number of florets per spike (15.9) were significantly higher in American Beauty. Corm weight (87.4 g) and number of cormels per plant (106.5) were highest in Her Majesty and American Beauty respectively.

Femina *et al.* (2006) conducted study on four anthurium cultivars namely, Tropical, Pistache, Mauritius Orange and Passion, to ascertain the influence of four different types of growing structures on growth and quality of flowers. The treatments varied significantly showing the response of different cultivars and the growing systems. The low cost structure with UV stabilized shade net to divert 75% light intensity and U V stabilized polyethylene film (120 gsm) on top to provide protection from rainfall and sides covered with 25% of shade nets and with irrigation facilities at a cost of construction of Rs. 3001m^2 was found suitable for growing anthurium in tropical plains. Low cost structure was superior in terms of plant height (18.06 cm), plant spread (22.49 cm) and leaf area (65.30 cm). Cultivars Pistache was the best in terms of plant spread (22.41cm), leaf number (5.68) and leaf area (22 cm^2). In case of cultivars which flowered regularly, the time taken for first flowering was the shortest in Pistache (65.67 day). Leaf longevity was higher in Pistache (163.32 day) compared to Tropical (152.43 day).

Swaroop *et al.* (2006) conducted an experiment at the Research Farm of Division of Floriculture and Landscaping, IARI, New Delhi, India. The experiment was laid out in a randomized block design and had four replications for each cultivar planted on raised bed of size 1 × 1 m with 15 cm height, consisting of nine plants in each replication. The naturally ventilated low cost polyhouse measuring 20 m length, 5 m width and the frame was constructed with galvanized iron pipes for better holding of insect proof nylon mesh. Misting was used to regulate the temperature and humidity inside the polyhouse from time to time. The study consisted of five Stanadard chrysanthemum cultivars, viz. 'Thai Chen Queen', 'Snow Ball', 'Poornima', 'Tata Centenary' and 'Snow Don'. Rooted cuttings were planted in drip irrigation system. The irrigation and fertilizers were also applied through drip system to raise a healthy crop. The best quality flowers with respect to the all flower trials were obtained in 'Poornima' and 'Snow Ball'.

Talukdar *et al.* (2006) evaluated eighteen standard chrysanthemum *(Dendrathema grandiflora*) cultivars to study their performance under polyhouse cum rain-shelter and open conditions, at the Experimental Farm. Department of Horticulture, Assam Agricultural University, Jorhat. Performance of cultivars for growth characters in general was higher under open conditions while that for flower characters under polyhouse cum rain-shelter conditions. There was considerable earliness with regard to days to full bloom of the cultivars under open conditions (79.60 day) compared to polyhouse cum rain-shelter conditions (88.40 day). However, cv. Bolareoeo bloomed earlier inside polyhouse (70.33 day) compared to open conditions (79.67 day) and it was also the earliest cultivar to bloom over the two conditions (75.00 day). Maximum flower size over the two conditions was recorded for Snow Ball (19.81cm) and Sonar Bangia (18.08 cm). Snow Ball bloomed for maximum number of days (30.00) over two conditions and for additional five day inside polyhouse (33.33 day) compared to open conditions (67.00 day). Snow Ball also exhibited maximum vase life (18.25 day), with enhancement of its vase life by four day inside polyhouse (20 day) compared to

open conditions (16 day). However, almost all the cultivars exhibited maximum blooming period and vase life inside polyhouse as compared to open conditions.

Barreto and Jagtap (2006) carried out a study with 5 varietal performance of gerbera in pot culture in simple polyhouse with a wooden framework and shade net without fan and pad cooling system. The different substrates assessed were cocopeat, peat, soil rite, perlite, vermicompost and compost in various combinations. The flower returns depended on both flower quality and quantity. Coco peat combined with compost (1:1) and coco peat (60%) + perlite (20%) + rice husk (20%) produced flowers with the highest net returns in Salvador and Intense variety.

Naik *et al*. (2006) conducted a study at Saidapur Farm in Hi-tech Floriculture Unit, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Among the 11 cultivars studied, there was a significant variation for various growth, cut flower yield and quality parameters. The cv. Lexus (38.82) produced maximum number of quality cut flowers followed by Alberino (37.20), Scilla (36.95) and Bonnie (31.26). The same cultivars also produced the longest stalk, bigger sized flowers and number of ray florets apart from vegetative parameters like more number of leaves per plant, plant spread, suckers production, leaf area and leaf area index. The cv. Lexus realized maximum net return of Rs. 2,70,672 in 560 m^2 area with a B:C ratio of 2.65 followed by Alberino (Rs. 2,55,120; 2.50), Scilla (Rs. 2,52,720; 2.48) and Bonnie (Rs. 1,98, 096; 1.94) compared to other genotypes studied.

Kishan *et al.* (2005) evaluated the performance of 10 gerbera cultivars in New Delhi, India and found that variety Yellow Firato produced tallest plants with longest flowering duration. Maximum plant spreading was observed in Diana Firato. Pink Shiva performed best with respect to growth, earliness and flowering.

Thomas *et al.* (2004) conducted an experiment on evaluation of gerbera (*Gerbera jamesonii*) cultivars under shade net house condition. Institute of Agriculture Technology and Science, Allahabad. The treatments comprised of 10 different cultivars of gerbera. The results revealed that cultivar Danacllen was found best for obtaining maximum plant height (45.15 cm), flower diameter (11.80 cm), vase life (14.15 days) and longevity of flower (24.00 days). While, plant spread (48.99 cm) and fresh weight of flower (29.30 g) found maximum in cultivar rosalin. The maximum number of days (50.35) for flower bud initiation as found in cultivars prime rose. The highest number of leaves (22.45) and stalk length (45.00 cm) was found in cultivar intense. Maximum number of flower (20.50) and flower yield per hectare (625000) in Lexus.

Singh and Mandhar (2004) studied the performance of 9 exotic cultivars of gerbera (*Gerbera jamesonii*) (Diablo, Lyonella, Ornella, Sunset, Tara, Thalassa and Tiramisu, Twiggy and Whitsun) under fan and pad cooled greenhouse environments at the Indian Institute of Horticulture Research, Bangalore, Karnataka, India. The greatest plant height (48.83 cm) and number of suckers (5.16) and leaves (46.27) per plant were obtained with Tiramisu, Lyonella and Ornella, respectively, while the lowest values of the aforementioned parameters were recorded for Whitsun (47.88 cm), Sunset (3.82) and Tiramisu (26.74), respectively. Flowering was earliest (47.88 and 57.47 days for 50 and 100% flowering, respectively) in Whitsun and latest (83.10 and 88.30 days) in Tiramisu. The greatest diameter of flower (10.70 cm) and length of flower stalk (58.27 cm) were recorded for Tiramisu and Lyonella, respectively. The thickest (0.70 cm diameter) and heaviest (22.20 g) flower stalks were observed in Twiggy, whereas the thinnest (0.60 cm diameter) and lightest (13.94) stalks were observed in Whitsun. The highest total number of flowers produced per plot in a year, and the mean number of flowers per plant and per month in a year were obtained with Ornella (1058.00, 47.26 and 5.02, respectively), followed by Thalassa (988.00, 44.52 and 4.61), whereas the lowest were obtained with Tara (591.33, 29.48 and 2.82), followed by Sunset (600.00, 31.15 and 3.11).

Bhuya and Sable (2003) conducted an experiment at Karnataka, India to evaluate the performance of anthurium cultivars. Hondura, Tinora, Senator, Tropical and Pasricha for cut flower production. The cultivars significantly influenced all the vegetative, physiological and flower parameters. Hondura was the most superior cultivar followed by Senator, Pasricha, Tinora and Tropical.

Patil (2003) examined the performance of nine exotic gladiolus cultivars (Sancerre, Poonam, Sapand, Tropic Seas, Happy End, Suchitra, Yellow Stone, Sylvia and IARI Sel-1) for export quality cut flower production in Maharashtra, India under protected condition. Among the cultivars, Sapana and Happy End were earliest to flower (70.2 days) followed by Sancerre and Tropic Seas (81.3 days) while Poonam required highest number of days to flower (93.5). Spike length ranged from 74.2 cm (Happy End) to 115.5 cm (Sancerre). Sancerre had the highest number of florets per spike (18.5). The largest florets were recorded by Sancerre, Poonam, and Yellow Stone while smallest from Happy End. Sancerre and Yellow Stone had the highest number of corms per plant (2.4 and 2.6 respectively). Corm size was highest in Yellow Stone followed by Sancerre and Tropic Seas. Vase life of flowers was highest in Sancerre (10.7 days) followed by Yellow Stone (9.6 days) and Tropic Seas (9.6 days) and lowest in Happy End (6.9 days). Sancerre, Yellow Stone and Tropic Seas were superior in terms of floret color, placement and texture. Based on qualitative and quantitative characters evaluated, Sancerre, Yellow Stone and Tropic Seas were best for commercial cultivation under protected condition.

