EVALUATION OF GERBERA (*Gerbera jamesonii* Bolus) VARIETIES FOR RAIN SHELTER CULTIVATION

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(2014 – 12 - 110)

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KERALA, INDIA

2016

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by

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(2014 – 12 - 110)

THESIS

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF AGRICULTURE

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DECLARATION

I, hereby declare that this thesis entitled **"EVALUATION OF GERBERA (*Gerbera jamesonii* Bolus) VARIETIES FOR RAIN SHELTER CULTIVATION"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Date: 31.10.2016 (2014-12-110)

CERTIFICATE

Certified that this thesis, entitled **"Evaluation of Gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation"** is a record of research work done independently by Ms. Irshana M. P (2014-12-110) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of Ms. Irshana M. P (2014-12-110) a candidate for the degree of **Master of Science in Horticulture**, agree that the thesis entitled **"Evaluation of Gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation"** may be submitted by Ms. Irshana M. P, in partial fulfillment of the requirement for the degree.

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EXTERNAL EXAMINER

ACKNOWLEDGEMENT

I bow my head before Allah Almighty for all the bountiful blessings he has showered on me at each and every moment without which this study never have seen light.

In a closely knit, complex interwoven and intricate social system such as ours, it is obvious that nothing of significance can ever be accomplished without the acts of assistance, words of encouragement and the gestures of helpfulness from the other members of the society. This work of mine is of no exception.

Foremost, I would consider myself lucky to have worked under the guidance of ***Dr. V. L. Sheela,*** *Professor, Department of Pomology &Floriculture. and Chairman of my advisory committee without her sincere guidance, constant encouragement, valuable suggestions and moral support throughout my post graduate programme, this task would not have been accomplished. I am much obliged to her for her keen interest and unfailing patience which greatly facilitated the preparation of this thesis.*

I express my sincere gratitude to ***Dr. Sabina George T,*** *Professor and Head, Department of Pomology & Floriculture and member of my advisory committee for her expert suggestions and critical evaluation of the thesis.*

I extend my heartfelt thanks to ***Dr. Vijayaraghavakumar*** *Professor and Head, Department of Agricultural Statistics and member of my advisory committee for the valuable suggestions, sincere help and cooperation during the period of study.*

I am equally thankful to ***Dr. K. Sudharma,*** *Professor and Head, Department of Agricultural Entomology and member of my advisory committee for her pertinent suggestions and thorough scrutiny of the manuscript.*

I would like to thank ***Dr. S. Simi,*** *Assistant Professor, Department Pomology & Floriculture for her proper guidance and constant support throughout the course of the study.*

My profound gratitude to to ***Dr. C.S Jayachandran Nair****, Professor and Head (Retd.), Department of Pomology & Floriculture for his care, valuable advices and guidance.*

I eagerly express my thankfulness to ***Dr. K. Umamaheshwaran, Dr. Gokulapalan, Dr. Roy Stephen, and Dr. Sam Kurumthottikkal*** *for their unsettled company and support.*

I also wish to express my deepest thanks to Mr. Ajith, Mrs. Grancis and all non teaching staffs of Department Pomology & Floriculture for their generous help during the entire research.

My thanks are due to all labourers of instructional farm, especially Shaji chettan, Latha chechi, Srikumar chetan for their sincere efforts help, and cooperation during my research work.

I sincerely thank the facilities rendered by ***Kerala Agricultural University*** *for successful completion of my research work.*

Words are inadequate to convey the depth of my heartfelt thanks to my grandparents for their unconditional love, and help to realize my self -worth.

I express my deep sense of gratitude and affection to my parents ***Sri. Abdul Nazer M. P*** *and* ***Smt. Rasiya,*** *sisters* ***Nishana, Zuhadha Sanam*** *and brother* ***Ali Janshar*** *for their affection, constant encouragement, moral support, prayers and blessings without which I would not have completed this research.*

I would like to thank Afiya, Aadil, Munnu, Jebin, Aanya and all my cousins for their loving wishes for completing the study.

I am also thankful to all my batchmates, Shewtha, Devi, Neethu, Moni, Lakshmi, Jaffin, Aishwarya, Shalini, Saranya, Athulya, Shaimy, Suma, Ambarish, Asha and seniors, Shajma Nafeesa Basheer, Ardhra Ann Paul, Anju Padmanabhan, and juniors , Annjoe, Salma, Aparna,Sabika,Athira and friends especially Sumayya, Thasni, Suhana, Haseena, Aneesa, Shamniya, Anusree, Nimisha, Greeshma and Aishwarya for their help and co-operation during the course of study.

This acknowledgement is incomplete without expressing my great affection and thankfulness to special person Yasar and his family for their loving wishes, support and encouragement during this thesis work.

Finally I thank all those people who have supported me during my post graduate programme and helped for the successful completion of this thesis.

Vellayani

31.10.2016 **Irshana M. P**

Dedicated to

My grandpa…

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LIST OF ABBREVIATIONS

%	-	per cent
^{0}C	-	Degree Celsius
ANOVA	-	Analysis of variance
CD	-	Critical Difference
cm	-	centimeter
et. al	-	and co-workers/co-authors
Fig.	-	Figure
FYM	-	Farm yard manure
g	-	gram
GA	-	Genetic Advance
GCV	-	Genotypic Coefficient of Variability
i.e.	-	that is
kg	-	kilogram
k.lux	-	Kilo lux
m^2	-	Square meter
MAP	-	Months After Planting
PCV	-	Phenotypic Coefficient of Variability
RH	-	Relative humidity
Var.	-	Variety
Viz.	-	Namely

Introduction

1. INTRODUCTION

Floriculture in India is being viewed as a high growth industry and has been shifting from traditional flowers to cut flowers as commercial floriculture is becoming important from export angle. Commercial floriculture has emerged as a high tech activity being undertaken under controlled climatic conditions inside the greenhouse (APEDA, 2016).

Gerbera (*Gerbera jamesonii* L.) also commonly known as Transvaal, African or Barberton Daisy is one of the most beautiful cut flower grown throughout the world (Syamal, 2014). The genus *Gerbera* was named in honour of German naturalist Traugott Gerber and the species *jamesonii* in honour of Captain Jameson (Das and Singh, 1989). Gerbera occupies a unique position in beauty and trade among cut flowers and has significant demand due to its multitude of colours. Variety in color has made this flowering plant attractive for use in garden decorations, such as herbaceous borders, bedding, pots, rock gardens and for cut flowers as it has a long vase life (Chung *et al*., 2005). The flower stalks are long, thin and leafless. Flowers lend themselves beautifully to different floral arrangements and stage decorations.

It is difficult to get good quality cut flowers of gerbera under open-field conditions (Pattanashetti, 2009). Cut flowers have very specific market requirement 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, the crop is being grown under fully protected climate in controlled green houses. Semi protected conditions are successfully employed in places near equator, with warmer sunny climate to cultivate the crop. Performance of gerbera varies with the region, season and other growing conditions.

Crop improvement programmes currently focus on developing hybrid cultivars to boost productivity and profitability. Genetic variability among parents is a prerequisite for selecting suitable parents in a breeding programme for various

economic characters. Several flower traits in gerbera have been examined using quantitative genetic approaches (Chobe *et al.,* 2010b; Kumari *et al.,*2011; Kumar *et al.,* 2012)

Almost the entire cut flower requirement of our state is now met from neighbouring states like Karnataka and Tamilnadu. Since commercial cultivation of gerbera have good potential, introduction and popularization of high yielding cultivars is gaining importance. Farmers have initiated cultivation of gerbera in poly houses in certain pockets of Kerala and the results are promising. However, very little research work has been taken up to assess performance of gerbera in the humid tropics and to identify varieties with good cut flower potential especially under protected conditions. The scientific information on improved production technology of gerbera varieties in Kerala is meager. Hence, the present investigation was planned with the objective to evaluate the performance of gerbera varieties under rain shelter in respect of growth, flowering and yield to explore the possibilities of identifying suitable varieties for commercial cultivation.

Review of Literature

2. REVIEW OF LITERATURE

Gerbera is one among the most popular flowers in the world, also this cut flower is gaining momentum in commercial floriculture industry in Kerala. Its demand and production area are increasing day by day. A wide range of cultivars are available and they are grown for cut flower purpose and also used in landscaping. Gerbera is grown throughout the world under wide range of climatic conditions. Some of important and informative works so far done in India and abroad related to varietal evaluation of gerbera, influence of various environmental parameters on growth and yield have been presented in this chapter.

2.1. ECONOMIC IMPORTANCE OF GERBERA

It has been found that commercial floriculture has higher potential per unit area than most of the field crops and is therefore a lucrative business (APEDA, 2016). Gerbera is one of the most important cut flower and it has tremendous demand in local as well as foreign market (Chobe *et al.,* 2010a). Demand of gerbera as cut flowers and also as an ornamental potted plant is gaining importance in the world market and has a very good export potential because of its graceful appearance, hardiness and ability to withstand transportation and long shelf life (Latha and Suresh, 2010). For this reason demand of gerbera as cut flower has increased dramatically in recent years. Plant breeders have developed varieties with outstanding flower colours (uni and bi), including purple, rose, pink, white in double and semi-double flowering forms which added much to the beauty (Shammy *et al.,* 2012).

During winter months, gerbera cannot be successfully grown in the cooler regions of the world. But gerbera is one among the top ten cut flowers of the world flower trade and there is a great demand for gerbera particularly in European markets during this season. India has very good scope and potential for the cultivation of gerbera since India is situated comparatively closer to major flower consuming countries than its Asian counter parts. As stated earlier, severe winter in major flower producing European countries is also an advantageous factor to India. Cities like Bangalore, Pune, Hyderabad, Nasik etc. which enjoy moderate climate all through the year besides cheap availability of land and labour.

Thus they have a great potential for producing gerbera on commercial scale (Kumar *et al.*, 2014a).

2. 2. CULTIVATION ASPECTS OF GERBERA

Das and Singh (1989) reported that plants grown in peat with ammonium nitrate + Super phosphate + potassium sulphate at 4g litre^{-1} produced highest number of flowers. Raising salt concentration from 2g to 4g litre^{-1} could improve vegetative growth and increased NPK concentration in leaves and roots.

Shading at 30 percent resulted in highest number of flowers and longest stems (Hell, 1996). Gerbera required good drainage. Heavy rains and water logging had adverse effect on growth and flowering of gerbera (Labeke and Dambre, 1999).

Gerbera shows zinc deficiency and symptoms appear as inter veinal chlorosis, little leaf and rosetting of leaves. Correction can be done by 0.2-0.4 percent spray of Zinc sulphate (Kumar, 2002).

As gerbera is a fairly hardy plant, it can be grown both in plains and hills. Gerbera grows well in sunny situations, in cool weather, but in summer, light shading should be provided. A night temperature of 12^{o}C is optimum. Well drained loam or sandy loam soil is the best suited. Soil for growing gerbera should have pH between 5 and 7.2 and should be rich in organic matter. In fairly light soils, application of 7.5 kg rotted stable manure meter $^{-2}$ obtained good results. (Sheela, 2008)

2.3. PROTECTED CULTIVATION OF GERBERA

Commercial floriculture has been steadily increasing with increased use of protected cultivation employing green house, shade nets, polyhouses etc. (Misra and Ghosh, 2016). Nowadays, all over the world gerbera is cultivated in most part of the year in protected conditions under green house (Syamal, 2014). Singh and Ramachandran (2002) and Singh and Mandhar (2002) observed better growth, yield and quality characteristics of gerbera under protected conditions. In protected environments, gerbera grew faster and produced larger and greener leaves with high dry matter content. As a result, the yield of the flowers increased and more side shoots were formed.

Kandpal *et al.* (2003) observed better growth, yield and quality characteristics of gerbera when grown under protected conditions. Gupta *et al.* (2004) conducted a study to standardize the growing media for gerbera and reported that gerbera performed well in media of coco peat+ saw dust + sand (1:1:1 ratio) under protected conditions of Himachal Pradesh.

Plants grown under protected environments exhibited significantly better performance in vegetative growth, yield and quality of flowers compared to open conditions with shade. All the vegetative and flowering attributes were superior under polyhouse conditions except production of suckers. Protected cultivation of cut flowers was beneficial for high yield, better quality and enhanced flowering duration. Despite higher initial investment, gerbera cultivation under polyhouse was profitable than field conditions owing to improved quality and higher yield. The varieties produced higher number of flowers under polyhouse compared to field conditions. This might be attributed to longer flowering duration and higher photosynthetic efficiency under polyhouse. (Kumar *et al*. 2014b)

2.4. VARIETAL EVALUATION OF GERBERA

Performance of gerbera varies with varying climatic conditions from region to region. Variations were observed in vegetative as well as floral characters. Attempts were made to evaluate performance of gerbera under open and protected conditions.

According to Kumar and Kumar (2001) vegetative and floral characteristics of gerbera cultivars varied in different months owing to the variable production.

Shammy *et al.* (2012) conducted an experiment to evaluate the growth and flowering of two varieties of gerbera viz., yellow and red varieties and these showed distinct variations on flower yield and yield contributing characteristics. Variety with yellow colored flowers showed better performance compared to variety with red colored flower.

Malik *et al.* (2013) evaluated growth, yield and quality characteristics of ten gerbera cultivars under protected condition. Highly significant variations were observed in all the characteristics among evaluated varieties. Cultivar Alberino exhibited longest stalk

length (60.3) followed by Lexus (59.0) and Mammut (54.0 cm). Alberino also produced flowers with highest diameter. Under protected conditions, cultivars Alberino and Lexus were found superior with respect to growth, yield and vase-life characteristics.

Kumari *et al*. (2013) conducted correlation studies in gerbera and found that flower diameter, number of flowers and suckers plant^{-1} were important yield characters and these should be considered as indices for breeding programme in gerbera.

2.5. VEGETATIVE PARAMETERS

Ahlawat *et al.* (2011) assessed the performance of eleven gerbera cultivars under a naturally ventilated polyhouse and reported that the variety Pink elegance showed highest plant spread.

Malik *et al.* (2013) observed significant difference among cultivars for plant spread. With respect to cultivars, Alberino recorded highest plant spread (60.0 cm) followed by Lexus (55.0 cm), Lilla (52 cm) and Avemaria (50 cm) while it was least in Terramixa (40 cm) followed by Labinel and Bonnie

Bhattacharjee (1981) reported that the leaf number variation in gerbera ranged from 50.0 -70.4.

Kumar and Kumar (2001) found that gerbera produced maximum 32.0 leaves plant^{-1} whereas maximum of 46.10 leaves plant^{-1} was found by Singh and Ramachandran (2002). On the other hand highest 16.87 leaves plant^{-1} was found by Sankar *et al.* (2003).Reddy *et al.* (2003) found 47.31 leaves plant^{-1}. Kandpal *et al.* (2003) recorded 48.3 leaves plant^{-1} year^{-1}. Similarly Singh and Mandhar (2002) also observed variation in number of leaves among the cultivars.

Kumari *et al.* (2011) reported high estimates of heritability and genetic advance in gerbera varieties for number of leaves plant^{-1}.

Das *et al.* (2012) recorded significant variation in number of leaves plant^{-1} at different days after transplanting of five gerbera varieties under the study. Orange flower recorded highest number of leaves plant^{-1} which was statistically identical with pink flower, while the lowest number from white flower at 20, 40, 60, 80, 100, 120 and 140 DAT respectively.

Magar and Siwakoti (2014) evaluated varietal characteristics of ten gerbera varieties in Katmandhu and found that amongst the varieties under study, Pirineo produced significantly more number of flowers and more number of leaves plant^{-1}.

Among the five exotic potted gerberas under study, Das *et al.* (2012) found that pink flowered cultivar recorded highest leaf breadth, which was statistically on par with orange flowered cultivar and white flowered cultivars recorded lowest leaf breadth.

Kumar et al. (2014a) evaluated twenty six genotypes of gerbera under different growing conditions of Kashmir and among the genotypes, Sunway recorded highest leaf length both under polyhouse (51.52 cm) and field (46.12 cm) conditions.

According to Kumari *et al.* (2013), number of suckers plant^{-1} had significant positive association with number of flowers and this indicated that cut flower production increased with number of suckers, and this is desirable for sucker production and multiplicability of the genotype.

Kumar *et al*. (2014a) studied performance of gerbera varieties under different growing conditions and found that number of suckers plant^{-1} was less under polyhouse as compared to field conditions. This might be due to diversion of more food material to flowering attributes like flower number, stalk length etc. under polyhouse conditions. The variety Dune developed highest number of suckers plant^{-1} (6.35), which was on par with Winter Queen (6.30) under polyhouse conditions, while under field it was highest in Winter Queen (8.00) which was statistically on par with Dune (7.90).

2.6. FLOWERING CHARACTERS

2.6.1. Number of Days Taken for Flowering and Flower Development

Sane and Gowada (2001) reported variation in first harvest among the cultivars was due to the genetic makeup of the varieties. Kandpal *et al.* (2003) also reported similar findings.