Jagadish *et al.* (2003) studied the performance of gladiolus cultivars (Aldebaran, Day Dream, Pink Friendship, George Mazure, Gold Dust, Ice Gold, Melody, Neelam, Oscar, Pusa Suhagan, Sancerre, Snow Princess, Sylvia, Surya Kiran and Vick Lin) in Uttaranchal, India under protected condition. Oscar cultivar showed best performance in respect of spike length (91.1 cm) and number of florets per spike (19.6). The number of corms per plant was highest in Melody (4.0) and lowest in Sylvia.

Gajanana *et al.* (2003) carried out an investigation to evaluate the performance of six genotypes under polyhouse conditions in India. The result revealed that genotype Lexus recorded maximum leaf length (38.75 cm), number of leaves/plant (23.22) and delayed bud burst (123.00 days) in first flower opening (130.00 days). Maximum stalk length (62.85 cm) and disc diameter (2.97 cm) was recorded in genotype Piton. Genotype Sangria recorded maximum leaf size, number of suckers/plant and number of ray florets/flower head. Maximum plant spread, stalk diameter, flower diameter and vase life was recorded in genotype Pink Elegance. However, genotype Sazou recorded maximum number of flowers/plant (37.65) followed by Piton (37.25) and Sangria (36.62). On the basis of overall performance, genotypes Pink Elegance, Piton and Sangria were found promising for cut flower production under polyhouse.

Singh (2002) conducted a study to evaluate eight varieties of gerbera for growth and flowering under polyhouse in India. The experiment was laid out in Randomized Block Design (RBD) with three replications having ten plants each in raised beds under polyhouse. Among the varieties studied, there were highly significant variations observed for growth, yield and quality parameters. The data revealed that among all the eight varieties under study, Dune had significantly highest plant height (53.50cm). The same cultivar also required minimum days (39.68) for visibility of flower bud, maximum flower size (14.55 cm), flower number (10.14) and stalk length (65.00 cm). With respect to vegetative parameters like number of leaves per plant was recorded highest in variety Goliath (35.00). Highest number of suckers per plant was found in variety Malibu (4.43). On the basis of overall performance, varieties Dune, Goliath and Malibu were found superior with respect to growth and flowering characteristics under polyhouse.

Kale *et al*. (2002) carried out an experiment under naturally ventilated polyhouse to evaluate ten varieties of carnation (*Dianthus caryophyllus* L.) for flowering and

flower quality parameters. Varieties Diana and Yellow Firato were found early to initiate flower buds and opening of flower buds. Among the flower quality parameters, flower stalk length was highest in variety Yellow Firato, followed by Diana, whereas the girth of flower stalks was found to be highest in variety Pink Shiva, Diana recorded higher diameter of flowers. Number of petals recorded was highest in variety Pink Shiva, Yellow Firato and Viking recorded longer life in vase. The weight of flower was highest in variety Pink Shiva followed by Diana and Firato. The best quality flowers with respect to the all flower traits were obtained in Diana, Yellow Firato and Pink Shiva.

Kumar and Kumar (2001) studied effect of different growing media with varietal performance on yield and quality parameters on gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.). The plants grown in earthen pots filled with enriched cocopeat produced flowers having maximum stalk length (59.84 cm), diameter (9.69 cm) and number of ray florets having maximum stalk length (59.84 cm), diameter (9.69 cm) and number of ray florets (68.67) in Dune. The gerbera plants with soil mixture produced highest flower stalk thickness (0.86 cm) and weight of flower (21.19 g) in Forza. The maximum number of flowers per plant (15.53) and per square meter (139.80) were recorded with enriched cocopeat in earthen pots with Lancaster variety.

Ambad *et al*. (2001) conducted a study to identify the suitable gerbera cultivars under naturally ventilated polyhouse with respect to yield and quality cut flowers in India. Among the eight cultivars studied there were wide and highly significant variations observed for various growth, floral, cut flower yield and quality parameters. The cultivar Lexus (29.30) produced maximum number of quality cut flowers followed by Scilla (25.90). The same cultivars were also produced the longest stalk length, bigger sized flowers and number of ray florets compare to other cultivars. With respect to vegetative parameters like number of leaves per

plant, plant spread, suckers production, leaf area and leaf area index were also maximum in the same cultivars. Similarly plant spread and number of leaves also showed positively and significant association with flower yield, flower diameter and length of ray florets. The cv. 'Lexus' realized maximum net return of Rs. 2,68,545 in 550 m^2 area with a B:C ratio of 2. 59 followed by Scilla Rs. 2, 50, 250; compared to other genotypes studied.

Sanjai and Brahma (2000) evaluated 10 gladiolus cultivars under polyhouse for cut flower and corm production in Ladakh, India and found that cultivar Princess Margaret Rose showed maximum plant height. Cultivar Victor Borge showed higher number of flower, corm and cormel per plant followed by White Prosperity Eurovision and Novelty.

Sidhu and Arora (2000) evaluated six gladiolus cultivars for summer flower production at Ludhiana in Punjab, India under protected condition and reported that cultivar White Prosperity produced significantly tall plants (130.9 cm) followed by Pole Position (11.6 cm). White Prosperity produced the longest spikes (102.3 cm) and size of florets was maximum in cultivar Rose Supreme (8.9 cm). Corm and cormel weight was significantly highest in cultivar Novalux. However, number of corms per plant was highest in cultivar White Prosperity (1.3) and number of cormels per plant was highest in cultivar Summer Sunshine (12). It was also found that cultivar Eurovision (5.2 days) showed longest vase life.

Choudhury *et al*. (1998) carried out an experiment to observe performance of some gerbera (*Gerbera jamesonii*) cultivars under the agro-climatic condition of Jorhat, Assam. Ten cultivars of gerbera were evaluated for growth and flowering parameters at Jorhat. Cultivars Popular, Evening Bells, Red Monarch and General Kaiser were promising under Jorhat conditions.

Pant *et al.* (1998) evaluated 40 cultivars of gladiolus at Uttar Paradesh, India. Apple Blossm (92.8 cm), Piccardy (87.44 cm) and Oscar (86.9 cm) had longest spikes and Carmine was the earliest to flower (82.3 days). Friendship had more florets per spike (19.5) followed by Oscar (17.5). Hn Van Mac Green had the heaviest spikes (123.1 g) followed by Oscar (122.3 g). Among the cultivars, Hawai produced more corms per plant (4.4).

An investigation was carried out by Singh *et al.* (1997) on gladiolus cultivars (Oscar and Friendship) in Nagaland, India. Spike length and number of florets per spike were higher in Oscar (77.6 cm and 18.2, respectively) than in Friendship (69.2 cm and 12.7 respectively) but floret diameter and vase life were similar in both the cases under protected condition.

Hegde (1994) studied the performance of gladiolus cultivars under at Dharwad, India under protected condition. From the experiment, it was found that cultivar Summer Pearl recorded the longest spike (100.7 cm). It was also found that daughter corm weight (97.2 g), number (2.5), size (7.2 cm) and vase life (15.0 days) were maximum in cultivar Summer Pearl under protected conditions.

Ravidas *et al.* (1993) evaluated 5 gladiolus cultivars (Agnirekha, American Beauty, Friendship, Mansoer Red and True Yellow) in Kerala, India under protected condition. American Beauty was superior to other cultivars with regard to all vegetative and floral characters.

Saini *et al.* (1991) studied the performance of six gerbera cultivars at Hissar in Haryana state, India and found that maximum plant height was recorded by the cv. Lexus. It was also found that Alberino was superior in respect of stalk length, flowering and vase life. Mammut was good for sucker production.

Dod *et al.* (1989) conducted studies at Akola in the state of Maharashtra in central India revealed that cv. Dibonar was best among different cultivars of gladiolus with respect to plant height, number of flower and flowering duration under polyhouse.

Nalwadi *et al.* (1988) conducted an experiment to evaluate the performance of anthuriums. Among the ten varieties tried, number of leaves (5.2), leaf length (18.4 cm), leaf breadth (14.8 cm) and leaf area (237.4 cm^2) was highest in variety 'Esmeralda' compared to other varieties. More number of suckers (4.1) was found in variety Ivory. Floral characters like stalk length (39.4 cm), stalk diameter (6.8 mm) and girth (18.33 m), spathe length (15.7 cm), spadix length (8.2 cm,) number of flowers per plant per year (9.3) and vase life (21 days) was highest in the variety Esmeralda.

Singh and Singh (1987) studied the performance of eleven gladiolus cultivars in Delhi and reported that cultivars Friendship and Melody were most suitable for floral characters. The number of days to first floret opening varied from 83.4 to 119.3 days. The early cultivars which flowered between 75 to 85 DAP were Snow Princess, Happy End and Vinks Glory. Cultivar Green Wood Pecker which flowered between 86 to 95 DAP. The cultivar was Sylvia. Friendship and Melody performed better for corm and cormel multiplication and found that the cultivar Sylvia produced highest number of cormels.

Misra *et al.* (1987) in their experiment at Katrain in Himachal Pradesh of India with 12 cultivars of gladiolus found that cultivar Salmon Queen had maximum spike length, rachis length, highest number of florets, floret diameter and vase life whereas Katrain Local and Psittacinus remain poor.

CHAPTER III
MATERIALS AND METHODS

Gerbera crop has little tolerance to high rainfall and cool temperature; grows well under partial shade and the exotic ones have to be cultivated in a partially modified structure (polytunnel) to produce quality blooms (Sujatha and Khan, 1997). The Research work was carried out to study the "Performance of gerbera cultivars under protected condition" during January 2014 to March 2015 at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The materials and methods that were used for conducting the experiment are presented in this chapter under the following sub-headings:

3.1 Experimental site

The experiment was conducted at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The location of the site was about 35 km North of Dhaka city with $24^0 09'$ N latitude and $90^0 26'$ E longitude and elevation of 8.40 m from the sea level (Naznin *et al.*, 2015).

3.2 Agro-Ecological Zone

The experimental field belongs the Agro-ecological zone of AEZ-28 under Modhupur Tract.

3.3 Soil

The soil of the experimental field was silty clay loam in texture and acidic in nature. Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Gazipur and have been presented in Appendix-I.

3.4 Climate

The climate of experimental site was under the subtropical region, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon, period or hot season from March to April and the monsoon, period from May to October. The weather data of the growing period are presented in Appendix II.

3.5 Experimental material

Seven genotypes of gerbera with BARI Gerbera-1 were collected from different sources for this investigation. Among them, 2 from Bangladesh, 4 from India, 1 from China and 1 from Malaysia. Suckers were used as planting materials. Sources of collection are summarized in Table 1.

Table 1. Source of gerbera genotypes/variety used in the study

Genotypes/variety	Source of collection
V_1	Bangladesh
V_2	Bangladesh
V_3	China
V_4	India
V_5	India
V_6	Malaysia
V_7	India
V_8 (BARI Gerbera-1)	India

3.6 Experimental treatments

It was a single factor experiment included with eight genotypes of gerbera which were coded as follows: V_1, V_2, V_3, V_4, V_5, V_6, V_7 and V_8 (BARI Gerbera-1) used as check.

3.7 Experimental design

The experiment was laid out in Randomized Complete Block (RCB) design with three replications (Plate 1). The unit plot size was 2 m × 2 m. The plots were raised up to 0.20 meter.

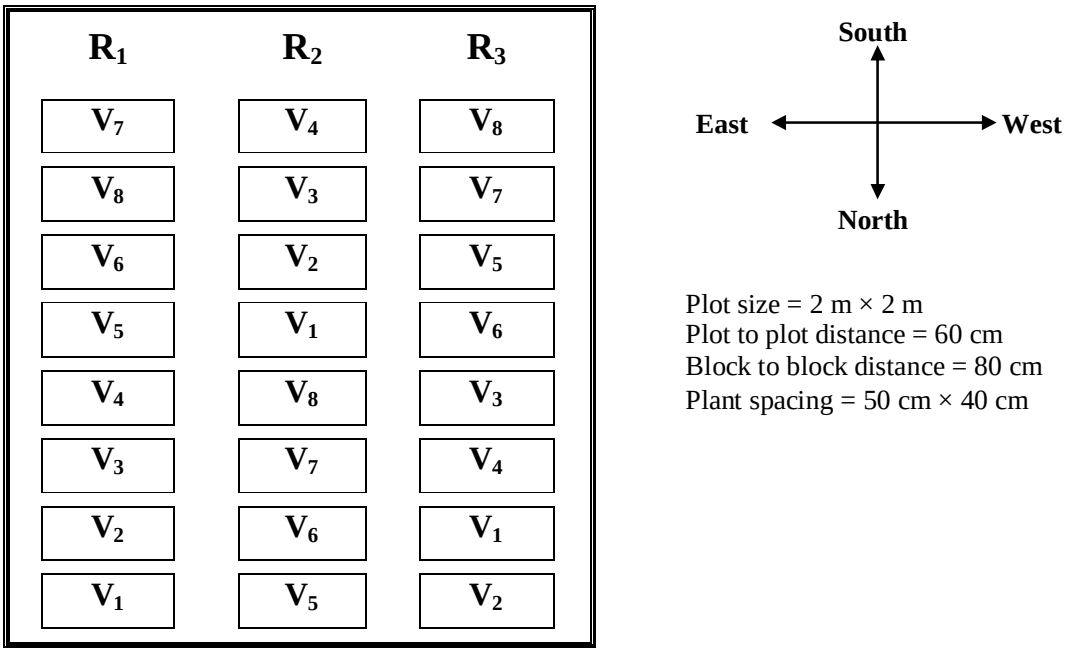

Figure 1. Layout of the experiment

3.8 Land preparation

The experimental plot was first opened on December 2014 with a power tiller for sun curing for 7 days before next ploughing. The land was then ploughed and cross ploughed several times using power tiller to obtain a good tilth. Ploughing was followed by laddering for breaking large soil clods and for levelling the land surface. The weeds and stubbles were removed from the land just after laddering with special care to remove the rhizomes of mutha grass.

3.9 Application of manure and fertilizer doses

The total amount of well decomposed cowdung, cocodust, TSP, MoP, B, Zn and S were applied during the final land preparation to incorporate them into the soil properly. Urea was applied in two equal installments at 35 and 65 days after planting of sucker (Table 1).

Table 2. Manure and fertilizer doses

Manures/ fertilizers	Dose/ha	During land preparation	35 days after sucker planting	65 days after sucker planting
Cowdung	10 t	10 t	-	-
Cocodust	2 t	2 t	-	-
TSP	250 kg	250 kg	-	-
MoP	225 kg	225 kg	-	-
Urea	280 kg	-	140 kg	140 kg
B	2 kg	2 kg	-	-
Zn	3 kg	3 kg	-	-
S	30 kg	30 kg	-	-

(Jamal and Raju, 2013)

3.10 Planting of suckers

Mother plants (large clumps) (Plate 2a) were divided into smaller units called suckers (Plate 2b). Before transplanting in the beds, the roots and leaves of the suckers were trimmed keeping the central shoot intact. Sucker of eight cultivars having uniform vigour and age were selected and planted on January, 2014 at 5.0 cm depth in furrows which were field with coco peat media by following the spacing of 50 cm × 40 cm under polyshade net. The polyshade net was hanged out with side height 2.0 meter and centre height of 3 meter.

(a) Mother plant **(b) Sucker ready for planting**

Plate 1 : Planting material of gerbera

3.11 Intercultural operations

3.11.1 Weeding

The experimental field was kept weed free by intercultural operations every 15 days interval started three weeks after transplanting.

3.11.2 Earthing up

The soil at the base of each plant was raised 25 - 30 cm at 40, 60 and 80 days after planting to make a continuous ridge for facilitating easy drainage of excess water.

3.11.3 Irrigation

Gerbera needs through irrigation instead of light sprinkling at frequent intervals as it blocks capillary tubes. So irrigation was followed from the day of transplanting in the field and maintained every 20 days interval. The surface of the experimental plot kept dry between irrigations to avoid dampness that encourages the development of Botrytis and Crown rot.

3.11.4 Disease and pest management

Diseases can be a major limiting factor for gerbera production. The experimental crop was affected by Powdery mildew during the early growing stage. Control measures were taken by spraying Dithane M-45 @ 2 ml/l against the disease. The fungicide was sprayed twice at 15 days interval. The crop was also attacked by mites during the growing stage. The mite was controlled by spraying Omite @ 1.5 ml/l of water. The miticide was sprayed two times at 15 days interval.

3.11.5 Selections and tagging of plants

Five plants from each plot were selected randomly and marked by tagging for recording data.

3.11.6 Harvesting of flowers

The spikes were harvested when the flower attained commercial stage (outer two rows of disc florets are perpendicular to the stalk).

3.12 Data collection

Data were collected from 5 plant samples taken at random from each unit plot. Gerbera generally start flowering in about three months after transplanting. When the outer two rows of disc florets remained perpendicular to the flower stalk, then data were collected on the following qualitative and quantitative parameters:

3.12.1 Qualitative traits

3.12.1.1 Colour of flower

The colour of flower was determined by comparing with colour chart and eye estimation. Varieties of colour were recorded.

3.12.1.2 Types of flower

Types of flower are graded as decorative, single and spider according to Bose *et al.* (2003).

3.12.1.3 Colour of disc floret

The disc floret colour was determined by comparing with colour chart and eye estimation.

3.12.1.4 Colour of disc floret

The disc floret colour was determined by comparing with colour chart and eye estimation.

3.13 Quantitative traits

3.13.1 Plant height

Plant height refers to the length of the plant from ground level to tip of erect leaf. Height of 5 randomly sampled plants of each unit plot was measured and the mean was calculated. It was measured in centimeter (cm).

3.13.2 Number of leaves

Number of leaves per plant was recorded by counting all the leaves from 5 randomly selected plants of each unit plot and the mean was calculated.

3.13.3 Length of leaves

The length of leaves from 5 randomly selected plants was measured by a measuring scale from leaf base to the tip in middle and was expressed in centimetre (cm).