Chobe *et al.* (2010b) reported high heritability along with lower genetic advance for number of days required for first flowering, number of flowers plant^{-1} year^{-1}, and vase life exhibiting non additive gene effects.

Das *et al.* (2012) evaluated five different coloured exotic potted gerberas and observed early flower bud initiation in white colored cultivar and late in orange cultivar.

It was revealed from the study by Wankhede and Gajbhiye (2013) that variety Dalma (41.60 days), Goldflor (41.73 days), Charmander (42.60 days), Glodengate (42.60 days), Vino (44.06 days), Savannah (44.70 days) and Diablo (44.80 days), Magnum (77.13 days), Rosalin (77.43 days) and Sangria (77.80 days) required optimum period for first flower bud initiation under shade net.

In a similar study conducted on gerbera under protected conditions by Kumar *et.al* (2014b) in Tumkur district of Karnataka revealed that variety Salvador (55.10 days), Winter Queen (56.75 days), Intense (56.85 days), Goliath (57.40 days), and Balance (58.75 days) required optimum period for first flower bud initiation.

Kumar *et al.* (2014a) evaluated twenty six gerbera varieties under different growing conditions of Kashmir and reported earliest flowering initiation in Dana Ellen (56.68 days), while delayed flower initiation was observed in variety Essence (72.01 days) under polyhouse conditions. Under field condition, late flowering initiation was recorded as compared to polyhouse condition.

2.6.2. Total Number of Flowers Produced

According to Li Zhang *et al.* (2008), the annual flower yield is between 20-35 flowers plant^{-1} and cultivars showed wide range of variation in flower yield.

Positive correlation of number of leaves with flower yield was reported by Anuradha and Gowda (2002). Magar *et al.* (2010) reported that number of leaves plant^{-1}, leaf area, plant spread, and number of suckers plant^{-1} were positively associated with the number of flowers plant^{-1} at genotypic level.

Kumari *et al.*(2011) conducted genetic variability studies in gerbera and found that number of flower plant^{-1} showed the high heritability along with highest genetic gain, followed by number of suckers plant^{-1} and flower dry weight and concluded that, for further breeding programme, selection based on number of flowers plant^{-1} would be more effective.

Kumar *et al.* (2014a) recorded highest number of flowers plant^{-1} (58.14) in Dune under polyhouse and it was higher for Dana Ellen (42.34) under field conditions. The number of flowers plant^{-1} for all varieties was higher under polyhouse compared to field conditions. This might be attributed to longer flowering duration and higher photosynthetic efficiency under polyhouse. Flower number plant^{-1} varied from 25.97 to 58.14 under polyhouse and 17.82 to 42.34 under field conditions.

2.6.3. Peak Flowering Period

Sankar (2003) observed that flower production increased in all varieties from planting up to five - six months, and there after a slight reduction in flower production was noticed.

Sheela (2008) reported significant association of total flower production with seasonal variations. The flowering peak was reached during summer but it became earlier in successive cropping years. The yield increased twice in the second and third years.

2.6.4. Life of Flower in the Plant

Wankhede and Gajbhiye (2013) recorded highest life span of flower on plant in Charbander (16.60 days) followed by Savannah (16.09 days) which was significantly superior over other varieties.

2.7. FLOWER QUALITY PARAMETERS

Gotz (1983) reported large differences in the flower diameter of different gerbera cultivars under greenhouse conditions. Significant differences were observed regarding the diameter of capitulum among the different cultivars of gerbera by Jawaharlal *et al*., 1998; Singh and Mandhar, 2001; Nair and Medhi, 2002; Kandpal *et al*., 2003; Rao and Vasudevan, 2009)

Chobe *et al.* (2010a) conducted a study to evaluate thirty gerbera cultivars under naturally ventilated polyhouse conditions and found that cultivar Martinique had highest flower diameter.

Kumari *et al.* (2013) reported that flower diameter was positively and significantly correlated with flower stalk diameter, both at genotypic and phenotypic levels.

In a study conducted by Malik *et al.* (2013), variety Alberino recorded highest flower diameter (9.6 cm), followed by Lilla and Avemaria (9.0 cm and 8.3 cm, respectively) while it was lowest for the variety Sarolta (5.3 cm)

Wankhede and Gajbhiye (2013) evaluated thirteen gerbera varieties for growth and flowering under shade net and recorded highest flower diameter in variety Sangria.

According to Kumar *et al.* (2014a), the flower size was found highest in Sunway (13.17 cm) under polyhouse conditions, while it was found highest in Dune (11.58 cm) under field conditions

Among thirty cultivars evaluated by Chobe *et al.* (2010a), cultivar Frisbel (435.73) recorded highest number of ray florets per flower, followed by Softcell, and cultivar Montblanc (54.13) recorded lowest number of ray florets per flower.

According to Sarkar and Ghimaray (2004) stalk length is a genetic factor therefore it is expected to vary among the cultivars. Rao and Vasudevan (2009) reported a positive correlation between stalk length and flower diameter.

Among the ten cultivars of gerbera evaluated by Malik *et al.* (2013), highest stalk length was recorded in Alberino (60.3 cm), followed by Lexus (59 cm), Mammut (54.0 cm) and Terramixa (49.6 cm) while it was lowest in Avemaria (40.6 cm), Labinel (41.3 cm) and Bonnie (43.6 cm) under protected conditions.

Winter Queen recorded highest Stalk length of flower (53 cm) followed by Goliath (51.25 cm), Intense (49.25 cm), Salvador (49.5 cm) and Balance (48.5 cm). Stalk diameter was highest in Salvador (1.04 cm) followed by Intense (0.86 cm).Highest neck diameter was also recorded in Winter Queen (0.64 cm) followed by Salvador (0.62 cm) (Kumar *et al.*, 2014b)

Kumar *et al.* (2014a) recorded significant and highest flower stalk diameter for Sunway (8.13 mm), which was on par with Kayak (8.11 mm) under polyhouse conditions, while under field conditions it was found highest for Kayak (8.21 mm) followed by Sunway (8.02 mm)

2.8. YIELD PARAMETERS

Under naturally ventilated polyhouse conditions, Ahlavath *et al.* (2011) observed significant variation among the varieties for number of flowers metre^{-2} year^{-1} and their vase life. Winter Queen produced the highest number of flowers (396) followed by Dalma (324), and Savannah (288). The lowest number of flowers meter^{-2} year^{-1} (132) was noticed in Essence, Dana Allen and Avant Garde. This increase in flower yield can be attributed to production and accumulation of more photosynthates resulted by greater plant spread, which led to the production of more number of flowers.

2.9. INFLUENCE OF ENVIRONMENTAL PARAMETERS ON GROWTH AND YIELD OF GERBERA

Soil and air temperatures were the most important factors limiting winter production in gerbera, as the flower quality and yield declined under low temperature regimes (Berninger, 1979).

Kumar and Sooch (2003) studied the effect of shading on gerbera and found that the cv. Priyadarshi recorded the highest number of leaves (5.73), plant spread (31.84 cm) and flower diameter (8.08 cm) under 75 percent shading conditions in gerbera.

Parthasarathy and Nagaraju (2003) conducted a three year trial in gerbera and observed that the flower bud initiation, growth, development and flowering were faster during warmer period (April – May and June – July), while flower longevity was more during October to November.

When the temperature increased from 18 to 27^{o}C, diameter of the stem and inflorescence of gerbera decreased by 19 and 6 percent respectively (Pettersen and Gislerod, 2003).

Sankar (2003) reported a highly negative correlation between relative humidity and number of leaves in gerbera.

Kumar et al. (2014a) studied influence of season and varieties on vase life of gerbera and longest vase life was found with the flowers harvested in winter, followed by those harvested in spring and autumn season. Cultivars exhibited varying vegetative and

floral characteristics during different months owing to the variable production environment prevalent.

Jamaluddin *et al.* (2012) observed that different light intensities showed significant influence (full sunlight equivalent to 10,000 lux or more, 60 percent reduced sunlight as 2400-4000 lux and 40 percent reduced sunlight as 6000-6500 lux) on growth and flowering of gerbera.

According to Keditsu (2013), crop response and flower yield in gerbera could be improved by utilizing the available soil moisture coupled with nutrient availability and climatic conditions. This could induce earliness in bud burst and reduce the time taken for full bloom along with other vegetative growth parameters

2.10. VASE LIFE OF FLOWERS

Both internal and external factors affect keeping quality of flowers. The rate of water absorption and transpiration are the internal factors which are responsible for the keeping quality of cut bloom. Both these factors again depend on the relative area of absorption and the total water holding capacity of the tissues. Area of absorption was reduced drastically when the flower is detached, whereas the rate of proportionate area for transpiration is much higher. Respiration is another internal factor that affects the life of the cut flower. Some environmental factors affecting cut flower life are temperature, relative humidity and wind velocity.

Stem end blockage was a major cause for imbalance between water uptake and loss from cut flowers (Silva, 2003). Bacteria caused vascular blockage which decreased water uptake and finally resulted in stem breaking, bending and petal wilting in gerbera flowers (Nair and Shiva, 2003). Pettersen and Gislerod (2003) reported that low carbohydrate content in inflorescence grown at high temperature caused reduced vase life of flowers. There are three types of stem end blockage in cut flowers *ie*. microbial due to living bacteria, by decay products, and wound-induced (Loubaud and van Doorn, 2004). According to He *et al.* (2006), termination of vase life was characterized by wilting.

Keeping quality of flowers can be enhanced by proper postharvest handling, wherein efforts were made to reduce stem plugging, restrict microbial activity, delay

flower senescence by providing external source of water and nutrients based in requirement of the flower. (Meman and Dabhi, 2006)

Acharya *et al.* (2010) evaluated vase life of three varieties of *Gerbera viz.,* Primrose, Malibu and Sunway to find out the effect of growing seasons (autumn, winter and spring) and found that the variety Sunway exhibited longest vase life followed by Primrose and Malibu. Longest vase life (23.2 days) was found in winter harvested Sunway whereas the shorter vase lives (5.7 and 7.8 days) were in Malibu and Primrose respectively harvested in autumn. Different varietal behavior and their interaction with the production environment caused variation among cultivars.

Highest total water uptake might be correlated with the vase life of flowers. In a study to evaluate influence of seasons on vase life, highest total water uptake was found in flowers grown in winter (34.88 ml) followed by spring (34.7 ml) and autumn (26.14 ml). (Kumar *et al.,* 2014a)

According to Elgimabi (2011), wilting, ethylene production and vascular blockage by air and micro organisms shortened the vase life of cut flowers.

Rene *et al.* (2012) studied stem bending and water relations in cut gerberas and concluded that, stem bending occurred due to a combination of several factors. Absence of a sclerenchyma cylinder higher up the stem and adverse water relations during vase life seemed to contribute. The stem parts lower than about 20 cm beneath the floral head contained a rather thick cylinder of sclerenchyma which provided adequate mechanical strength to prevent bending in this part of the stem.

Kumar *et al*. (2013) conducted a study to evaluate the post harvest performance of ten commercial gerbera cultivars for quality, vase life and stem bending and observed significant differences with respect to floral traits, water relation parameters, and vase life among different cultivars. The cultivar Dune exhibited longest vase life (15.67 days) followed by Winter Queen (14.47 days) and Dana Ellen (14.40 days). The cultivars Cacharell and Winter Queen recorded lowest stem bending incidence (0°- 15°).

Wankhede and Gajbhiye (2013) studied vase life of thirteen cultivars of gerbera and found that variety Vino had longest vase life.

Kumar *et al.* (2014b) conducted experiments on vase life of cut gerberas, and found that the varieties Salvador, Winter Queen, Goliath were superior than other varieties in respect of vase life of flowers.

2.11. GENETIC VARIABILITY AND CORRELATION STUDIES

For any breeding programme, genetic variability is a pre requisite for selection of parents. Quantitative genetic approaches were used to examine several characters in gerbera. (Kumar *et al.* 2012; Chobe *et al.,* 2010b).

Quantum of variability present in genotypes can be detected using genotypic and phenotypic coefficients of variation. Comparison of the expected gains from selection based on alternative selection strategies was possible by estimating heritability and genetic parameters that compose heritability estimates (Holland *et al.,* 2003)

Selection was effective only when the observed variability in the population was heritable in nature. Genetic variance, heritability and other genetic parameters were subjected to fluctuations with changing environments (Lal *et al.,* 1985).

According to Kumari *et al*. (2011), high heritability and high genetic advance indicated additive gene action for that particular character. Maji and Dastidhar (2005) reported that number of leaves plant^{-1} showed high heritability and high genetic advance.

Chobe *et al*. (2010b) reported high heritability along with lower genetic advance for number of days required for first flowering, vase life and number of flowers plant^{-1} year^{-1}, indicating non additive gene effects. Number of flowers plant^{-1} showed high heritability along with high genetic gain. Therefore selection of individual plants based on this character might be effective for crop improvement.

Kumari *et al*. (2011) reported that number of suckers plant^{-1}, flower dry weight, number of flower plant^{-1}, shelf life, flower diameter and flower stalk diameter showed close correspondence between PCV (Phenotypic Coefficient of Variability) and GCV (Genotypic Coefficient of Variability)indicating little environmental influences on these characters.

Kumar (2013) noticed high heritability with medium genetic advance as percent of mean for plant spread and number of flowers plant^{-1} month^{-1}, indicating the presence of dominant and epistatic gene effects.

Senapathi *et al*. (2013) recorded high estimates of heritability for number of leaves plant^{-1} followed by leaf area index, fresh weight of flower, hollowness of the stalk, clumps plant^{-1}, number of flowers plant^{-1}, neck diameter, stalk diameter, petal thickness, leaf area, stalk length, plant height and flower diameter, which indicated that these traits can be improved through selection.

Pleiotropy or linkage may be the reason for correlation between various characters (Mode and Robinson, 1959).

According to Anuradha and Gowda (2000), number of leaves plant^{-1}, weight of ray florets and days taken to flower opening are significantly and positively correlated with cut flower yield. Path analysis revealed that number of leaves plant^{-1} had the greatest positive direct effect on flower yield.

Magar *et al*. (2010) conducted correlation and path analysis studies in gerbera and reported that number of flowers plant^{-1} showed positive correlation with number of leaves plant^{-1}, leaf area, plant spread and number of suckers plant^{-1} at genotypic level.

Kumari *et al.* (2013) found that stalk length showed positive correlation with shelf life. Stalk length is a major quality trait determining market value of gerbera. Therefore selection could be done based on stalk length. Correlation studies in gerbera also revealed that flower diameter, number of flowers and suckers plant^{-1} are important yield characters and these should be considered as indices for breeding programme in gerbera.

Materials and Methods

3. MATERIALS AND METHODS

The study entitled "Evaluation of Gerbera varieties for rain shelter cultivation" was conducted at the Department of Pomology and Floriculture, College of agriculture, Vellayani, Thiruvananthapuram during the year 2015-2016. The experimental field was located at $8^{o}5'$ north latitude $76^{o}9'$ east longitude and at an altitude of 29 meters above mean sea level. The aim of the study was to evaluate the performance of gerbera varieties under rain shelter.

One month old tissue culture plantlets of 20 varieties of gerbera were purchased from SPIC agro biotech centre, Coimbatore. Plantlets were transplanted and grown under rain shelter with UV stabilized polythene roofing and sides provided with shade nets .The varieties were evaluated for vegetative and floral parameters, yield, pests and disease incidence, flower quality and economic feasibility for a period of one year.

3.1. PLANTING

40x20 cm sized poly bags filled with media containing soil, sand, cow dung, leaf mould, and coir pith compost in the ratio 2:2:2:1:1 were used for planting of gerbera. Poly bags were placed in plots, with 16 plants in two rows. Experimental design was CRD with 20 treatments and each treatment was replicated four times with 4 plants in a replication. Uniform cultural practices were followed in all varieties.

3.2. CULTURAL PRACTICES

Weeding was done twice in a week during initial stages up to 45 days and later at fortnightly intervals. Farmyard manure was applied at a rate of 50 grams per pot at monthly intervals along with slight raking for proper aeration in the media and root development. Plants were irrigated regularly. Plant protection measures were undertaken whenever necessary. In order to protect plants from fungal infection, Carbendazim at 1ml/l were sprayed at 30 days interval. Insect pests (mites) were controlled by Spiromesifen (Oberon®) at 0.4 ml/l.