3.13.4 Breadth of leaves

The breadth of leaves from 5 randomly selected plants was measured by a measuring scale from one side of the middle and was expressed in centimetre (cm).

3.13.5 Plant spread

The plant spread was measured in cross way (North-South and East-West) by measuring scale. The average of the two measurements was done and expressed in centimetre (cm).

3.13.6 Number of sucker

Number of suckers per plant was recorded by counting suckers from 5 individual plants and then mean was calculated.

3.13.7 Days to flower bud visibility

It was recorded by counting the days from planting to first visibility of flower bud in the plant from each unit plot.

3.13.8 Days to full bloom

It was recorded by counting the days from planting to full blooming of flower in the plant from each unit plot.

3.13.9 Number of flower

Number of flowers produced per plant was counted and recorded.

3.13.10 Flower size

Flower size was measured in cross way following North-South and East-West position by a measuring scale and the average of the two measurements was done and expressed in cm for a single flower. Later on, the mean of individual flower size from 5 selected plants was calculated.

3.13.11 Number of ray florets

Number of ray florets produced per flower was counted and recorded. After collecting five flowers from selected entities the ray florets were counted and finally mean was calculated.

3.13.12 Ray floret size

Diameter of ray florets was measured in cross way by scale and expressed in centimeter.

3.13.13 Disc florets weight

Weight of disc floret was measured and expressed in grams.

3.13.14 Stalk length

Stalk length of the flowers was measured from the point of origin of stalk to the point just below the flower head and the average stalk length of flowers was recorded and expressed in centimeter.

3.13.15 Flower stalk weight

Weight of flower stalk was measured and expressed in grams.

3.13.16 Flower stalk diameter

Diameter of flower stalk were measured and expressed in centimeter.

3.13.17 Shelf life

It was recorded by counting the days from first visibility of flower bud to senescence in the field (Negi *et al.,* 1983).

3.13.18 Vase life

For good vase life, cut flowers should be placed in fresh water immediately after harvest. The flower spikes were harvested at late afternoon with sharp sterile knife when the outer two rows of disc florets remained perpendicular to the flower stalk

or two whorls of ray florets open. The flower spikes were then carried out to the Horticulture Research Centre Laboratory, BARI, Joydebpur, Gazipur and placed in the glass bottles partially filled with 100 ml fresh water to study the vase life of gerbera and expressed in days.

3.13.19 Flowering duration

Flowering duration was recorded from the time of first floret opening to the maximum freshness in 5 randomly selected spikes of plants in whole span of time and expressed in days.

3.13.20 Flower quality

Flower quality was determined with the help of scale ranging from 1 to 5 as very poor, poor, satisfactory, good, excellent, respectively (Khosa *et al.,* 2011). A panel of five judges was asked to perform sensory assessment using the above mentioned scale.

3.14 Statistical analysis

The collected data for various traits were statistically analyzed using MSTAT-C computer package programme. The mean for all the treatments was calculated and the analysis of variance for each of the characteristics was performed by F (variance ratio) test. The differences between treatment means were separated by Duncan's Multiple Range Test according to Steel *et al.* (1997) for the interpretation of the results.

CHAPTER IV
RESULTS AND DISCUSSION

The results obtained from the present investigation on various character of growth, flowering and yield of gerbera cultivars under protected condition revealed significant differences among the cultivars have been presented and discussed in this chapter under the following sub-headings.

4.1 Qualitative traits of gerbera genotypes

The qualitative traits of eight gerbera genotypes are presented in Table 3. Variations were observed in respect of flower colour. The colours of flower were categorized into white, yellow, red, pink, majenta, orange and pink rose. Type of flowers was graded as decorative, spider and single. Among the genotypes, 75% were decorative, 12.5% for spider and the rest 12.5% for single (Figure 2). Variations were also observed in respect of leaf colour. All the germplasm were categorized into 3 groups on the basis of their colour of leaf. They were green, light green and deep green (Table 3). As regards to the colour of disc floret, the observed germplasm showed remarkable variation such as yellow withblakish centre, reddish yellow, Pink rose with blackish centre , creamy white, light pink with blakish centre, orange blackish centre, majenta blackish centre and red blackish centre. The variability on disc floret colour of gerbera are shown in Plate 2.

Table 3. Qualitative traits of different gerbera genotypes

Genotypes	Leave colour	Flower colour	Disc floret colour
V_1	Light green	Yellow	Yellow blakish centre
V_2	Green	Red	Reddish yellow
V_3	Light green	Pink rose	Pink rose blackish centre
V_4	Light green	White	Creamy white
V_5	Green	Light pink	Light pink blakish centre
V_6	Green	Orange	Orange blackish centre
V_7	Deep green	Majenta	Majenta blackish centre
V_8 (BARI Gerbera-1)	Green	Red	Red blackish centre

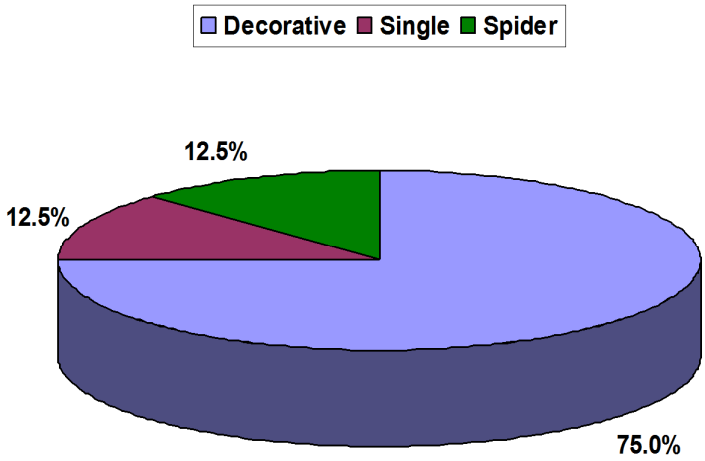

Figure 2. Variability in flower type

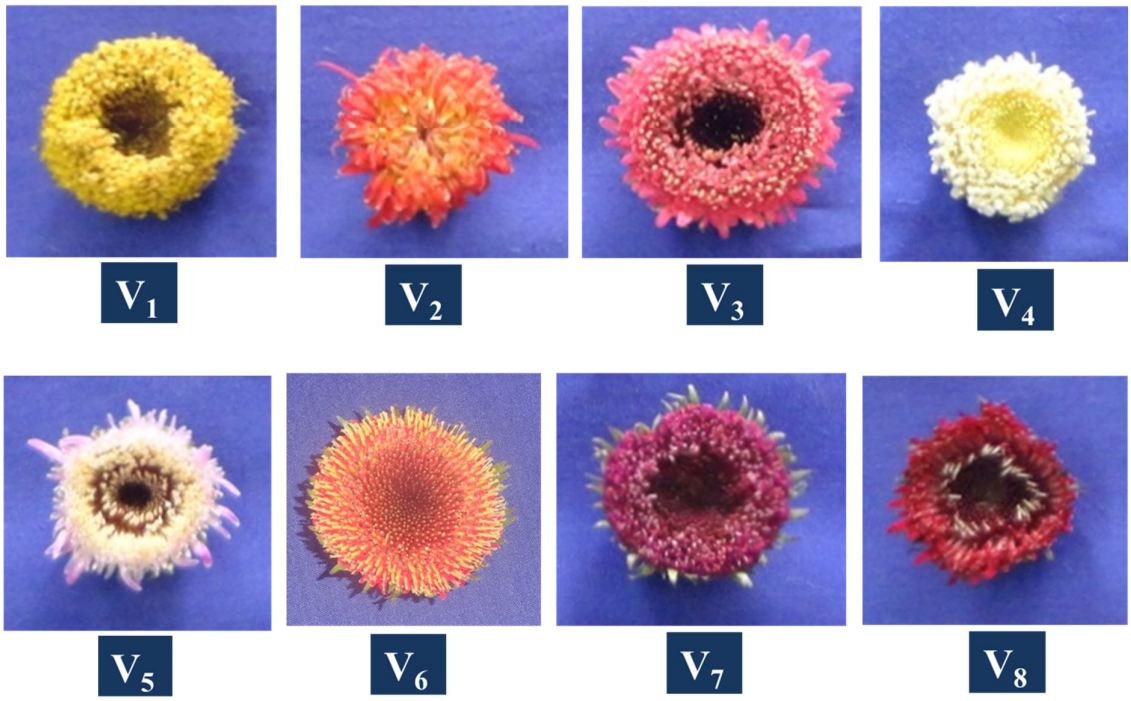

Plate 2. Disc floret of different genotypes of gerbera

4.2 Plant height

Analysis of variances revealed marked differences among the genotypes in respect of plant height (Appendix III). It varied from 20.4 to 30.0 cm where the tallest plant was produced by the genotype V_6 and the shortest plant was recorded in

genotype V_2 (Table 4). The co-efficient of variation (cv.) was moderately high for this trait indicating the presence of variability among the genotypes. Singh and Mandhar (2004) and Chauhan (2005) conducted a performance trial of gerbera cultivars and reported that plant height ranged from 18.8-37.8 cm which was not at par with the present investigation. The variation observed here might be due to difference in genetic constituents among the genotypes along with environmental effects.

4.3 Number of leaves

Significant variation was observed as to the number of leaves among the genotypes. The maximum number of 20.0 leaves was produced by the cultivar V_3 closely followed by V_6 and V_7 with 18.0 and 17.5 leaves per plant, respectively. On the contrary, the cultivar V_1 produced minimum number of 9.0 leaves/plant. Mahanta and Paswan (2003) and Nanjan (1994) evaluated a number of gerbera cultivars and observed variation (10-30) in case of number of leaves per plant which was partially in consonance with the present study. The co-efficient of variation (cv.) for number of leaves/plant was found higher indicating the presence of variability among the genotypes providing scope for selection within the genotypes for the trait. This variation occurred due to genotypic variation along with environmental effects as influenced for its expression. Plants produce food materials through the process of photosynthesis. Generally, the increasing number of leaves, photosynthesis is supposed to be increased, thus plant produces more photosynthates can influence its growth and development in the long run. Genotypes those produced more leaves had more scope for higher growth leading to higher yield.

4.4 Leaf length

Leaf length was affected by genotypes and varied from 15.4 cm to 25.0 cm (Plate 3). The longest leaf (25.0 cm) was recorded in V_3 followed by V_4, V_6 and

(22.0 cm) while the shortest one was in V_2 (15.4 cm). Leaf length of gerbera varied among the cultivars and maximum 25.0 cm were found by Sanker *et al*. (2003). Reddy *et al*. (2003) and Mohanta *et al.* (2003) also found the variation in leaf length of gerbera that represent the resemblance of the present study.

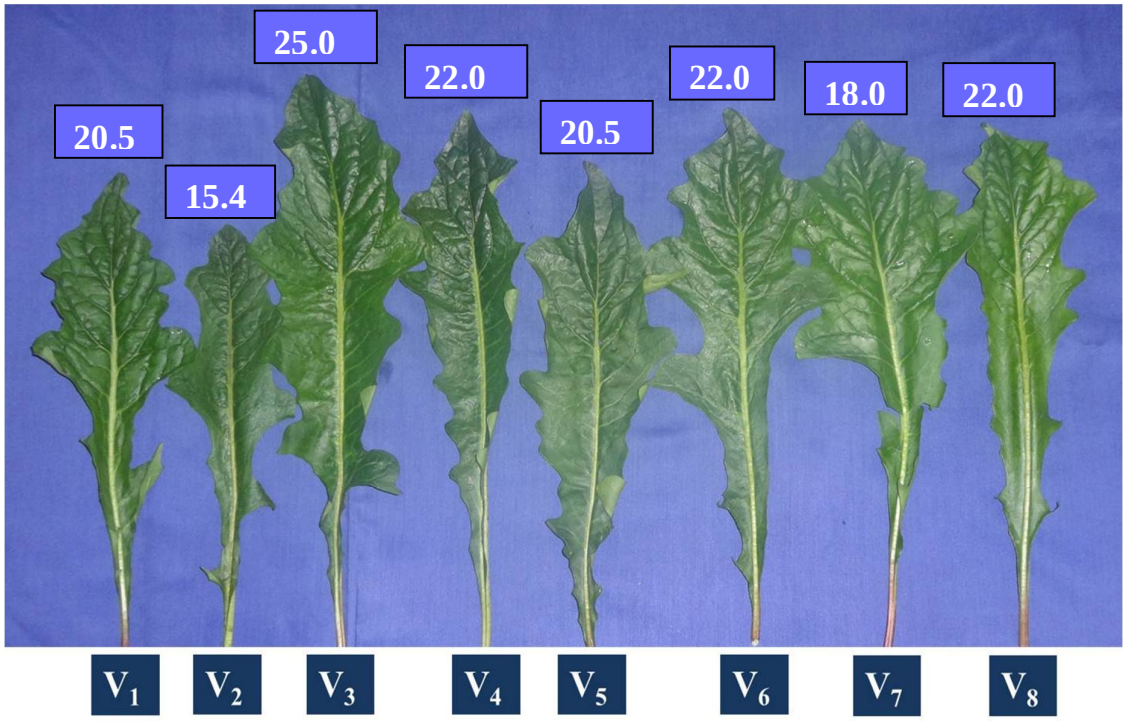

Plate 3. Leaf length of different gerbera genotypes

4.5 Leaf breadth

Significant variation was observed as to the leave breadth among the genotypes (Table 4). The longest leave breadth 8.5 cm was produced by the cultivar V_6 and V_7followed by V_3 (8.4 cm). On the contrary, the cultivar V_2 produced shortest leave breadth of 6.0 cm. The variation in leaf breadth due to variation in cultivars and that were genetically and environmentally controlled. The results are also in accordance with the findings of Singh and Ramachandran (2002) and Mahmood *et al.* (2013) in gerbera.

Table 4. Vegetative growth of different genotypes of gerbera

Genotypes	Plant height (cm)	Number of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Plant spread (cm)
V_1	25.4 b	9.0 c	20.5 b	7.7 ab	8.0 b
V_2	20.4 c	17.0 ab	15.4 c	6.0 b	12.0 ab
V_3	29.0 ab	20.0 a	25.0 a	8.4 a	15.0 a
V_4	27.0 ab	13.0 bc	22.0ab	7.5 ab	12.5 ab
V_5	28.0 ab	16.0 ab	20.5 b	8.0ab	13.0ab
V_6	30.0 a	18.0ab	22.0 ab	8.5 a	13.9ab
V_7	27.5 bc	17.5ab	18.0 bc	8.5 a	13.7ab
V_8	26.3 ab	15.0 ab	21.8 ab	7.8 ab	12.3 ab
Level of sig.	*	*	*	*	*
CV (%)	**15.6**	**16.3**	**12.2**	**13.3**	**16.4**

Means having same letter(s) and without letters in a column are not significant by DMRT.
* indicates significant at 5% level.

4.6 Plant spread

The character plant spread ranged from 8.0 cm -15.0 cm. The maximum plant spread of 15.0 cm was observed in V_3 closely followed by V_6 (13.9 cm) and V_7 (13.7 cm).The cultivar V_1 had minimum plant spread of 8.0 cm. This difference among the cultivars may be due to bigger sized leaves produced by respective cultivars. The results are in accordance with the findings of Gharge *et al.* (2009) and Chauhan (2005) in gerbera. The highest range of co-efficient of variation (cv.) was also observed for plant spread studied indicates for good scope of selection within the collected genotypes. Variation in plant spread was due to the inherent genetic character of the individual cultivars and also it depended upon the leaf size of the cultivars.

4.7 Number of sucker

Variation regarding number of sucker per plant among the genotypes was observed and varied from 4 to 8.The highest number of 8 suckers per plant was produced by V_3 where the genotype V_1 produced the lowest number of 4 suckers per plant (Figure 3). Sujatha *et al.* (2002) and Emongor (2004) conducted an experiment with gerbera plants under protected condition and reported number of suckers varied from 4-10 which was partially similar with the present study and also mentioned plants with more number of leaves produced more photosynthates that converted to sink; the rest of the photosynthates have been used for the production of suckers. The cultivars V_3 ,V_6 and V_7 which produced higher number of leaves per plant exhibited greater plant spread and produced higher number of suckers per plant compared to other cultivars indicating a positive correlation between number of leaves and suckers which is in accordance with the results of Chobe *et al.* (2010) and Malik *et al.* (2013) in gerbera.