Table 1. Gerbera varieties selected for study

Sl. no.	Variety	Colour of ray florets	Colour of disc
1	Aragon	Light red	Yellow
2	Mammut	Cream	Greenish yellow
3	Bismark	Pink	black
4	Aviance	Pink	Greenish yellow
5	Mariata	Bi-color (pink with white tip)	Black
6	Ruble	Purple	Black
7	Jinx	Yellow	Greenish yellow
8	Lexington	Red	Greenish yellow
9	Aquamelone	Pink	Black
10	Palm beach	Yellow	Greenish yellow
11	Atletico	Orange	Black
12	Canzone	White	Black
13	Orinaco	Orange	Black
14	Esmara	Pink	Greenish yellow
15	Double date	Bi-color (orange with yellow tip)	Greenish yellow
16	Ballroom	Pink	Greenish yellow
17	Carrera	Red	Black
18	Poseidon	White	Yellow
19	Louvre	White	Greenish yellow
20	Beaudine	Red	Black

Beaudine

Carrera

Lexington

Aragon

Orinaco

Atletico

Double date

Palm beach

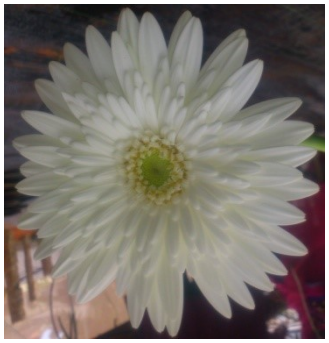
Jinx

Mammut

Plate 1. Gerbera varieties selected for study

Canzone

Louvre



Poseidon

Esmara

Ballroom

Bismark

Mariata

Aviance

Plate 1 continues…

Aquamelone

Ruble

Plate 2. One month old tissue culture plantlets of gerbera used for planting.

a b c

Plate 3. Field view after a. five days. b. one month. c. three months.

3.3. HARVESTING

Flowers for field observation were allowed to remain on the plant till it started wilting and those for vase life studies were harvested at commercial stage of harvesting, when the outer two rows of disc florets are open and perpendicular to the flower stalk.

3.4. DATA COLLECTION

The data were collected from each replication in respect of plant growth, floral characters and yield contributing characters and mean values were calculated and recorded.

Observations were made on the following parameters

3.4.1. Vegetative Parameters

Initial observations were made at the time of planting. There after monthly observations were taken for the following parameters

3.4.1.1. Plant spread (cm)

Diameter of plant was measured both in east to west and north to south directions and circumference was calculated and expressed in centimeters.

3.4.1.2. Number of leaves

Total number of leaves at the time of each observation was taken as number of leaves.

3.4.1.3. Leaf length (cm)

Leaf length was measured from base of the leaf to tip of petiole and expressed in centimeters.

3.4.1.4. Leaf breadth (cm)

Breadth of leaf at broadest point was measured and expressed in centimeters.

3.4.1.5. Number of suckers plant^{-1}

Number of suckers plant^{-1} was counted from second month onwards at the time of each observation and recorded.

3.4.2. Flowering Characters

3.4.2.1. Number of days taken for flowering

Number of days taken from planting to first flower bud appearance for each variety was recorded from tagged plants.

3.4.2..2. Number of days taken from flower bud opening to harvest

Days taken for flower bud opening to commercial harvesting stage, when outer two rows of disc florets are open and perpendicular to the flower stalk, was recorded.

3.4.2.3. Total number of flowers produced

Total numbers of flowers produced in each plant in the treatments were recorded.

3.4.2.4. Peak flowering period

Peak flowering period for each variety were recorded from the number of flowers produced in summer and rainy seasons.

3.4.2.5. Life of flower in the plant

Days from commercial harvesting stage to starting of wilting when the flower is allowed to remain on plant were recorded.

3.4.3. Flower Quality Parameters

3.4.3.1. Flower diameter (cm)

Diameter of the flower at commercial stage of harvesting was recorded and expressed in centimeters

3.4.3.2. Diameter of the flower disc (cm)

Disc diameter was measured in centimeters when outer two rows of disc florets are open and perpendicular to the flower stalk

3.4.3.3. Colour of the flower disc

Color of flower disc at harvesting stage was noted.

3.4.3.4. Number of ray florets

Total number of ray florets in each flower was counted and recorded.

3.4.3.5. Colour of ray florets

Colour of ray florets at commercial stage of harvesting was noted for each variety.

3.4.3.6. Length of the ray florets (cm)

Length of ray floret from base of petal to tip was measured in centimeters and recorded

3.4.3.7. Width of ray florets (cm)

Width of ray floret at the middle of the petal was recorded and expressed in centimeters

3.4.3.8. Length of flower stalk (cm)

Length from base of stalk to flower head was recorded in centimeters.

3.4.3.9. Girth of flower stalk (cm)

Girth of the stalk was measured at 15 centimeter height from the base and expressed in centimeters.

3.4.3.10. Visual appeal

Scoring of flowers was done by a panel of four members, based on general appearance, size of flower and colour development, and given scores from 0 to 5

3.4.4. Yield Parameters

3.4.4.1. Number of flowers plant^{-1} year^{-1}

Total number of flowers produced year^{-1} was recorded for each variety.

3.4.4.2. Yield of flowers in relation to season or month of the year.

Variation in number of flowers obtained in summer and rainy season was observed and recorded.

3.4.5. Vase Life of Flowers in Distilled Water

Vase life was tested in distilled water. Flowers for vase life study were harvested at early morning when outer two rows of disc florets became perpendicular to flower stalk, and kept in distilled water. Vase life of flower was recorded as number of days taken for flower to show signs of wilting, days taken for drooping of flower heads, days taken for discoloration of petals, or days taken for petal fall whichever happens first.

3.4.6. Pest and Disease Incidence

Plants were periodically observed for incidence of pest and diseases.

3.4.7. Environmental Parameters

3.4.7..1. Temperature (^{o}C)

Maximum and minimum temperatures inside the structure were measured using maximum- minimum thermometer and recorded.

3.4.7.2. Relative humidity (%)

Relative humidity inside the structure was recorded using wet and dry bulb thermometer.

3.4.7.3. Light intensity (Lux)

Light intensity both inside and outside the rain shelter was recorded using Lux meter and expressed in Lux.

3.4.8. Economics of Cultivation

Economics of cultivation for gerbera was calculated for 100 plants.

Cost of cultivation was worked out for each variety including cost of planting materials, manures, fertilizers, plant protection chemicals, labour wages, packing and transportation charges. Based on average yield and total returns, benefit cost ratios for each variety were calculated.

3.4.9. Statistical Analysis

The data obtained for different characters were statistically analyzed to find out differences among the varieties. Variance and covariance analysis, estimation of variability components, heritability, genetic advance and phenotypic and genotypic correlations were estimated.

Analysis of variance (ANOVA) technique was used to test significance of genotypic differences among varieties. Mean, variance, standard error and co efficient of variation were estimated. Analysis of Covariance (ANCOVA) technique was used to estimate character associations using correlation coefficients (Panse and Sukhatme, 1957).

3.4.9.1. Estimation of genetic parameters

For each character, phenotypic and genotypic components for variance were estimated by equating the expected value of mean squares (MS) to the respective variance components (Jain, 1982). Based on this, following variance components were estimated.

$$\text{Genotypic variance } (V_G) = \frac{MST - MSE}{r}$$

$$\text{Environmental variance } (V_E) = MSE$$

$$\text{Phenotypic variance } (V_P) = V_G + V_E$$

3.4.9.2. Coefficient of variation

Genotypic and phenotypic coefficients of variation were worked out using the estimates of V_G and V_P expressed in percentage for each trait (Burton, 1952).

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sqrt{V_P}}{\bar{X}} \times 100$$

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{V_G}}{\bar{X}} \times 100$$

$\bar{X}$ is the mean of each character estimated over all the treatments.

3.4.9.3. Heritability coefficient and genetic advance

For each trait, heritability (broad sense) was calculated as the ratio of genotypic variance to phenotypic variance and expressed as percentage (Jain, 1982).

$$\text{Heritability } (H^2) = \frac{V_G}{V_P} \times 100$$

Heritability was categorized as low (< 30%), moderate (31-60%) and high (>60%) as suggested by Johnson *et al*. (1955).

Genetic advance is the measure of genetic gain under selection depends upon standardized selection differential, heritability and phenotypic standard deviation (Allard, 1960).

Genetic advance (GA) = $k\, H^2 \sqrt{V_P}$

Where k is the standardized selection differential (2.06 at 5% selection).

GA as percentage of mean = $k\, H^2 \frac{\sqrt{V_P}}{\bar{X}} \times 100$

Genetic advance as percentage of mean was categorized as low (<10%), moderate (11-20%) and high (>20%) as suggested by Johnson et al. (1955).

3.4.9.4. Correlation analysis

Phenotypic and genotypic correlation coefficients were calculated using the respective variances and co-variances of the characters which showed significant variation in the ANOVA.

Phenotypic correlation coefficient, $r_{Pxy} = \frac{CoV_{P(x,y)}}{\sqrt{V_{P(x)} V_{P(y)}}}$

Genotypic correlation coefficient, $r_{Gxy} = \frac{CoV_{G(x,y)}}{\sqrt{V_{G(x)} V_{G(y)}}}$

Where CoV_P (x,y) and CoV_G (x,y) denote the phenotypic and genotypic co-variances between the two traits x and y respectively. V_P(x) and V_G(x) are the phenotypic and genotypic variances for x and V_P(y) and V_G(y) indicate the phenotypic and genotypic variances for y.

Results

4. RESULTS

A study entitled "Evaluation of gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation" was conducted at Department of Pomology and Floriculture, College of Agriculture; Vellayani from January 2015 to June 2016. Objective of the study was to evaluate varieties/accessions of *Gerbera jamesonii* Bolus for growth, yield and floral attributes under rain shelter for selecting promising varieties for commercial cultivation.

One month old tissue culture plantlets of 20 varieties of gerbera were planted and various vegetative, floral and yield parameters were recorded and evaluated under rain shelter. Data collected were statistically analyzed and the results obtained from the study are presented in this chapter.

4.1. VEGETATIVE PARAMETERS

Data related to mean vegetative parameters of twenty gerbera varieties is given in Table 7.

4.1.1. Plant Spread

Analysis of data on plant spread is given in Table 2 and fig. 1. Significant differences were noticed among varieties for plant spread. Variety Beaudine exhibited highest mean plant spread of 197.82 cm at 2 MAP which was on par with Orinaco (192.59 cm), Double date (182.12 cm) and Aquamelone (175.84 cm). At 5 MAP Beaudine recorded highest mean plant spread of 188.40 cm, which was on par with Orinaco (183.69 cm), Aquamelone (174.27 cm), Ruble (172.70 cm), Mammut (171.13 cm), Bismark (169.56 cm) and double date (167.05 cm). Beaudine also recorded highest mean plant spread at 8 MAP (175.84 cm) which was on par with Orinaco (174.27 cm), Aquamelone (166.42 cm), Poseidon (160.14 cm), Double date (158.26 cm), Aviance (158.05 cm), Esmara (154.49 cm), Carrera (149.15 cm), and Mammut (149.15 cm).

At 11 months after planting also, Beaudine recorded highest mean plant spread (205.67 cm), which was on par with Double date (181.49 cm). Lowest plant spread after 11 months was recorded in Bismark (111.47 cm)

Table 2. Mean plant spread of gerbera varieties (cm)

Variety	2MAP	5MAP	8MAP	11MAP
Aragon	107.81	113.82	121.41	112.77
Mammut	164.85	171.13	149.15	169.56
Bismark	102.57	169.56	114.09	111.47
Aviance	157.00	149.15	158.05	152.81
Mariata	135.02	150.72	137.11	149.67
Ruble	144.44	172.70	144.44	160.14
Jinx	135.02	116.18	128.74	131.88
Lexington	131.88	109.90	106.76	135.86
Aquamelone	175.84	174.27	166.42	174.27
Palm beach	128.74	108.33	105.19	124.03
Atletico	133.45	127.17	114.61	138.16
Canzone	129.79	138.16	132.93	133.97
Orinaco	192.59	183.69	174.27	177.41
Esmara	150.72	155.12	154.49	156.04
Double date	182.12	167.05	158.26	181.49
Ballroom	133.45	138.16	134.24	142.87
Carrera	130.31	139.73	149.15	153.86
Poseidon	166.42	136.59	160.14	144.44
Louvre	139.73	103.62	120.89	147.58
Beaudine	197.82	188.40	175.84	205.67
CD at 5%	26.31	31.43	31.23	24.42

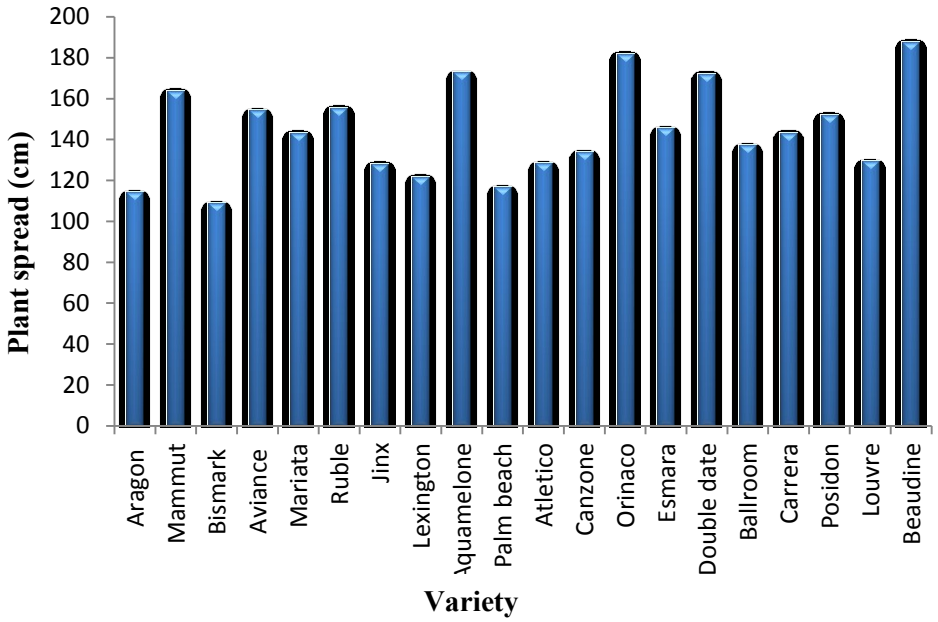


Figure 1. Mean plant spread (cm) of gerbera varieties

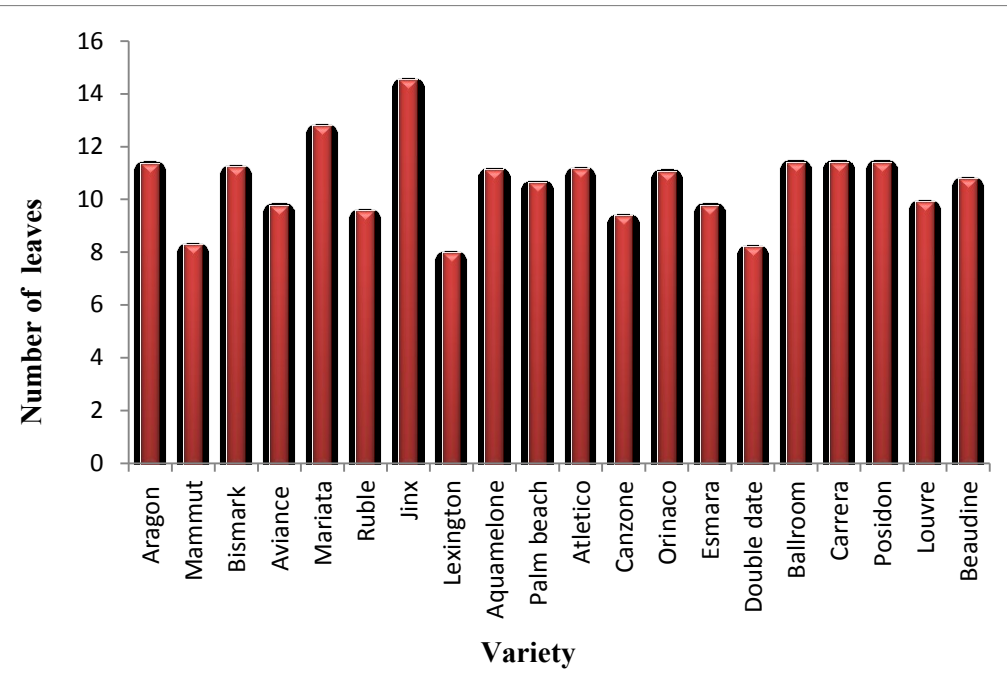


Figure 2. Mean number of leaves of gerbera varieties

4.1.2. Number of Leaves Plant^{-1}

Data pertaining to number of leaves is given in Table 3 and fig. 2, showed significant difference for number of leaves. Highest mean number of leaves at 5 MAP was observed in variety Aragon (16.33) which was on par with Orinaco (14.50), Jinx (14.50), Ballroom (13.00), Carrera (13.00), Atletico (12.50), Beaudine (12.50), Mariata (12.00), and Poseidon (11.50). Double date produced lowest number of leaves (6.50). There were no significant differences among varieties for number of leaves at 2, 8 and 11 MAP.

4.1.3. Leaf Length

Data on leaf length among evaluated varieties is given in Table 4 and fig. 3. Analysis of data revealed that significant difference exists for leaf length among varieties. Mean leaf length at 2 MAP was highest for Beaudine (41.00 cm), which was on par with Canzone (36.70 cm). Ballroom recorded lowest mean leaf length at 2 MAP. At 5MAP also, Beaudine recorded highest mean leaf length (42.25 cm). Lowest mean leaf length after 5 months was recorded for Esmara (24.70 cm).

After 8 months, Canzone recorded highest mean leaf length (37.50 cm) which was on par with Poseidon (36.30 cm), Jinx (36.25 cm), Beaudine (35.00 cm), Palm beach (33.00 cm) and Bismark (32.87 cm). Lowest mean leaf length at 8MAP was observed for Ballroom (22.50 cm). Jinx recorded highest mean leaf length (41.25 cm) at 11 MAP which was on par with Canzone (38.37 cm), Aviance (37.50 cm), Mammut (35.80 cm), Carrera (35.15 cm), Beaudine (34.45 cm), Bismark (33.75 cm), Aquamelone (33.15 cm), Ruble (33.00 cm), Palm beach (32.35 cm), Poseidon (32.25 cm), Mariata (31.33 cm) and Louvre (30.55 cm). Leaf length was lowest for Esmara (19.28 cm) at 11 MAP.

4.1.4. Leaf Breadth

Data on leaf breadth is given in Table 5 and fig. 3. Significant differences were noticed for leaf breadth among varieties at 8 MAP and 11 MAP. There was no significant difference among varieties for leaf breadth at 2 MAP and 5 MAP.

Table 3. Mean number of leaves of gerbera varieties

Variety	2MAP	5MAP	8MAP	11MAP
Aragon	11.33	16.33	10.00	9.00
Mammut	6.50	8.50	9.00	9.00
Bismark	11.67	9.33	11.33	12.50
Aviance	9.00	8.00	10.33	11.67
Mariata	14.00	12.00	13.67	11.33
Ruble	12.33	9.00	8.33	8.50
Jinx	13.50	14.50	18.00	12.00
Lexington	7.00	7.00	8.00	7.00
Aquamelone	9.33	11.00	9.00	15.00
Palm beach	12.50	9.00	11.50	9.50
Atletico	8.50	12.50	13.50	10.00
Canzone	8.33	8.67	10.67	9.67
Orinaco	9.67	14.50	9.50	10.50
Esmara	9.25	10.00	9.75	10.00
Double date	8.50	6.50	7.88	9.75
Ballroom	10.00	13.00	12.00	10.50
Carrera	11.00	13.00	11.00	10.50
Poseidon	10.50	11.50	13.00	10.50
Louvre	10.00	9.50	8.50	11.50
Beaudine	11.00	12.50	10.50	9.00
CD 5%	NS	5.04	NS	NS

Table 4. Mean leaf length of gerbera varieties (cm)

Variety	2MAP	5MAP	8MAP	11MAP
Aragon	23.27	30.30	29.43	24.27
Mammut	33.10	30.05	30.70	35.80
Bismark	30.77	28.80	32.87	33.75
Aviance	30.10	29.65	28.70	37.50
Mariata	31.33	27.27	29.70	31.33
Ruble	31.43	29.43	26.10	33.00
Jinx	34.50	31.50	36.25	41.25
Lexington	27.50	27.00	29.50	30.00
Aquamelone	30.30	32.05	28.25	33.15
Palm beach	36.00	33.70	33.00	32.35
Atletico	28.90	25.50	25.75	27.70
Canzone	36.70	36.83	37.50	38.37
Orinaco	30.67	29.05	27.40	28.55
Esmara	24.00	24.70	24.60	19.28
Double date	29.00	26.60	25.20	28.80
Ballroom	22.40	27.10	22.50	22.25
Carrera	30.75	28.50	31.50	35.15
Poseidon	26.00	27.80	36.30	32.25
Louvre	34.70	27.45	29.10	30.55
Beaudine	41.00	42.25	35.00	34.45
CD 5%	4.67	5.05	5.45	10.74

Table.5. Mean leaf breadth of gerbera varieties (cm)

Variety	2MAP	5MAP	8MAP	11MAP
Aragon	6.53	9.70	8.63	7.47
Mammut	10.80	7.30	9.15	8.50
Bismark	9.77	11.43	12.30	11.75
Aviance	8.35	8.25	8.30	8.43
Mariata	9.63	9.20	9.03	9.47
Ruble	12.57	11.17	10.47	12.25
Jinx	10.60	9.30	11.40	9.60
Lexington	8.50	7.40	7.50	7.80
Aquamelone	9.80	11.15	9.60	11.00
Palm beach	11.65	8.80	10.10	11.65
Atletico	10.25	9.20	11.10	11.45
Canzone	10.00	10.77	10.73	11.60
Orinaco	8.83	5.25	7.90	8.95
Esmara	9.38	8.75	7.63	8.78
Double date	9.20	11.80	10.70	10.50
Ballroom	10.10	9.50	7.70	9.00
Carrera	10.05	9.75	10.35	11.30
Poseidon	8.35	8.00	8.55	9.30
Louvre	11.10	8.45	9.75	9.40
Beaudine	9.40	9.35	9.65	6.55
CD 5%	NS	NS	2.47	1.74

Table. 6. Mean number of suckers plant^{-1} in gerbera varieties

Variety	2MAP	5MAP	8MAP	11MAP
Aragon	3.33	2.00	2.33	2.00
Mammut	1.50	2.50	2.50	2.00
Bismark	3.00	2.67	3.00	2.00
Aviance	2.00	1.50	1.33	1.33
Mariata	2.33	2.00	2.33	2.33
Ruble	2.67	2.67	2.33	2.00
Jinx	2.00	5.50	4.00	4.00
Lexington	2.00	3.00	1.00	1.00
Aquamelone	2.33	2.50	2.50	2.00
Palm beach	2.50	3.00	4.00	3.50
Atletico	2.50	1.50	1.50	1.50
Canzone	1.33	1.67	1.33	1.33
Orinaco	1.67	1.00	1.50	1.50
Esmara	4.00	3.50	3.50	3.75
Double date	2.00	2.00	1.00	2.00
Ballroom	1.00	1.00	1.00	1.00
Carrera	2.50	2.00	3.00	2.00
Poseidon	2.00	2.50	2.50	2.50
Louvre	1.00	1.00	1.50	1.50
Beaudine	2.50	3.50	3.00	3.50
CD 5%	1.346	1.392	1.184	1.491

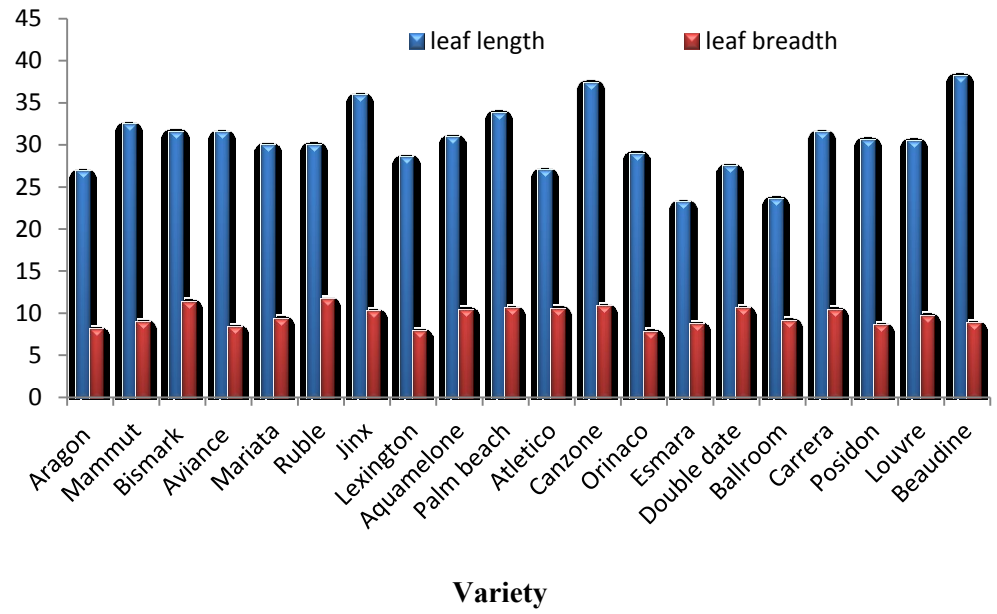


Figure 3. Mean leaf length and breadth (cm) of gerbera varieties

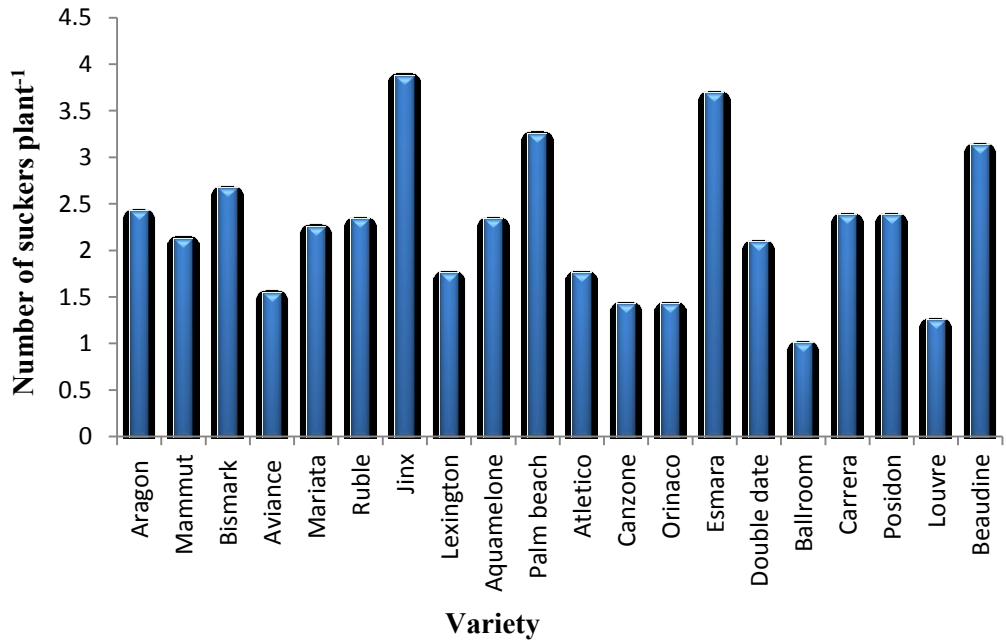


Figure 4. Mean number of suckers plant^{-1} in gerbera varieties

Table 7. Mean performance of gerbera varieties for vegetative characters

Variety	Plant spread (cm)	Number of leaves plant^{-1}	Leaf length (cm)	Leaf breadth (cm)	Number of suckers plant^{-1}
Aragon	114.08	11.33	26.82	8.07	2.42
Mammut	163.67	8.25	32.41	8.94	2.13
Bismark	108.72	11.21	31.55	11.31	2.67
Aviance	154.25	9.75	31.49	8.33	1.54
Mariata	143.13	12.75	29.91	9.33	2.25
Ruble	155.43	9.54	29.99	11.61	2.33
Jinx	127.95	14.50	35.88	10.23	3.88
Lexington	121.67	7.94	28.50	7.80	1.75
Aquamelone	172.70	11.08	30.94	10.39	2.33
Palm beach	116.57	10.63	33.76	10.55	3.25
Atletico	128.34	11.13	26.96	10.50	1.75
Canzone	133.71	9.33	37.35	10.78	1.42
Orinaco	181.98	11.04	28.92	7.73	1.42
Esmara	145.34	9.75	23.14	8.63	3.69
Double date	172.07	8.16	27.40	10.55	2.08
Ballroom	137.17	11.38	23.56	9.08	1.00
Carrera	143.26	11.38	31.48	10.36	2.38
Poseidon	151.89	11.38	30.59	8.55	2.38
Louvre	129.13	9.88	30.49	9.68	1.25
Beaudine	187.61	10.75	38.18	8.74	3.13
CD at 5%	15.47	2.48	3.93	1.45	0.756

Highest mean leaf breadth was observed for Bismark (12.30 cm) at 8MAP which was on par with Jinx (11.40 cm), Atletico (11.10 cm), Canzone (10.73 cm), Double date (10.70 cm), Ruble (10.47 cm), Carrera (10.35 cm) and Palm beach (10.10 cm). Lowest mean leaf breadth at 8 MAP was recorded for Lexington (7.50 cm).

Mean leaf breadth at 11 MAP was highest for Ruble (12.25 cm), which was on par with Bismark (11.75 cm), Palm beach (11.65 cm), Canzone (11.60 cm), Atletico (11.45 cm), Carrera (11.30 cm) and Aquamelone (11.00 cm). Lowest mean leaf breadth at 11 MAP was observed for Beaudine (6.55 cm).

4.1.5. Number of Suckers Plant^{-1}.

Data on Sucker production is given in Table 6 and fig. 4. Varieties showed significant difference in sucker production. At 2 MAP, mean sucker production was highest in variety Esmara (4.00) which was on par with Aragon (3.33), Bismark (3.00), and Ruble (2.67). Lowest number of suckers at 2 MAP was produced in varieties Louvre (1.00) and Ballroom (1.00). Jinx recorded highest mean number of suckers at 5MAP (5.50), and lowest number of suckers at 5 MAP were produced in Ballroom and Louvre (1.00).

At 8MAP, Jinx and palm beach had highest mean number of suckers (4.00) which was on par with Esmara (3.50), Bismark (3.00), Beaudine (3.00) and Carrera (3.00).Ballroom, Double date and Lexington recorded lowest number of suckers at 8 MAP. Jinx recorded highest number of suckers (4.00) at 11 MAP, which was on par with Esmara (3.75), Beaudine (3.50) and Palm beach (3.50). Lowest number of suckers at 11 MAP was recorded in Lexington and Ballroom (1.00).

4.2. FLOWERING CHARACTERS

Mean values for flowering characters of twenty gerbera varieties are presented in Table 8.

Table 8. Mean performance of gerbera varieties for flowering characters

Variety	Number of days taken for flowering (Days)	Number of days taken for flower bud initiation to harvest(Days)	Total number of flowers produced	Life of flower in plant (Days)
Aragon	47.50	10.75	23.00	6.83
Mammut	86.46	12.00	11.38	7.25
Bismark	69.42	9.63	24.88	6.88
Aviance	79.00	8.38	22.75	6.46
Mariata	58.17	9.83	24.33	7.25
Ruble	56.54	8.92	24.71	7.71
Jinx	73.88	7.00	20.25	7.52
Lexington	72.00	9.37	23.75	8.70
Aquamelone	58.75	8.25	26.21	6.56
Palm beach	129.75	8.63	22.63	7.13
Atletico	66.63	7.88	21.25	5.75
Canzone	86.17	7.83	22.42	6.92
Orinaco	84.79	7.33	23.31	6.42
Esmara	49.88	13.13	24.19	7.69
Double date	56.05	8.33	26.65	7.25
Ballroom	71.25	7.88	26.50	8.13
Carrera	78.25	10.13	23.88	7.50
Poseidon	53.25	8.25	23.50	6.25
Louvre	63.88	12.50	25.00	7.50
Beaudine	61.00	10.25	23.50	8.25
CD 5%	3.47	1.09	1.87	0.73