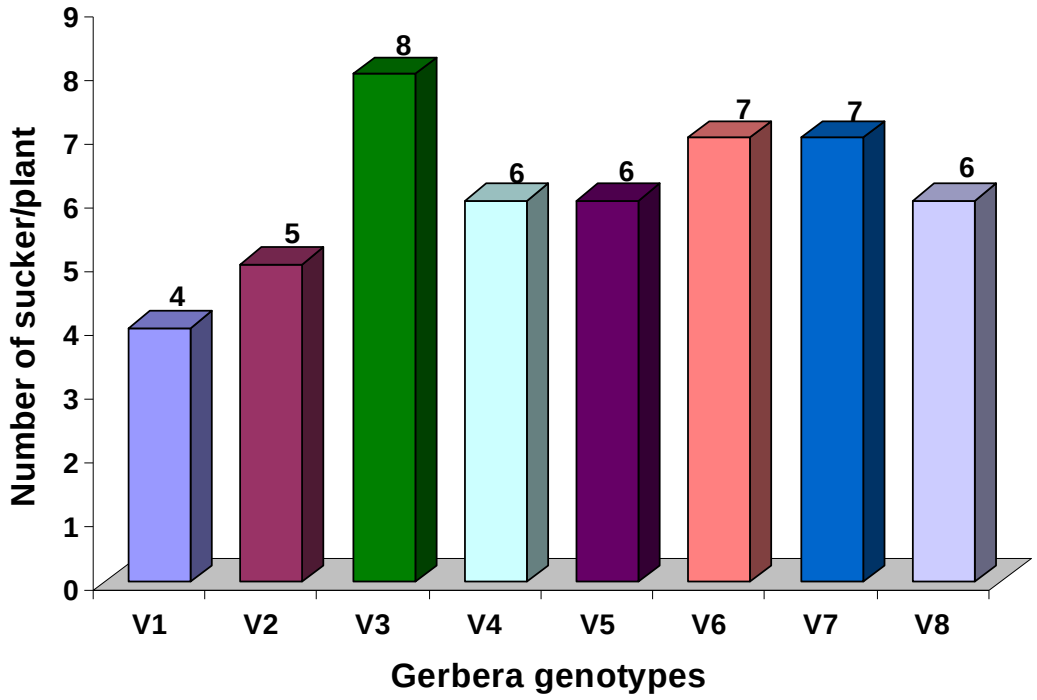

Figure 3. Production of suckers of different gerbera genotypes

4.8 Days to flower bud visibility

Marked genotypic differences were recorded in respect of number of days required for first flower bud visibility among the genotypes under protected condition. The genotype V_3 took minimum of 69 days to first flower bud visibility closely followed by V_6 (71.0 days) and V_7 (72.0 days).The two genotypes V_2 (77.0 days) and V_1 (75.0 days) took maximum duration to initiate flower bud visibility. In a varietal trial, Nair and Medhi (2002) reported that the varieties required 70-80 days to first flower bud visibility which was in consonance with majority of the genotypes under investigation. Thedifferences in days required to first flower bud visibility were due to the presence of variable genotypes obtained from different collection sources. Production of flower in a plant is controlled by photoperiod in association with the genetic factor available for expression.

Table 5. Flower characteristics of gerbera genotypes

Genotypes	Days to flower bud visibility	Days to full bloom	Flower size(cm)	No. of ray florets	Ray floret size (cm)	Disc florets weight (g)
V_1	75.0 ab	85.0 ab	9.3 ab	43.0 cd	1.8 ab	1.7 ab
V_2	77.0 a	89.0 a	6.5 b	40.0 d	1.2 b	1.3 b
V_3	69.0c	81.0 c	10.0 a	55.0 a	2.8 a	2.8 a
V_4	74.0 b	87.0 ab	9.2 ab	50.0 b	2.0 ab	2.0 ab
V_5	73.0 bc	85.0 ab	9.3ab	48.0 bc	2.2 ab	2.4 ab
V_6	71.0 bc	84.0 b	9.9 a	53.0 ab	2.5 ab	2.5 ab
V_7	72.0 ab	84.0 b	9.8 a	52.0 ab	2.4 ab	2.4 ab
V_8	74.0 b	86.0 ab	9.3ab	45.0 c	2.0 ab	2.3 ab
Level of sig.	*	*	*	*	*	*
CV (%)	**11.7**	**12.5**	**14.7**	**12.5**	**11.3**	**9.8**

Means having same letter(s) and without letters in a column are not significant by DMRT.* indicates significant at 5% level.

4.9 Days to full bloom

Marked genotypic differences were recorded in respect of number of days required for full bloom among the genotypes under protected condition. The genotype V_3 took minimum of 81.0 days to full bloom closely followed by V_6 and V_7 (84.0 days) and V_2 (89.0 days) took maximum days to full bloom visibility. In a varietal trial, Kumar *et al.* (2014) reported that the varieties required 80-90 days to full bloom of gerbera which was in consonance with majority of the genotypes under investigation. This variation might be attributed to the inherent varietal character of the cultivars as have also been reported by Pattanashetti *et al.* (2009) in gerbera. The full bloom of flower from visibility of bud was generally early in cultivars with more number of leaves, higher leaf area and more number of suckers.

4.10 Number of flowers per plant

Distinct variation was observed in respect of number of flowers within the genotypes (Figure 4). The maximum number of flowers per plant was produced by V_3 (20) closely followed by V_6 and V_7 (18). The genotypeV_1 produced the lowest number of 10flowers per plant. The number of flowers per plant varied from 10.0 - 25.0 as reported by Negi *et al.* (1983) from their experiment at the Haryana Agricultural University Farm, Hissar, India. Their result has similarity with the present study. The increase in flower number may be attributed to the greater leaf area and more number of leaves per plant as well as plant spread which might have resulted in production and accumulation of maximum photosynthates, ultimately resulting in more number of flowers with bigger size. This was in accordance to the findings of Kumar and Yadav (2013) in gerbera under protected condition.

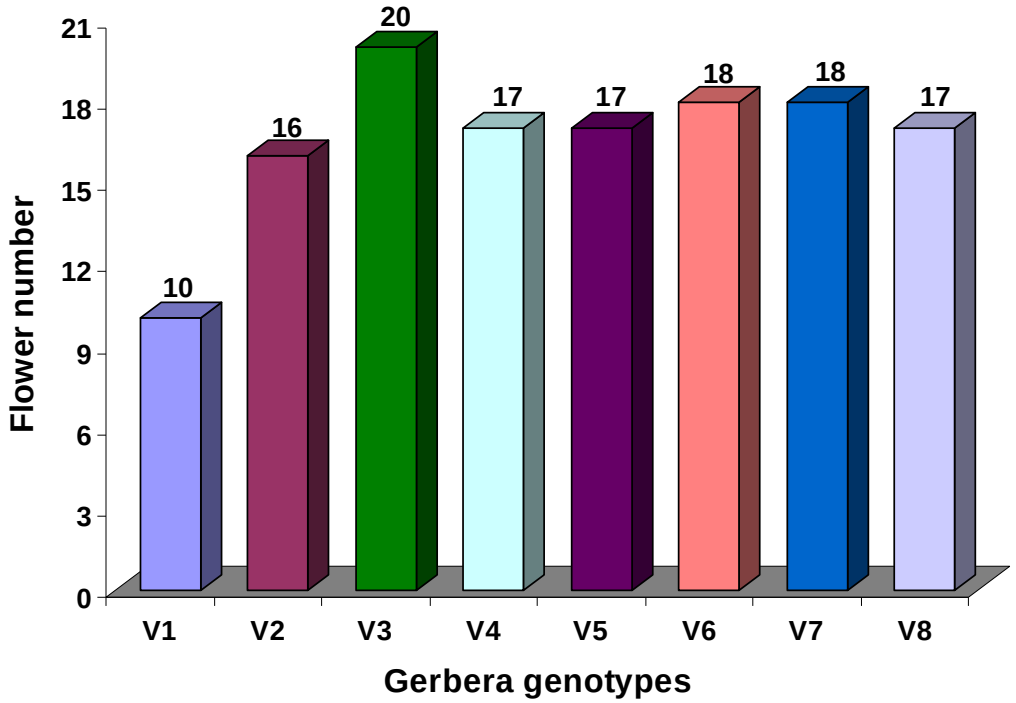

Figure 4. Flower number in different genotypes of gerbera

4.11 Flower size

It was revealed that flower size varied significantly and ranged from 6.5 cm to 10.0 cm. The genotype V_3 showed the highest flower size (10.0 cm) followed by genotype V_6 (9.9 cm) and V_7 (9.8 cm) respectively. The lowest flower size (6.5 cm) was observed in genotype V_2 (Table 6). Sujatha and Medhi (2002) conducted an experiment with 25 genotypes of gerbera and found flower size varied from 6.5–11.5 cm which was at par with the present investigation and also mentioned this difference due to inherent genetic factors.

Table 6. Flower characteristics of gerbera genotypes

Genotypes	Length of flower stalk (cm)	Stalk weight (g)	Flower stalk diameter (cm)	Shelf life (days)	Vase life (days)	Flower quality
V_1	35.0 b	15.0 c	0.15 bc	8.0 bc	7.0 bc	2.8 ab
V_2	30.0 c	10.0 d	0.09 c	7.0 c	5.0 c	2.5 b
V_3	40.0 a	25.0 a	0.55 a	17.0 a	15.0 a	4.3 a
V_4	36.0 ab	20.0 b	0.20 bc	12.0 b	10.0 b	3.5 ab
V_5	36.0 ab	21.0 ab	0.45 ab	15.0 ab	13.0 ab	4.1 ab
V_6	38.0 ab	23.0 ab	0.48 ab	16.0 ab	14.0 ab	4.1 ab
V_7	37.4 ab	22.0 ab	0.46 ab	16.0 ab	14.0 ab	4.1 ab
V_8	35.9 ab	18.0 bc	0.25 b	14.0 ab	12.0 ab	3.7 ab
Level of Sig.	*	*	*	*	*	*
CV (%)	**15.9**	**10.4**	**10.4**	**12.3**	**12.8**	**-**

Means having same letter(s) and without letters in a column are not significant by DMRT.* indicates significant at 5% level.

4.12 Number of ray florets per flower

Data recorded in respect of number of ray florets per flower in eight genotypes of gerbera are presented in Table 4. The number of ray florets per flower was the highest in V_3 (55.0) followed by V_6 (53.0) and V_7 (52.0). The lowest number of 40.0 ray florets were produced by the genotype V_2. Khosa *et al.* (2011) evaluated gerbera cultivars and counted ray florets which were partially at par with the present findings.

4.13 Ray floret size

It was revealed that ray floret varied significantly and ranged from 1.2 to 2.8 cm. The genotype V_3 showed the highest ray floret (2.8 cm) followed by genotype V_6 (2.5 cm) and V_7 (2.4 cm). The lowest ray floret (1.2 cm) was observed in genotype V_2 (Table 3). Chouhan (2005) conducted an experiment with 15 genotypes of gerbera and found ray floret size varied from 1.0 – 3.0 cm which was at par with the present investigation and also mentioned this difference due to inherent genetic factors.

4.14 Disc floret weight

Maximum disc floret weight was recorded in cultivar V_3 followed by V_6 and V_7 (2.6 and 2.5 g respectively) while it was minimum in V_2 (1.3 g) (Table 2). The highest weight of disc floret might be due to the inherent characters of individual cultivars. These findings are also in accordance with the results of Gotz (1983), who also reported large differences in the disc floret weight of different gerbera cultivars under greenhouse conditions.

4.15 Length of flower stalk

Variation in respect of stalk length was observed among the genotypes. The longest stalk of 40.0 cm was produced by genotype V_3 followed by V_6 (38.0 cm) and V_7 (37.4 cm) while the shortest stalk of 30.0 cm was produced by V_2. Shruti and Gajbhiye (2013) recorded stalk length ranged from 30.0 to 45.0 cm in varietal evaluation of gerbera showed similarity with the present investigation. The stalk length is a genetic factor therefore it is expected to vary among the cultivars as earlier observed by Sarkar and Ghimaray (2004). Stalk length is a very important factor for a cut flower, especially for gerbera flower. It decides the quality cut flowers. As there will be more stalk length more reserved food will be stored in the stalk which will later be available to the flower for longer time period.

4.16 Flower stalk weight

Significant variation in respect of stalk weight was observed among the genotypes (Table 6). The highest stalk weight of 25.0 g was produced by genotype V_3 followed by V_6 (23.0 g) and V_7 (22.0 g) while the shortest spike of 10.0 g was produced by V_2. Chobe *et al.* (1981) recorded flower stalk weight ranged from 10.0–25.0 g in varietal evaluation of gerbera showed similarity with the present investigation.

4.17 Flower stalk diameter

Flower stalk diameter was recorded maximum in V_3 (0.55 cm) followed by V_6 (0.48 cm) and V_7 (0.46 cm), whereas, it was recorded minimum in genotype V_2 (0.09 cm). Variation in flower stalk diameter ranged from 0.02 to 0.90 cm has also been reported by Kumar *et al.* (2012) in gerbera.

4.18 Shelf life

Shelf life was found significant among the cultivars. It was evident from Table 5 that the V_3 recorded maximum shelf life (17.0 days) closely followed by cultivar V_6 and V_7 (16.0 days). Minimum shelf life was recorded in cv. V_2 (7.0 days) and V_1 (8.0 days). The variation in shelf life of different cultivars of gerbera might be attributed to genetic variability. The result were confirmity of findings of Ahawat *et al.* (2012) and Chobe *et al.* (2012) in gerbera.In general, shelf life of flower greatly depend on the general condition of the mother plant. The varieties which exhibit longer shelf life might possess better water uptake capacity and higher accumulation of metabolic sugars (reducing and non-reducing) in the plant as well as in the petal cells. The cultivar V_3 due to its long shelf life could be a very popular choice in the wholesale market.

4.19 Vase life

A great deal of genotypic variation was observed in case of vase life (Figure 6). Among the genotypes, V_3 exhibited the longest vase life of 15 days closely followed by V_6 and V_7 (14 days). On the contrary, the shortest duration of 5 and 7 days was recorded in V_2 and V_1 which might be due to their loose arrangement of florets. The present findings more or less agreed with Bhattacharjee (1981) where he recommended that gerbera flower remains in a good condition for 6-15 days. This could be due to inherent differences among genotypes. Similar results were also reported by Sujatha *et al.* (2002) in gebera.

4.20 Flowering duration

A great deal of genotypic variation was observed in case of flower durability (Figure 5). Among the genotypes, V_3 exhibited the longest duration of 125 days followed by V_6 (118 days) and V_7 (117 days). On the contrary, the shortest duration of 105 and 107 days was recorded in V_2 and V_1 which might be due to their loose arrangement of florets. The present findings more or less agreed with Bhattacharjee (1981) and Sujatha *et al.* (2002) in gerbera.

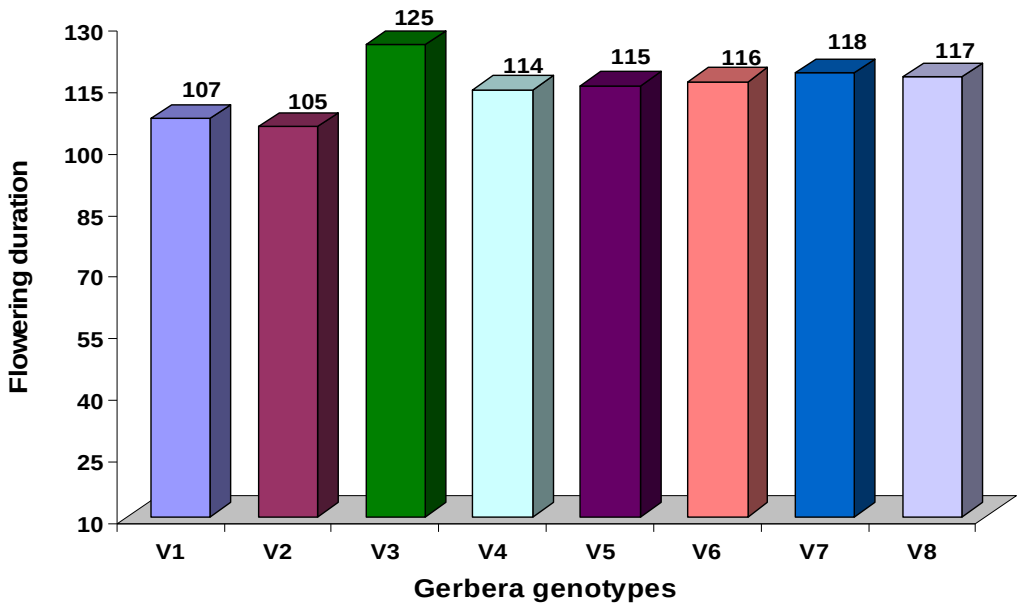

Figure 5. Flowering duration of different genotypes of gerbera

4.21 Flower quality

Flower quality is an important parameter for evaluation of cut flower quality, for both domestic and export markets. Excellent quality flowers were found in gerbera cultivar V_3 (4.4) followed by 'V_6' (4.2) and 'V_7' (4.1) (Table 2). Flowers of cultivars 'V_1' and 'V_2' were of inferior quality (2.8) and (2.5). Similar results were also reported by Nair and Shiva (2003), and Awad *et al.* (1986) in gerbera .Among the eleven cv. studied, Naik *et al.* (2006) observed best flower quality in cultivar 'Lexus' which is more or less in line with our results.

4.22 Disease and insect infestation

Gerbera is susceptible to several diseases and insect which adversely affect the quality and quantity of flower. The crop is mostly infested by aphid, thrips and mite (Das *et al.*, 2003). No infestation of thrips was occurred at study period but infestation of aphid and mite was found very low which is in agreement with the findings of Sujatha and Medhi (2002). In case of disease, only leaf spot disease infection was occurred which effect were also negligible (Table 7).

Table 7. Disease and insect infestation of gerbera genotypes

Genotypes	Disease infestation			Insect infestation		
	Powdery mildew	Fusarium rot	Leaf spot	Aphid	Thrips	Mite
V_1	-	-	+	1	-	+
V_2	-	-	+	1	-	+
V_3	-	-	+	0	-	+
V_4	-	-	+	1	-	+
V_5	-	-	+	1	-	+
V_6	-	-	+	0	-	+
V_7	-	-	+	0	-	+
V_8 (BARI Gerbera-1)	-	-	+	1	-	+

0 = No population; 1 = a small colony of 10-20 aphid/plant; 2 = a colony with > 20 aphid/plant; 3 = > one colony; 4 = Severe infestation of maximum plantsand - = Nil; + = Less; ++ = Medium; +++ = High

4.24 Selection of superior genotypes

Gerbera showed variation for all quantitative and qualitative characters. The number of flower per plant as well as stalk length, flower size and vase life of flower were reported to be desired selection criteria for increasing flower yield by Negi *et al.*(1983) and Nair and Medhi (2002) in gerbera. Based on these selection criteria, the genotypes V_3, V_6 and V_7 were identified as good genotypes.