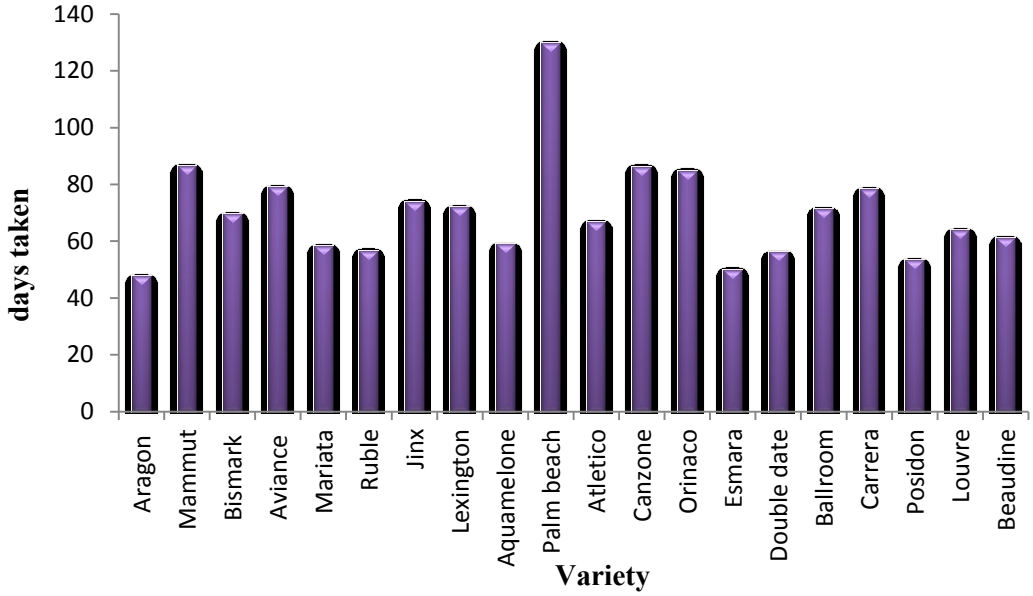


Figure 5. Mean number of days taken for flowering of gerbera varieties

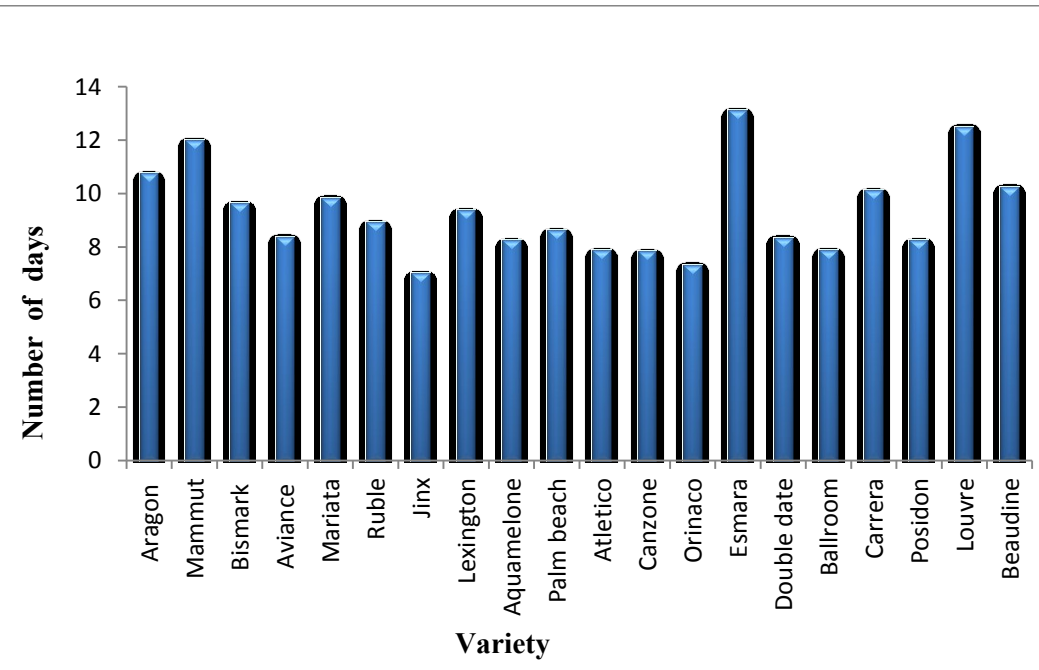


Figure 6. Number of days taken for flowerbud opening to harvest for gerbera varieties

4.2.1. Number of Days Taken for Flowering

Data related to number of days taken for flowering is given in Table 8 and fig. 5.Varieties exhibited significant variations for number of days for first flower bud initiation. Lowest mean number of days for flowering (47.50 days) was taken by variety Aragon followed by Esmara (49.88 days). Palm beach recorded highest mean number of days for first flowering (129.75 days).

4.2.2. Number of Days Taken for Flower Bud Opening to Harvest

Data on Number of days taken for flower bud opening to harvest is given in Table 8 and fig. 6. Significant difference was observed in mean number of days from bud opening to harvest among varieties. Variety Jinx took lowest number of days from bud opening to harvest maturity (7.00 days) followed by Orinaco(7.33 days), Canzone (7.83 days), Atletico(7.88 days) and Ballroom (7.88 days).Esmara recorded highest number of days from bud opening to harvest maturity (13.13 days).

4.2.3. Total Number of Flowers Produced

Data for total number of flowers produced by varieties is given in Table 8 and fig. 7. Varieties exhibited significant difference for total number of flowers produced. Flower production plant^{-1} year^{-1} was highest for variety Double date (26.65) which was on par with Ballroom (26.50), Aquamelone (26.21), Louvre (25.00) and Bismark (24.88). Highest number of flowers in double date was recorded during rainy season. Lowest number of flowers was produced by variety Mammut (11.38).

4.2.4. Peak Flowering Period

The data showed that most of the varieties exhibited peak production during rainy season, and in a few varieties, peak flowering observed in summer season.

Varieties such as Mammut (9.10), Mariata (14.60), Ruble (14.83), Jinx (15.19), Lexington (17.81), Atletico (18.06), Canzone (19.05), Orinaco, Double

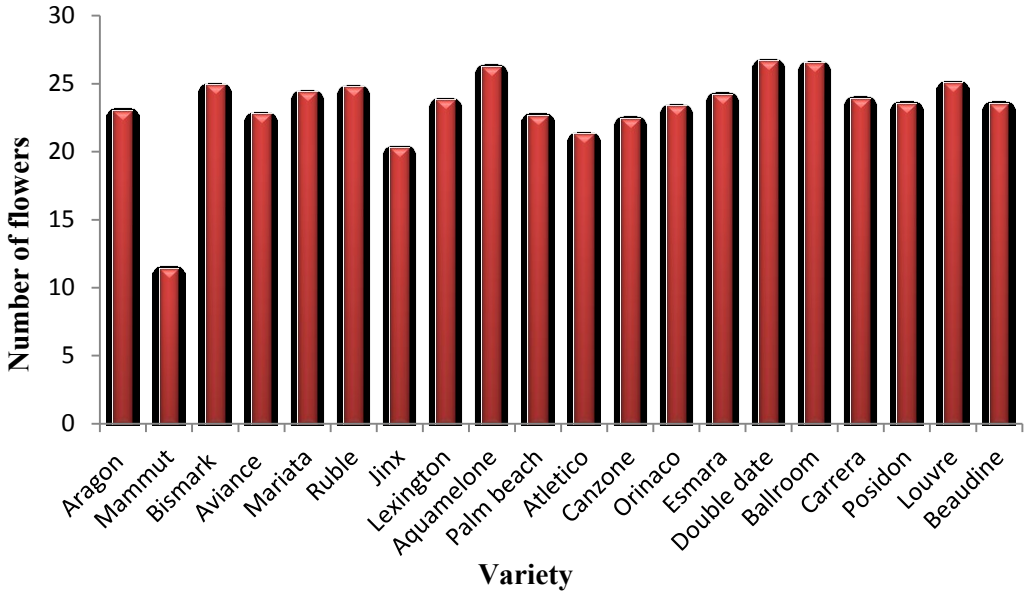


Figure 7. Total number of flowers produced in gerbera varieties

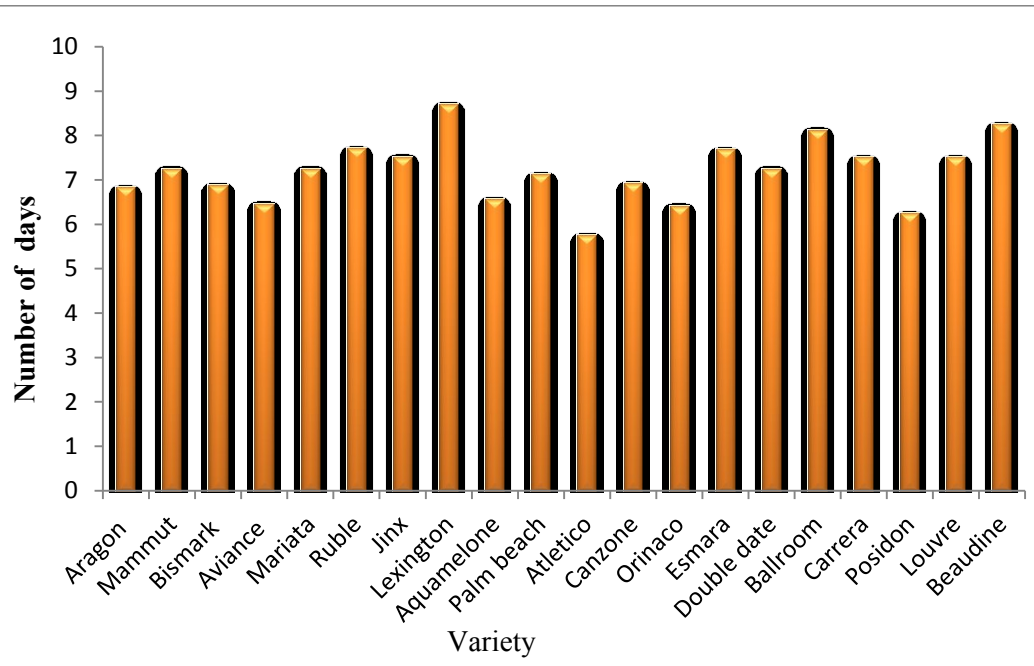


Figure 8. Mean life of flower in plant (days) of gerbera varieties

date, Ballroom, Louvre produced highest number of flowers in rainy season whereas Beaudine (14.10) and Carrera (14.33) yielded highest in summer.

4.2.5. Longevity of Flower in the Plant

Data on life of flower in plant is given in Table 8 and fig. 8. Significant differences were noticed among varieties for life of flower in plant. Flowers of variety Lexington were found to have highest mean life in plant (8.70 days) which was on par with Beaudine (8.25 days) and Ballroom (8.13 days). Atletico recorded lowest days (5.75 days) followed by Poseidon (6.25 days) and Orinaco (6.42 days)

4.3. FLOWER QUALITY PARAMETERS

Details regarding flower quality parameters are given in Table 9.

4.3.1. Flower Diameter

Data related to flower diameter is given in Table 9 and fig. 9. Significant differences were observed for flower diameter among evaluated varieties. Flowers with highest mean diameter were produced by Variety Beaudine (11.55 cm) which was on par with Mammut (11.06 cm). Aragon recorded lowest flower diameter (8.49 cm) which was on par with Ballroom (8.64 cm), Lexington (8.70 cm), Palm beach (8.86 cm), Canzone (9.05 cm), Orinaco (9.17 cm) and Aquamelone (9.23 cm).

4.3.2. Diameter of the Flower Disc

Data on disc diameter is given in Table 9. Disc diameter differed significantly among varieties. Mean value for disc diameter was highest for variety Esmara (4.75 cm) followed by Ruble (2.97 cm) which was on par with Mammut (2.79 cm).Lowest mean disc diameter was observed in Jinx(2.20 cm) followed by Canzone (2.27 cm) and Carrera (2.29 cm).

Table 9. Mean performance of gerbera varieties for flower quality characters

Variety	Flower diameter (cm)	Disc diameter (cm)	Number of ray florets	Length of ray florets (cm)	Width of ray florets (cm)	Length of flower stalk (cm)	Girth of flower stalk (cm)
Aragon	8.49	2.30	61.00	3.57	0.87	38.08	2.23
Mammut	11.06	2.79	55.13	4.28	1.08	51.40	2.34
Bismark	10.20	2.48	66.58	4.02	0.94	45.10	2.27
Aviance	10.27	2.37	52.83	4.34	0.81	56.73	2.20
Mariata	10.34	2.53	54.50	4.33	1.01	40.67	2.14
Ruble	9.62	2.97	75.71	3.68	0.78	40.00	2.02
Jinx	9.45	2.20	43.63	4.14	0.84	41.56	2.15
Lexington	8.70	2.40	45.25	3.73	0.78	57.28	2.07
Aquamelone	9.23	2.44	59.96	3.80	1.10	46.59	2.08
Palm beach	8.86	2.44	43.38	3.68	0.95	54.44	2.30
Atletico	9.39	2.50	46.00	3.89	1.03	47.59	2.15
Canzone	9.05	2.27	54.67	3.52	0.83	45.25	2.14
Orinaco	9.17	2.47	50.75	3.71	0.83	47.94	2.23
Esmara	10.24	4.75	59.44	3.09	0.66	49.29	2.23
Double date	9.38	2.40	53.50	3.65	0.93	44.33	2.23
Ballroom	8.64	2.36	65.38	3.25	0.71	37.13	2.28
Carrera	10.21	2.29	55.88	4.06	0.68	44.44	2.25
Poseidon	10.40	2.39	45.38	4.48	0.88	52.10	2.24
Louvre	10.38	2.33	48.38	4.61	1.08	41.94	2.26
Beaudine	11.55	2.38	58.00	4.81	0.89	57.48	2.25
CD at 5%	0.8486	0.3027	5.29	0.5295	0.1179	6.53	0.1095

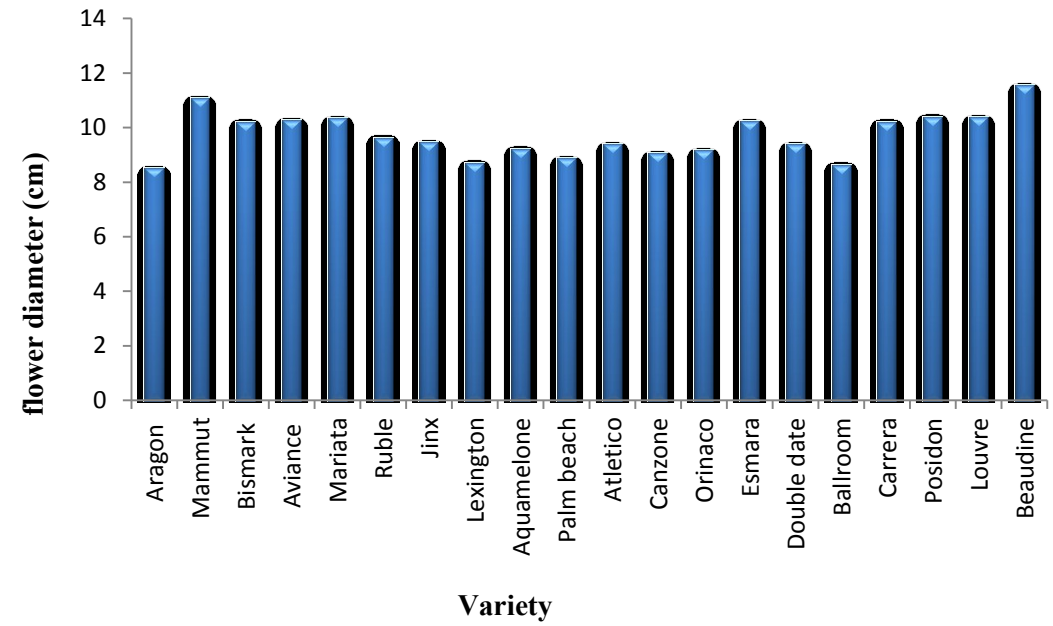


Figure 9. Mean flower diameter (cm) of gerbera varieties

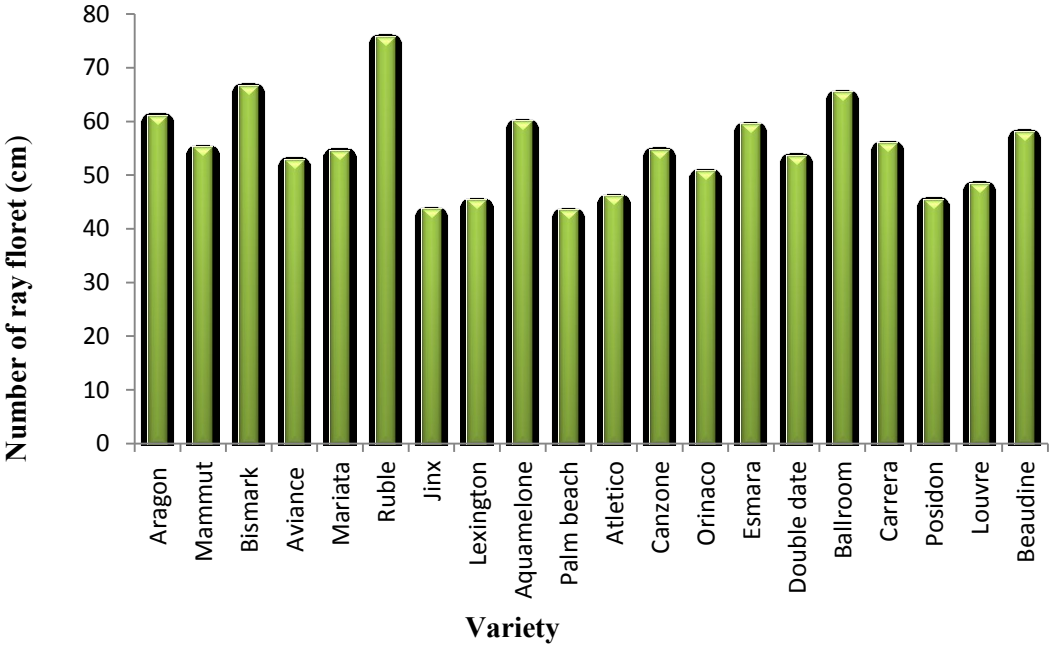


Figure 10. Mean number of ray florets in gerbera varieties

4.3.3. Colour of the Flower Disc

Flower disc colour varied among the varieties from greenish yellow to yellow and black. Greenish yellow disc was observed in Mammut, Aviance, Jinx, Lexington, Palm beach, Double date, Ballroom and Louvre.