CHAPTER V
SUMMARY AND CONCLUSIONS

An investigation was carried out at Floriculture Experimental field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during January 2014 to March 2015 to study performance of gerbera cultivars under protected condition. The salient findings of the present study had been summarized below :

A total of eight (8) gerbera genotypes were collected from different sources for this investigation. Among them, 2 from Bangladesh, 4 from India, 1 from China and 1 from Malaysia were collected. Suckers were used as planting materials. It was a single factor experiment included with eight genotypes of gerbera which were coded as follows: V_1, V_2, V_3, V_4, V_5, V_6, V_7 and V_8 (BARI Gerbera-1). The experiment was laid out in Randomized Complete Block Design with three replications. The unit plot size was 2 m × 2 m. The plots were raised up 0.20 meter.

Variations were observed in respect of flower colour among gerbera cultivars. The colours of flower were categorized into white, yellow, red, pink, majenta, orange and pink rose. Type of flowers was graded as decorative, spider and single. Among the genotypes, 75% were decorative, 12.5% for spider and the rest 12.5% for single. Variations were also observed in respect of leaf colour. All the germplasm were categorized into 3 groups on the basis of their leaf colour. They were green, light green and deep green. As regards to the colour of disc floret, the observed germplasm showed remarkable variation such as yellow with blakish centre, reddish yellow, pink rose with blackish centre, creamy white, red blackish centre, light pink with blakish centre, orange blackish centre and red blackish centre.

Analysis of variances revealed marked differences among the genotypes in respect of plant height. It varied from 20.4 to 30.0 cm where the tallest plant was produced by the genotype V_6 and the shortest plant was recorded in genotype V_2. Significant variation was observed as to the number of leaves among the genotypes. The maximum number of 20.0 leaves was produced by the cultivar V_3 closely followed by V_6 and V_7 with 18.6 and 17.5 leaves per plant, respectively. On the contrary, the cultivar V_1 produced minimum number of 9.0 leaves/plant.

Leaf length were affected by genotypes and varied from 15.4 cm to 25.0 cm. The longest leaf (25.0 cm) was recorded in V_3 followed by V_4 and V_6 (22.0 cm) while the shortest one was in V_2 (15.4 cm). Significant variation was also observed as to the leave breadth among the genotypes. The longest leave breadth 8.5 cm was produced by the cultivar V_6 and V_7 followed by V_3 (8.3 cm). On the contrary, the cultivar V_2 produced shortest leave breadth of 6.0 cm.

Plant spread ranged from 8.0-15.0 cm. The maximum plant spread of 15.0 cm was observed in V_3 closely followed by V_6 (13.9 cm) and V_7 (13.7 cm). The cultivar V_1 had minimum plant spread of 8.0 cm. Variation regarding number of sucker per plant among the genotypes was observed and varied from 4 to 8.The highest number of 8 suckers per plant was produced by V_3 where the genotype V_1 produced the lowest number of 4 suckers per plant.

Marked differences were recorded in respect of number of days required for first flower bud visibility and full bloom among the genotypes under protected condition. The genotype V_3 took minimum of 69.0 days to first flower bud visibility and 81 days to full bloom, whereas V_2 took maximum days (77.0 days and 89 days) to initiate flower bud and full bloom visibility, respectively.

Distinct variation were observed in respect of number of flowers and flower size within the genotypes. The maximum number of flowers (20) and biggest size of flower (10.0 cm) was produced by V_3 closely followed by V_6 and V_7. The genotype V_1 produced the lowest number of flowers (10) per plant and lowest size (6.5 cm) of flower was observed in genotype V_2.

The number of ray florets per flower was the highest in V_3 (55.0) followed by V_6 (53.0) and V_7 (52.0). The lowest numbers of 40.0 ray florets were produced by the genotype V_2. It was revealed that ray floret varied significantly and ranged from 1.2 to 2.8 cm. The genotype V_3 also showed the highest ray floret (2.8 cm) followed by genotype V_6 (2.5 cm) and V_7 (2.4 cm). The lowest ray floret (1.2 cm) was observed in genotype V_2.

Significant variations in respect of stalk length and stalk weight were observed among the genotypes. The longest stalk of 41.0 cm and highest stalk weight of 25.0 g was produced by genotype V_3 followed by V_6 (23.0 g) and V_7 (22.0 g) while the shortest stalk of 10.0 cm and lowest stalk weight 10.0 g was observed in V_2. A great deal of genotypes variation was observed in case of vase life and shelf life. Among the genotypes V_3 exhibited the longest vase life and shelf life (15.0 days and 17.0 days) closely followed by V_6 and V_7 (14 days and 16.0 days).

Maximum flower stalk diameter and disc floret weight were recorded in V_3 followed by V_6 and V_7, whereas, it was recorded minimum in genotype V_2. A great deal of genotypic variation was observed in case of flower durability. Among the genotypes, V_3 exhibited the longest duration of 125 days followed by V_6 (118 days) and V_7 (117 days). On the contrary, the shortest duration of 105 and 107 days was recorded in V_2 and V_1, respectively.

Flower quality is an important parameter for evaluation of cut flower. Excellent quality flowers were found in gerbera cultivar 'V_3' (4.4) followed by 'V_6' (4.2) and 'V_7' (4.1). Flowers of cultivars 'V_1' and 'V_2' were of inferior quality (2.8) and (2.5).

Gerbera is susceptible to several diseases and insect which adversely affect the quality and quantity of flower. The crop is mostly infested by aphid, thrips and mite. However, no infestation of thrips was occurred at study period but infestation of aphid and mite was found which was very low. In case of disease, only leaf spot disease infection was occurred which effect was also negligible.

Based on the results of the present study, the following conclusions may be drawn:-

- Considering the important characteristics, the cultivar V_3 is the best having long stalk length, more number of leaves, plant spread and highest number of flowers, long vase life and better flower quality.
- While V_6 and V_7 also exhibited acceptable physical and flowering quality characteristics, so they can also be cultivated under protected conditions.
- Cultivars V_3, V_6 and V_7 being better physical adaptation, high yield and excellent flower quality can be successfully cultivated under protected condition.

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APPENDICES

Appendix I. Mean monthly weather data during January 2014 to March 2015

Year	Month	Air temperature (°C)		Relative Humidity (%)	Rainfall (mm)
		Max.	Min.		
2014	January	16.10	11.25	88.09	000.00
2014	February	20.54	18.12	87.12	07.40
2014	March	31.42	25.98	69.15	06.40
2014	April	32.10	29.00	75.00	57.50
2014	May	31.33	27.42	76.15	250.10
2014	June	32.00	29.15	64.10	377.50
2014	July	31.20	25.95	85.00	361.50
2014	August	30.86	25.75	86.40	590.00
2014	September	31.50	27.00	86.50	208.45
2014	October	29.75	26.80	85.28	183.40
2014	November	26.22	22.75	80.17	07.50
2014	December	19.90	15.45	89.05	0.00
2015	January	14.22	10.55	90.03	000.0
2015	February	23.75	18.81	86.63	06.49
2015	March	32.20	26.30	70.04	6.85

Source: Bangladesh Agricultural Research Institute (BARI), Gazipur

Appendix II. Analytical data of soil sample at Floriculture field of HRC, BARI

Year	pH	Total N	OM	Ca	Mg	K
		%		Meq/100g		
2014	6.1	0.077	1.46	4.76	1.97	0.15
Critical level				2.0	0.8	0.2

Appendix II. Cont'd.

Year	pH	P	S	B	Cu	Fe	Mn	Zn
		µg/g						
2014	6.1	15	38	0.32	6.0	232	10	3.30
Critical level		14	14	0.2	1.0	10.0	5.0	2.0

Source: Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Gazipur

Appendix III. Analysis of variance of the data on different plant characteristics of gerbera

Source of variation	Degrees of freedom	Mean sum of square					
		Plant height	Leaf number	Leaf length	Leaf breadth	Plant spread	Sucker number
Replication	2	03.20	25.30	21.14	15.64	4.12	28.17
Treatment	7	309.50	313.06	289.50	350.12	211.92	322.60
Error	14	07.25	8.40	6.58	7.51	6.35	9.28

Appendix IV. Analysis of variance of the data on different flower characteristics of gerbera

Source of variation	Degrees of freedom	Mean sum of square					
		Flower bulb visibility	Full bloom	Flower number	Flower size	Ray floret number	Ray floret size
Replication	2	11.60	12.50	11.52	0.09	12.41	10.40
Treatment	7	113.25	110.14	2.53	18.50	8.76	12.12
Error	14	4.65	5.10	4.75	6.54	3.61	4.96

Appendix V. Analysis of variance of the data on different floret characters of gerbera

Source of variation	Degrees of freedom	Mean sum of square						
		Stalk length	Flower weight	Stalk diameter	Disc floret weight	Shelf life	Vase life	Flowering duration
Replication	2	20.15	13.40	18.10	0.91	11.50	3.64	10.17
Treatment	7	190.40	14.55	180.54	280.20	113.10	211.45	210.25
Error	14	6.41	4.94	3.69	4.90	4.60	07.50	5.70