Aragon, Esmara and Poseidon were found to have yellow flower disc. Black colour for disc was observed in Bismark, Mariata, Ruble, Aquamelone, Atletico, Canzone, Orinaco, Carrera and Beaudine.

4.3.4. Number of Ray Florets

Data for number of ray florets is given in Table 9 and fig. 10. Highest mean number of ray florets was recorded for variety Ruble (75.71) followed by Bismark (66.58), which was on par with Ballroom (65.38).

Mean number of ray florets was lowest in variety Palm beach (43.38), which was on par with Jinx (43.63), Lexington (45.25), Poseidon (45.38), Atletico (46.00) and Louvre (48.38).

4.3.5. Colour of Ray Florets

Varieties exhibited wide variation in colour of ray florets, ranging from white to cream, Pink to purple, and orange to dark red. Bi-coloured ray florets with light coloured tips were also noticed.

Canzone, Poseidon, Louvre produced ray florets with white colour. Mammut was the only variety with cream coloured ray florets. Pink coloured ray florets were observed in Bismark, Aviance, Esmara and Ballroom. Purple coloured ray florets were noticed in variety Ruble. Orinaco and Atletico produced orange coloured ray florets. Aragon produced light red coloured ray florets, and red coloured ray florets were produced by Lexington, Carrera and Beaudine. Bicoloured petals were also observed in varieties such as Double date (orange with yellow tip) and Mariata (Pink with white tip)

4.3.6. Length of Ray Florets

Data on ray floret length is given in Table 9. Varieties exhibited significant differences for length of ray florets. Mean ray floret length was highest for variety Beaudine (4.81 cm) which was on par with Louvre (4.61 cm), Poseidon (4.48 cm), Aviance (4.34 cm), Mariata (4.33 cm) and Mammut (4.28 cm). Ballroom recorded lowest length (3.25 cm).

4.3.7. Width of Ray Florets

Data related to width of ray florets is given in Table 9 and fig. 11. Varieties differed significantly from each other for ray floret width. Variety Aquamelone produced flowers with highest mean ray floret width (1.10 cm), which was on par with Louvre (1.08 cm), Mammut (1.08 cm), and Mariata (1.01 cm). Lowest mean ray floret width was observed in Esmara (0.66 cm) followed by Carrera (0.68 cm) and ballroom (0.71 cm).

4.3.8. Length of Flower Stalk

Data for length of flower stalk is given in Table 9 and fig. 12. Significant differences were noticed for flower stalk length among varieties. Highest mean length of flower stalk was recorded in Beaudine (57.48 cm) which was on par with Lexington (57.28 cm), Aviance (56.73 cm), Palm beach (54.44 cm) and Poseidon (52.10 cm). Flowers with lowest mean stalk length were observed in Ballroom (37.13 cm).

4.3.9. Girth of Flower Stalk

Data on flower stalk girth is given in Table 9. There was not much difference in flower stalk girth among varieties. Flowers with highest mean stalk girth was produced by variety Mammut (2.34cm).Lowest stalk girth was recorded in variety Ruble (2.02 cm).

4.3.10. Visual Appeal

Mean scores obtained for varieties are given as appendix I. Scoring for visual appeal of flowers was done from 1 to 5 based on general appearance, size

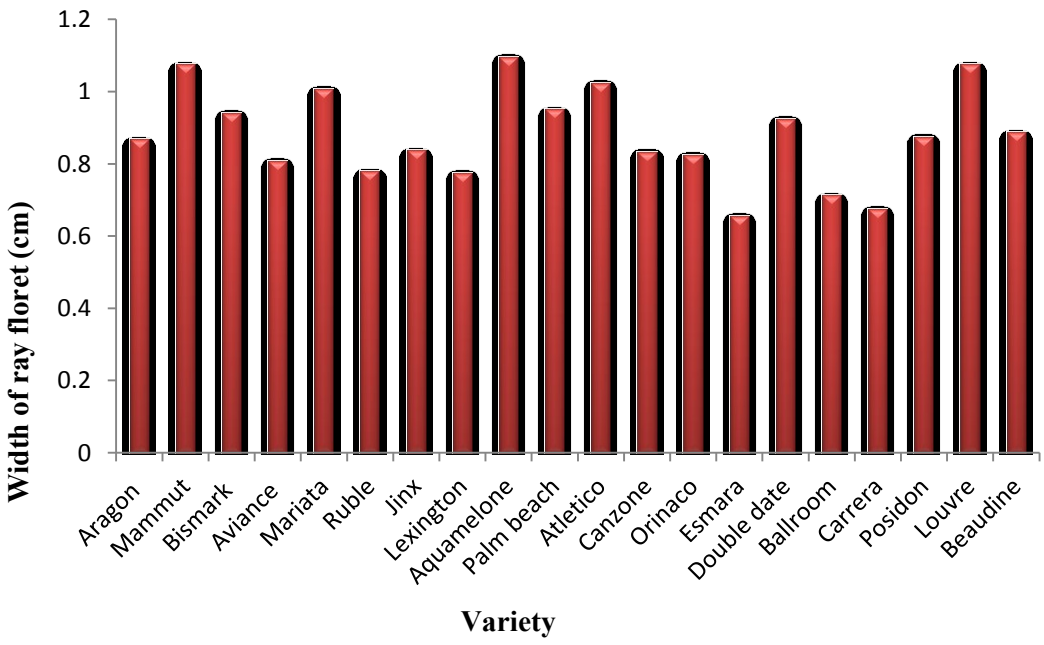


Figure 11. Mean width of ray florets (cm) of gerbera varieties

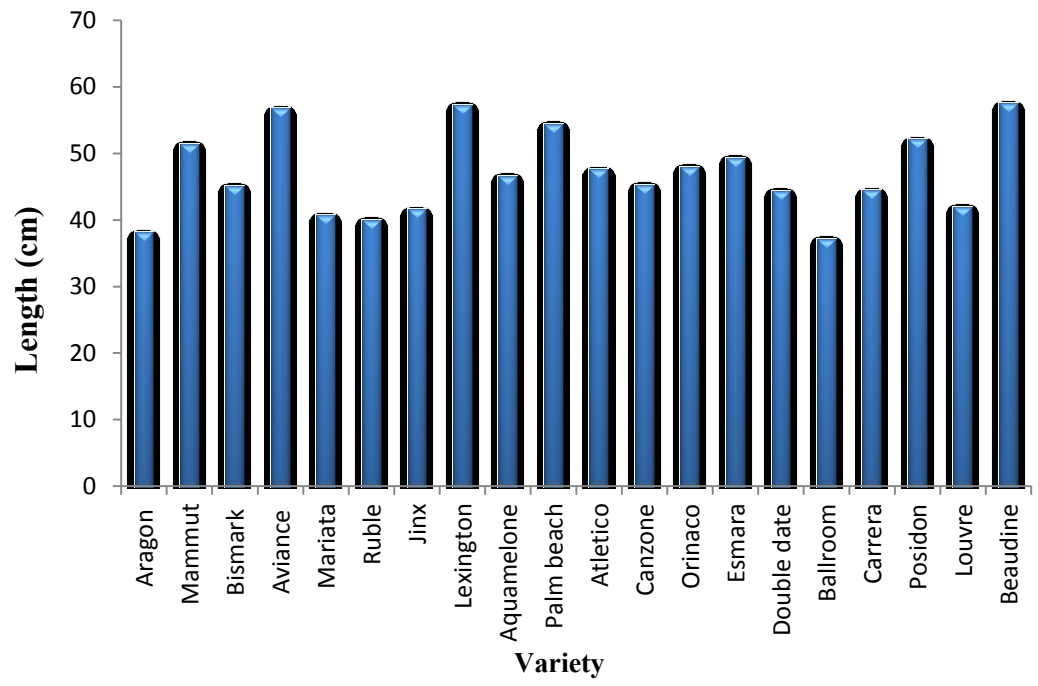


Figure 12. Mean length of flower stalk (cm) of gerbera varieties

of flower and colour development. Varieties Beaudine, Mammut, obtained highest score (4.91) and had best quality flowers, with good appearance, size, and proper and uniform color development. Carrera (4.83), Mariata (4.83), Aquamelone (4.83) and Ruble (4.75) also obtained high scores. Esmara produced superior quality flowers and obtained score 4.41. Palm beach (3.33), Double date (3.41), Orinaco (3.41) and Aragon (3.41) obtained lowest scores for visual appeal.

4.4. YIELD PARAMETERS

Mean values obtained for yield parameters for varieties are given in Table 10.

4.4.1. Number of Flowers Plant^{-1} Year^{-1}

Data on number of flowers plant-1 year-1 is given in Table 10 and fig. 13. Significant differences were observed for number of flowers plant^{-1} year^{-1}.Variety Double date produced highest mean number of flowers year^{-1} (26.65) which was on par with Ballroom (26.50), Aquamelone (26.21) Louvre (25.00) and Bismark (24.88). Mean flower production was lowest for variety Mammut (11.38).

4.4.2. Yield of Flowers in Relation to Season or Month of the Year.

Flower yield varied among the varieties during rainy and summer seasons. Some of the varieties produced more flowers during rainy season, whereas in some others, flower production was highest in summer season. Variety Mammut was the low yielder in both seasons.

4.4.2.1. Yield in rainy season

Data on yield in rainy season is given in Table 10 and fig. 14. Variety Double date produced highest number of flowers (19.99) during rainy season which was on par with the varieties Ballroom (19.88), Palm beach (19.23), and Canzone (19.05). Mammut yielded lowest number of flowers (9.10) which was on par with Beaudine (9.40) and Carrera (9.55).

Table 10. Mean yield parameters for gerbera varieties

Variety	No. of flowers plant $^{-1}$ year^{-1}	yield in rainy season(flowers plant^{-1})	yield in summer season(flowers plant^{-1})
Aragon	23.00	13.80	9.20
Mammut	11.38	9.10	2.28
Bismark	24.88	13.68	11.19
Aviance	22.75	12.51	10.24
Mariata	24.33	14.60	9.73
Ruble	24.71	14.83	9.88
Jinx	20.25	15.19	5.06
Lexington	23.75	17.81	5.94
Aquamelone	26.21	13.63	12.58
Palm beach	22.63	19.23	3.39
Atletico	21.25	18.06	3.19
Canzone	22.42	19.05	3.36
Orinaco	23.31	18.65	4.66
Esmara	24.19	13.30	10.88
Double date	26.65	19.99	6.66
Ballroom	26.50	19.88	6.63
Carrera	23.88	9.55	14.33
Poseidon	23.50	12.93	10.58
Louvre	25.00	17.50	7.50
Beaudine	23.50	9.40	14.10
CD 5%	1.87	1.20	0.72

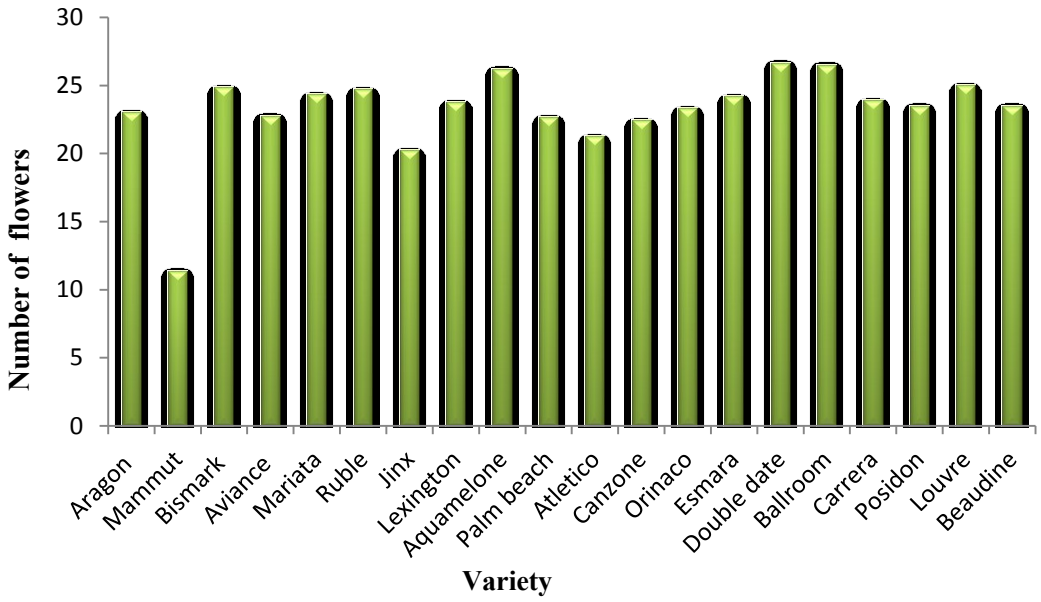


Figure 13. Mean number of flowers plant^{-1} year^{-1} for gerbera varieties

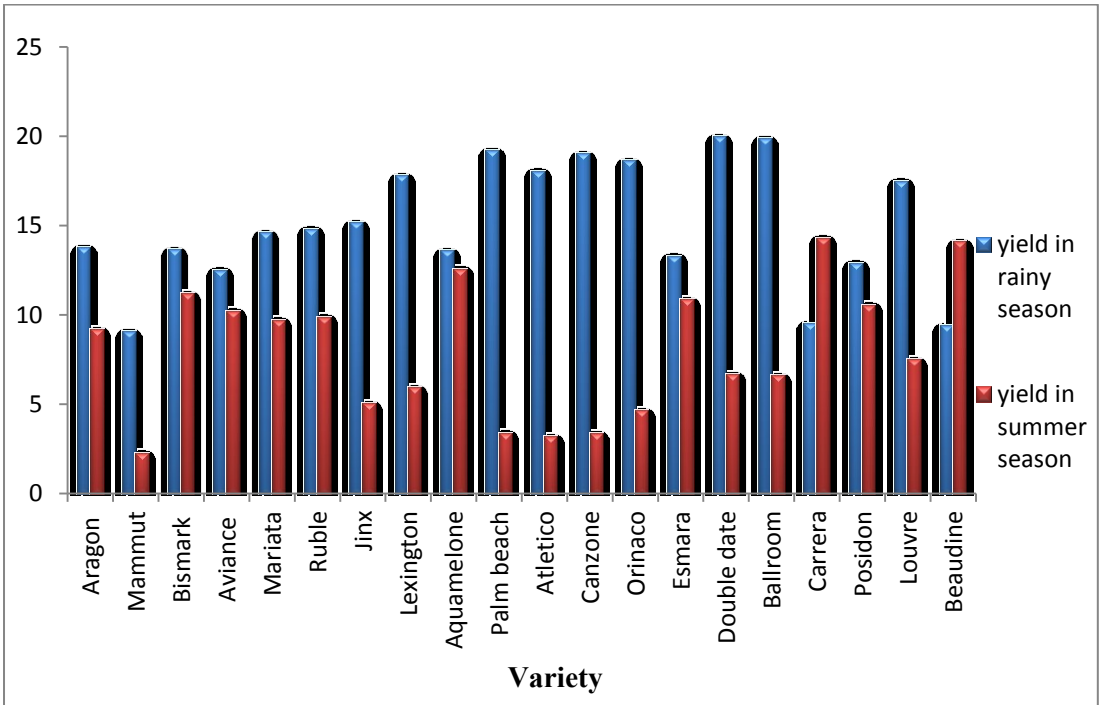


Figure 14. Flower yield of gerbera varieties in relation to season

Plate 4.Variation in leaf size and shape among evaluated varieties

a b c

Plate 5. Variation in colour of flower disc. a. greenish yellow . b. Yellow c. Black

Plate 6. Ruble: variety with highest number of ray florets

Plate 7. Aquamelone: variety with highest ray floret width

Mammut Beaudine

Plate 8. Varieties with highest mean scores for visual appeal

Plate 9. Variation in length of flower stalk: Ballroom with lowest mean stalk length and Beaudine with highest mean stalk length

Double date. Mariata.

Plate 10. Varieties with double coloured ray florets.

4.4.2.2. Yield in summer season

Data on flower yield during summer season is given in Table 10 and fig. 14. Highest yield in summer was obtained from variety Carrera (14.33), which was on par with Beaudine (14.10). Mammut obtained lowest yield (2.28) during summer season, followed by Atletico (3.19) which was on par with Canzone (3.36) and Palm beach (3.39).

4.5. VASE LIFE OF FLOWERS IN DISTILLED WATER

Data related to vase life studies of 20 gerbera varieties is given in Table 11 and fig. 15. Evaluated varieties exhibited significant difference in vase life. Highest vase life was recorded for varieties Mariata and Aragon (10.75 days) and vase life was lowest for Orinaco and Louvre (6.25 days)

4.6. PEST AND DISEASE INCIDENCE

Mite infestation was observed in the experimental field during the study. Data on percentage of plants infested by mites in each variety is given in Table 12. Extend of resistance to the pest varied among the varieties. Varieties such as Aragon, Mammut, Bismark, Mariata, Ruble, Aquamelone, Palm beach, Esmara, Beaudine, and Louvre were free from infestation by mites. More than 50 per cent of plants were infested in varieties Ballroom (87.50 per cent), Double date (75 per cent), Atletico (68.75 per cent), Lexington (68.75 per cent), and Orinaco (62.50 per cent).

Minor incidence of snails was noticed in plants, which were found only in the border rows. Deficiencies of zinc and magnesium were observed during early vegetative growth stages of varieties Aragon and Beaudine.

4.6. ENVIRONMENTAL PARAMETERS

Data on environmental parameters from May 2015 to May 2016 is given as appendix II, fig. 16 and fig.17 and month wise total flower yield as appendix III. From the data, it was clear that yield was higher in rainy season, particularly during September, October, and November. Mean maximum and minimum temperatures during these months ranged from 39.67 to 41.67 and 24 to 27.5 ^{o}C

Table 11. Mean vase life of gerbera varieties in distilled water

Variety	Vase life in days
Aragon	10.75
Mammut	7.75
Bismark	7.75
Aviance	8.75
Mariata	10.75
Ruble	9.5
Jinx	7.25
Lexington	6.5
Aquamelone	6.75
Palm beach	7.75
Atletico	7.00
Canzone	7.00
Orinaco	6.25
Esmara	8.25
Double date	7.00
Ballroom	7.25
Carrera	7.00
Poseidon	6.75
Louvre	6.25
Beaudine	8.25
CD at 5%	1.0083

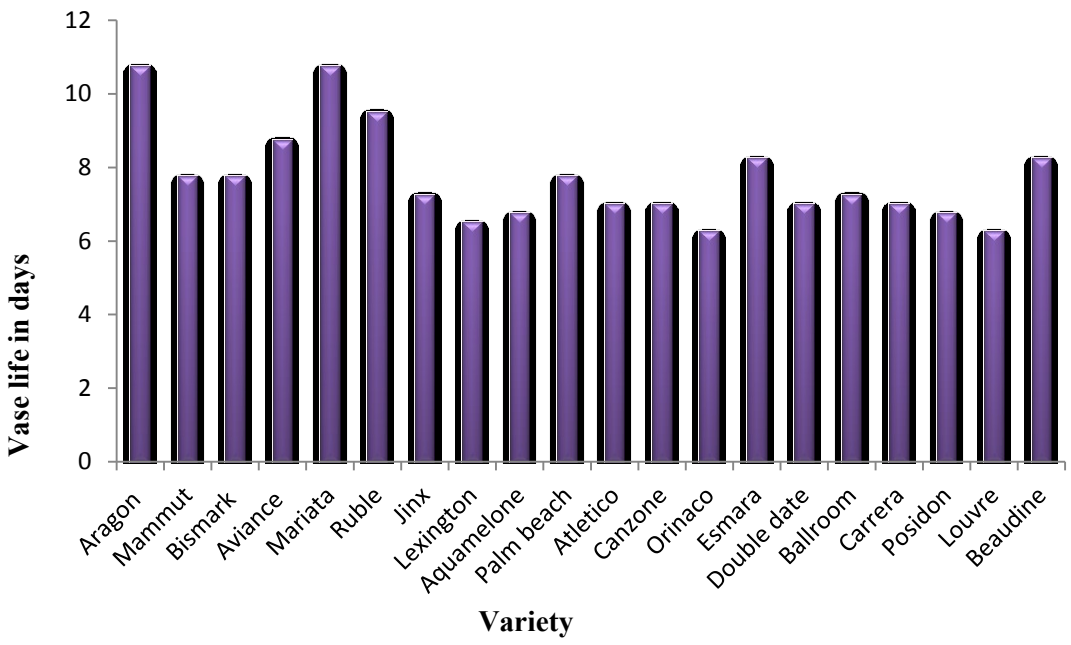


Figure 15. Mean vase life of gerbera varieties in distilled water (days)

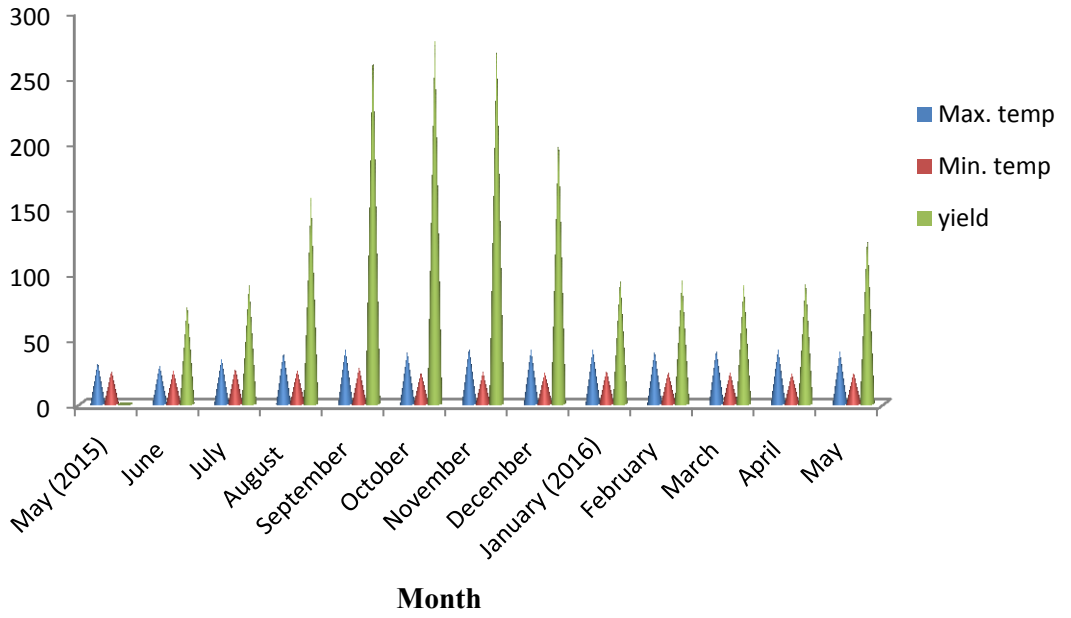


Figure 16. Monthly flower yield in relation to temperature (°c)

Plate 11. Flower and leaves showing symptoms of mite infestation

Plate 12. Snail infestation on gerbera

Plate 13. Nutrient deficiency (Mg and Zn) during early growth stage

Plate 14. Unmarketable flowers

Table 12. Percentage of plants infested by mites in varieties of gerbera

Variety	Mite infestation (percentage)
Aragon	0.00
Mammut	0.00
Bismark	0.00
Aviance	43.75
Mariata	0.00
Ruble	0.00
Jinx	50.00
Lexington	68.75
Aquamelone	0.00
Palm beach	0.00
Atletico	68.75
Canzone	31.25
Orinaco	62.50
Esmara	0.00
Double date	75.00
Ballroom	87.50
Carrera	18.75
Poseidon	25.00
Louvre	0.00
Beaudine	0.00

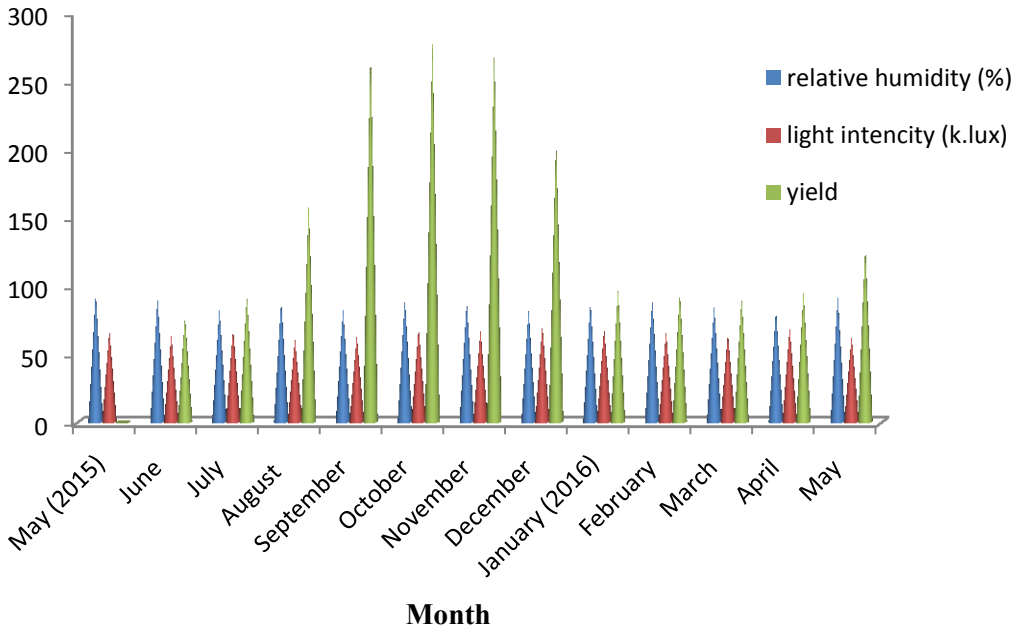


Figure 17. Monthly flower yield in relation to relative humidity (%) and light intensity (k.lux)

respectively. Relative humidity ranged from 82 to 87 percent, and light intensity ranged from 62.8 to 68.5 k. Lux.

4.7. ECONOMICS OF CULTIVATION

Benefit Cost ratios obtained from 100 plants of each variety are given in Table 13. Wide variations were noticed for benefit cost ratio among varieties. Highest BC ratio was recorded for double date and ballroom (1.35) followed by Aquamelone (1.30), Louvre, Ruble (1.25) and Beaudine (1.20). Mammut recorded lowest BC ratio (0.60).

4.8. ESTIMATION OF GENETIC PARAMETERS

Estimation genetic variability in available germplasm is a prerequisite for a successful breeding programme since most of the yield contributing characters are controlled by poly genes.

4.8.1. Estimation of Variability

Data on phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) for characters is given in Table 14 and fig. 18. For all the observed characters, phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV), indicated influence of environment on expression of these characters.

Highest GCV and PCV were noticed for yield in summer season (GCV 45.99, PCV 46.42), followed by number of suckers plant^{-1}(GCV 32.80, PCV 40.50), number of days for first flowering (GCV 26.22, PCV 26.46), yield in rainy season (GCV 23.02 PCV 23.69).

Moderate values of GCV and PCV were obtained for disc diameter (GCV 20.98 PCV 22.59), plant spread (GCV 15.35, PCV 17.12), leaf breadth (GCV 11.19, PCV 15.54), length of ray florets (GCV 10.41, PCV 14.11), life of flower in plant (GCV 9.37, PCV 11.80).

Girth of flower stalk recorded lowest GCV and PCV (GCV 3.30, PCV 4.82) followed by flower diameter (GCV 8.00, PCV 10.10).

Table 13. Benefit cost ratio for 100 plants of gerbera

Variety	Total cost of cultivation (Rs.)	Total income (Rs.)	BC ratio
Aragon	9828.433	11327.5	1.153
Mammut	9828.433	5910	0.601
Bismark	9828.433	12312.5	1.253
Aviance	9828.433	11327.5	1.153
Mariata	9828.433	11820	1.203
Ruble	9828.433	12312.5	1.253
Jinx	9828.433	9850	1.002
Lexington	9828.433	11820	1.203
Aquamelone	9828.433	12805	1.303
Palm beach	9828.433	11327.5	1.153
Atletico	9828.433	10835	1.102
Canzone	9828.433	10835	1.102
Orinaco	9828.433	11820	1.203
Esmara	9828.433	11820	1.203
Double date	9828.433	13297.5	1.353
Ballroom	9828.433	13297.5	1.353
Carrera	9828.433	11820	1.203
Posidon	9828.433	11820	1.203
Louvre	9828.433	12312.5	1.253
Beaudine	9828.433	11820	1.203

Table 14. Genotypic and phenotypic coefficients of variability for 20 characters of gerbera

Sl. no	Characters	Range	Mean	GCV	PCV
1	Plant spread (cm)	108.72-187.61	144.43	15.35	17.12
2	No. of leaves plant^{-1}	7.94-14.5	10.55	12.27	20.66
3	Leaf length (cm)	23.14-38.17	30.46	12.15	15.20
4	Leaf breadth (cm)	7.73-11.61	9.55	11.19	15.54
5	No. of suckers plant^{-1}	1-3.875	2.25	32.80	40.50
6	No. of days for first flowering	47.5-129.75	70.13	26.22	26.46
7	No. of days from bud initiation to harvest	7-13.125	9.31	18.00	19.82
8	Total no. of flowers produced	11.375-26.65	23.20	13.58	14.72
9	Life of flower in plant (days)	5.75-8.70	7.19	9.37	11.80
10	Flower diameter (cm)	8.49-11.55	9.73	8.00	10.10
11	Disc diameter (cm)	2.2-4.75	2.55	20.98	22.59
12	No. of ray florets	43.37-75.70	54.76	15.08	16.56
13	Length of ray florets(cm)	3.08-4.61	3.93	10.41	14.11
14	Width of ray florets(cm)	0.86-1.07	0.88	14.05	16.94
15	Length of flower stalk (cm)	37.13-57.47	46.97	12.53	15.93
16	Girth of flower stalk (cm)	2.02-2.34	2.20	3.30	4.82
17	No. of flowers plant^{-1} year^{-1}	11.37-26.65	23.20	13.58	14.72
18	Yield in rainy season	9.1-19.98	15.13	23.02	23.69
19	Yield in summer season	2.27-14.333	8.06	45.99	46.42
20	Vase life in distilled water (days)	6.25-10.75	7.73	16.52	18.92

Difference between phenotypic and genotypic coefficients of variation was highest for number of suckers per plant and number of leaves plant^{-1}. This indicates influence of environment on expression of these characters. Number of days for first flowering, yield in summer season, yield in rainy season, number of ray florets, and plant spread showed very low difference.

4.8.2. Heritability and Genetic Advance

Data on heritability and genetic advance of characters is given in Table 15 and fig. 19. For a particular character, high heritability estimates provide a measure of effectiveness of selection on phenotypic basis. All the characters showed high heritability.

High heritability was noticed for number of days for first flowering (98.25 per cent), yield in summer season (98.13 per cent), yield in rainy season (94.36 per cent), disc diameter (86.22 per cent), number of flowers plant^{-1} year^{-1} (85.06 per cent), number of ray florets (82.92 per cent), number of days from bud initiation to harvest (82.43 per cent) and plant spread (80.41 per cent). Number of leaves plant^{-1} recorded lowest value for heritability (35.29 per cent) followed by girth of flower stalk (46.88 per cent).

High genetic advance was observed in characters like yield in summer season (93.84 per cent), number of sucker per plant(54.72 per cent), number of days for first flowering(53.54 per cent), yield in rainy season (46.05 per cent), disc diameter(40.12 per cent), number of days from bud initiation to harvest (33.65 per cent), vase life in distilled water (29.71per cent), Plant spread (28.35 per cent), number of ray florets(28.28 per cent), number of flowers plant^{-1} year^{-1}(25.79 per cent), total number of flowers produced (25.79 per cent) and width of ray florets(24.01 per cent).

Flower diameter (13.06 per cent), number of leaves plant^{-1}(15.01 per cent) and life of flower in plant (15.31 per cent) were found to have moderate genetic advance. Lowest value for genetic advance was recorded for girth of flower stalk (4.65 per cent).

Table 15. Heritability and genetic advance for 20 characters of gerbera

Sl. no	Character	Heritability (Percentage)	Genetic advance as % of mean
1	Plant spread (cm)	80.41	28.35
2	No. of leaves plant^{-1}	35.29	15.01
3	Leaf length (cm)	63.89	20.01
4	Leaf breadth (cm)	51.9	16.61
5	No .of suckers plant^{-1}	65.59	54.72
6	No. of days for first flowering	98.25	53.54
7	No. of days from bud initiation to harvest	82.43	33.65
8	Total no of flowers produced	85.06	25.79
9	Life of flower in plant (days)	62.99	15.31
10	Flower diameter (cm)	62.75	13.06
11	Disc diameter (cm)	86.22	40.12
12	No. of ray florets	82.92	28.28
13	Length of ray florets (cm)	54.44	15.82
14	Width of ray florets (cm)	68.81	24.01
15	Length of flower stalk (cm)	61.85	20.29
16	Girth of flower stalk (cm)	46.88	4.65
17	No. of flowersplant^{-1} yr^{-1}	85.06	25.79
18	Yield in rainy season	94.36	46.05
19	Yield in summer season	98.13	93.84
20	Vase life in distilled water (days)	76.21	29.71

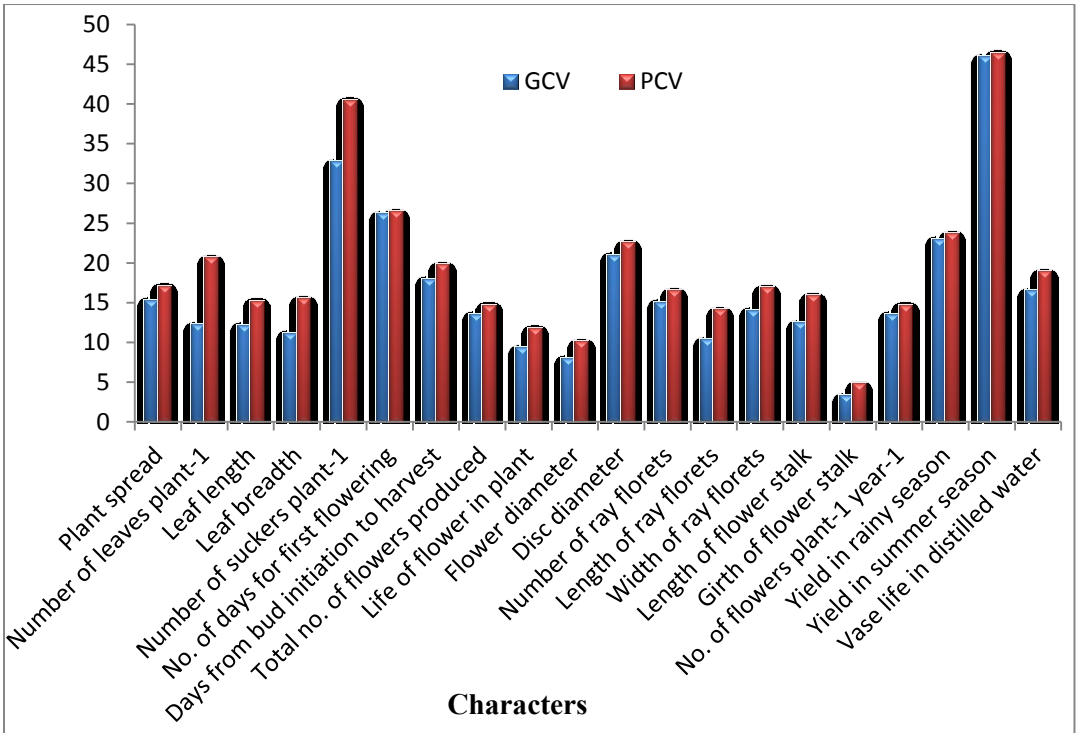


Figure 18. Phenotypic and genotypic coefficients of variation for 20 characters of gerbera

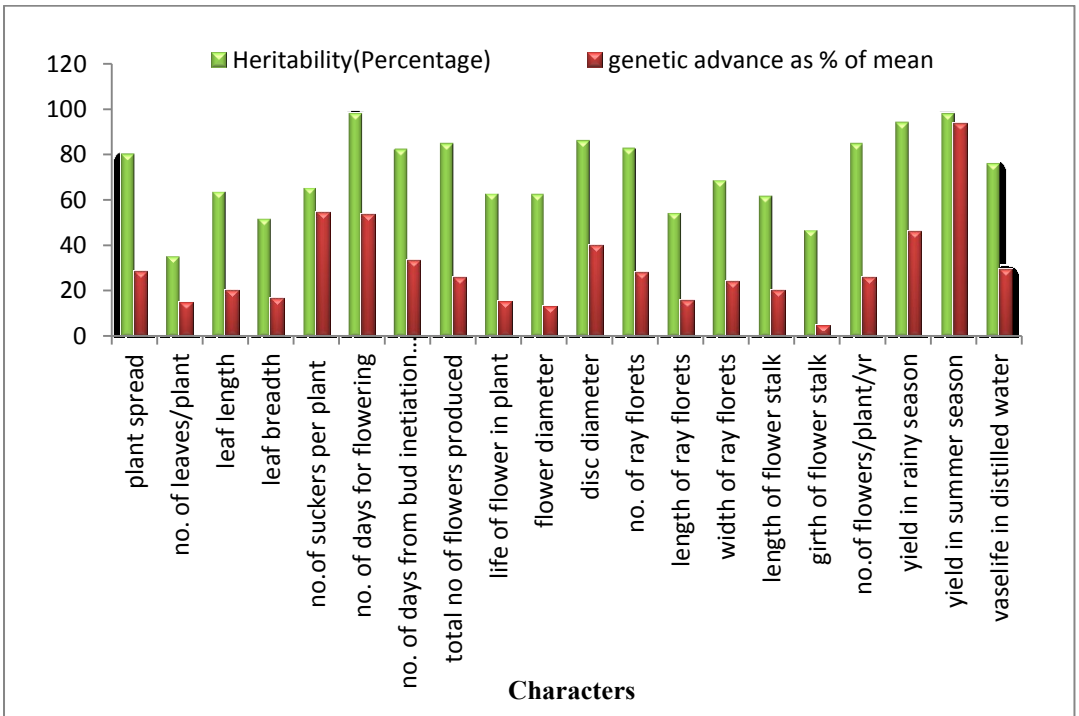


Figure 19. Heritability and genetic advance as percentage of mean for 20 characters of gerbera

4.8.3. Correlation Studies

4.8.3.1. Phenotypic correlation

Phenotypic correlation coefficients for 20 characters of gerbera are given in Table 16. Highly significant and positive phenotypic correlation was obtained for flower diameter with length of ray florets (0.7364). Flower diameter was found to have highly significant and negative correlation with yield in rainy season (-0.5966).Number of days from bud initiation to harvest showed a positive correlation with disc diameter (0.4780).Significant positive correlation was also found between leaf length and length of ray florets (0.4963). Length of ray florets also exhibited significant positive correlation with width of ray florets (0.5002).

Yield in summer season exhibited a significant negative correlation with number of days for first flowering (-0.5186). But it exhibited significant positive correlation with total number of flowers produced (0.5018) and number of flowers plant $-^{1}$(0.5018). Highly significant negative correlation was found between yield in summer season and yield in rainy season (-0.5666).

4.8.3.2. Genotypic correlation

Genotypic correlation coefficients for 20 characters of gerbera are given in Table 17. Plant spread exhibited significant positive genotypic correlation with flower diameter (0.4385).Number of leaves was positively correlated with number of suckers Plant^{-1}(0.5004) and negatively correlated with length of flower stalk (-0.5473). Leaf length showed significant positive correlation with disc diameter (0.5052). Girth of flower stalk was found to have highly significant negative correlation with leaf length (-0.6346).

Number of days from bud initiation to harvest was positively correlated with flower diameter (0.5357) and had highly significant association with disc diameter (0.5763), but negative correlation was obtained with yield in rainy season (-0.4788).

Highly significant positive correlation was obtained for length of ray florets with leaf length (0.6183) and flower diameter (0.7229). Significant

Table.16. Phenotypic correlation coefficients for 20 characters of gerbera

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
X1	1	-0.1394	0.1544	-0.1348	-0.0374	-0.1701	-0.2184	-0.0509	-0.0137	0.3735	0.1126	0.1324	0.173	0.0414	0.2284	-0.035	-0.0509	-0.2722	0.2141	-0.1282
X2		1	0.2014	0.097	0.1897	-0.0449	-0.1984	0.1144	-0.1233	0.1079	-0.0843	-0.0145	0.2208	0.054	-0.188	0.0696	0.1144	-0.0556	0.1575	0.074
X3			1	0.3044	0.1331	0.3466	-0.1494	-0.2085	-0.0456	0.4034	-0.3515	-0.1384	0.4963*	0.2259	0.3042	0.0518	-0.2085	-0.2168	0.0174	-0.0962
X4				1	0.0576	0.1121	-0.1519	0.0955	-0.1122	0.0873	-0.0659	0.2607	0.0397	0.1986	-0.249	-0.0533	0.0955	0.1	-0.0086	-0.0493
X5					1	-0.02	0.1136	-0.1166	0.0984	0.1618	0.3212	-0.0314	0.0308	-0.1	0.1263	0.0536	-0.1166	-0.3457	0.2245	0.2002
X6						1	-0.2362	-0.3242	-0.044	-0.1511	-0.2462	-0.3668	-0.0307	0.0572	0.3027	0.2465	-0.3242	0.2329	-0.5186*	-0.2474
X7							1	-0.175	0.2767	0.4026	0.478*	0.1646	0.1301	0.059	0.0487	0.2906	-0.175	-0.4189	0.2414	0.218
X8								1	0.0834	-0.2278	-0.0298	0.2435	-0.1831	-0.2297	-0.189	-0.1911	1	0.4284	0.5018*	-0.0347
X9									1	0.0333	0.1397	0.1653	-0.061	-0.2716	0.0193	-0.0597	0.0834	-0.0484	0.1224	0.0626
X10										1	0.2562	0.118	0.7364**	0.304	0.4247	0.2759	-0.2278	-0.5966**	0.3634	0.063
X11											1	0.2834	-0.258	-0.2199	0.131	0.0276	-0.0298	-0.1642	0.13	0.1548
X12												1	-0.1712	-0.1634	-0.3451	-0.0735	0.2435	-0.2085	0.4217	0.3887
X13													1	0.5002*	0.4099	0.1329	-0.1831	-0.3999	0.2158	-0.002
X14														1	0.1388	0.0522	-0.2297	0.0007	-0.2101	-0.0009
X15															1	0.0674	-0.189	-0.1932	0.0126	-0.1943
X16																1	-0.1911	-0.1217	-0.0578	-0.0254
X17																	1	0.4284	0.5018*	-0.0347
X18																		1	-0.5666**	-0.2875
X19																			1	0.2436
X20																				1

X1: plant spread, X2: no. of leaves plant^{-1} X3: leaf length, X4: leaf breadth, X5: no. of suckers plant^{-1}, X6: no. of days for flowering, X7: no. of days from bud Initiation to harvest, X8: total no of flowers produced, X9: life of flower in plant, X10: flower diameter, X11: disc diameter, X12: no. of ray florets, X13: length of ray florets, X14: width of ray florets, X15: length of flower stalk, X16:girth of flower stalk, X17: no.of flowers plant^{-1} yr^{-1}, X18: yield in rainy season, X19: yield in summer season, X20: vaselife in distilled water *Significance at 5% level **significance at 1% level

Table 17. Genotypic correlation coefficients for 20 characters of gerbera

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
X1	1	-0.2365	0.1057	-0.2440	-0.0372	-0.1982	-0.2594	-0.0100	-0.0318	0.4385*	0.0823	0.1458	0.2615	0.0611	0.2698	-0.0389	-0.0100	-0.2808	0.2551	-0.1249
X2			0.1163	0.0910	0.5004*	-0.0790	-0.4115	0.1223	-0.2808	-0.1234	-0.3206	-0.1636	0.1614	-0.04	-0.5473*	-0.0914	0.1223	-0.1379	0.2334	0.2724
X3			1	0.2507	0.3096	0.4343	-0.2165	-0.3632	0.0466	0.3282	0.5052*	0.2586	0.6183**	0.265	0.3325	-0.6346**	-0.3632	-0.3195	-0.0084	-0.0777
X4				1	0.2250	0.1588	-0.2466	0.1829	-0.1197	-0.1312	-0.1204	0.2978	-0.1676	0.2246	-0.4329	-0.355	0.1829	0.1798	-0.0135	-0.065
X5					1	-0.0150	0.2176	-0.1280	0.1875	0.2866	0.4290	-0.0504	0.0295	-0.1111	0.1624	0.0355	-0.128	-0.4241	0.2894	0.2858
X6						1	-0.2591	-0.3528	-0.0458	-0.1960	-0.2613	-0.399	-0.0533	0.0625	0.3713	0.3715	0.3528	0.2418	-0.5265*	-0.2857
X7							1	-0.2152	0.3589	0.5357*	0.5763**	0.2002	0.1242	0.0730	0.0404	0.4012	-0.2152	-0.4788*	0.2667	0.2708
X8								1	0.1450	-0.3580	-0.0228	0.2693	-0.2824	-0.2874	-0.3097	-0.3718	1.0000	0.3777	0.4945*	-0.0282
X9									1	0.0709	0.1594	0.2302	-0.0881	-0.4658*	0.0078	-0.0413	0.1450	-0.0432	0.1637	0.0370
X10										1	0.1835	0.0281	0.7229**	0.1443	0.2959	0.3562	-0.358	-0.7996**	0.4466*	0.1099
X11											1	0.2732	-0.5136*	-0.3642	0.0572	-0.0247	-0.0228	-0.1753	0.1451	0.1944
X12												1	-0.3588	-0.2588	-0.4868*	-0.2101	0.2693	-0.2463	0.4599*	0.4717*
X13													1	0.4437	0.2593	0.2103	-0.2824	-0.5656**	0.2912	-0.0068
X14														1	-0.0354	0.0911	-0.2874	0.0057	-0.2494	-0.0657
X15															1	0.1667	-0.3097	-0.2868	0.0063	0.2870
X16																1	-0.3718	-0.2137	-0.1151	-0.1579
X17																	1	0.3777	0.4945*	-0.0282
X18																		1	-0.6180**	-0.3287
X19																			1	0.2846
X20																				1

X1: plant spread, X2: no. of leaves plant^{-1}, X3:leaf length, X4: leaf breadth, X5: no. of suckers plant^{-1}, X6: no. of days for flowering, X7: no. of days from bud Initiation to harvest, X8: total no of flowers produced, X9:life of flower in plant, X10:flower diameter, X11:disc diameter, X12:no. of ray florets, X13: length of ray florets, X14: width of ray florets, X15: length of flower stalk, X16: girth of flower stalk, X17: no.of flowers plant $^{-1}$yr^{-1}, X18: yield in rainy season, X19: yield in summer season, X20: vaselife in distilled water * Significance at 5% level **Significance at 1% level

negative association between disc diameter and ray floret length (-0.5136) was also noticed. Life of flower in plant exhibited positive correlation with width of ray florets (0.4658). Length of flower stalk showed positive and significant correlation with number of ray florets (0.4868).

Highly significant negative correlation was obtained for yield in rainy season with flower diameter (-0.7996) and length of ray florets (-0.5656).Yield in summer season was found to have significant positive correlation with total number of flowers produced (0.4945), flower diameter (0.4466) and number of ray florets (0.4599). Highly significant negative correlation was exhibited by yield in summer season (-0.6180) with yield in rainy season. Number of days for first flowering showed significant negative correlation (-0.5265) with yield in summer season. Number of ray florets showed significant positive correlation (0.4717) with vase life of flowers in distilled water.

Table 18. Best performed varieties with respect to economically important characters

Character	Varieties
Lowest number of days to first flowering	Aragon, Esmara, Poseidon
Flower yield plant^{-1}	Double date, Ballroom, Aquamelone
Flower diameter	Beaudine, Mammut, Poseidon
Number of ray florets	Ruble, Bismark, Ballroom
Flower stalk length	Beaudine, Lexington, Aviance
Visual appeal	Beaudine, Mammut, Aquamelone
Vase life	Mariata, Aragon, Ruble

Discussion

5. DISCUSSION

Gerbera is one among the most important commercial flower crops grown throughout the world, both under open and protected conditions. Plants are used in landscaping as borders, in flower beds, and also in rockery. Due to its multitude of colours and beauty, flowers have high demand for floral arrangements and decorations. Diverse agro-climatic and ecological conditions in India are highly suitable for most of the gerbera varieties found in different parts of the world. As gerbera is a high value crop, protected cultivation should be promoted for obtaining high quality flowers, but high initial investment and lack of suitable varieties for protected cultivation are the major limitations for large scale production in Kerala.

A study was conducted at department of Pomology and Floriculture, College of Agriculture, Vellayani, from January 2015 to June 2016 with the objective to evaluate the performance of 20 gerbera varieties under rain shelter to identify varieties with good cut flower qualities suitable for rain shelter cultivation in Kerala. The data on vegetative and floral parameters, yield parameters and vase life were obtained and statistically analyzed. The results of the study are discussed below.

5.1. VEGETATIVE PARAMETERS

Significant variations were observed in vegetative characters of evaluated varieties.

5.1.1. Plant Spread

Plant spread is an important parameter which determines the vigour and yield of the plant. Plant spread of evaluated gerbera varieties ranged from 187.61 cm in variety Beaudine to 108.72 cm in Bismark. Several workers like Malik *et al*. (2013), Thomas *et al.* (2004) and Singh and Ramachandran (2002) also reported difference in plant spread among varieties and they suggest that the differences might be due to the variations in leaf size of respective varieties.

5.1.2. Number of Leaves

In the present study, there was variation in number of leaves among the varieties. Mean number of leaves was highest for Jinx (14.50) which was on par with variety Mariata (12.75). Lexington produced lowest number of leaves (7.94). Malik *et al*. (2013) also observed significant differences in number of leaves when ten gerbera cultivars were evaluated under protected conditions. Wankhede and Gajbhiye (2013) suggested that variation in number of leaves among the varieties might be due to varietal characters. Significant variations in number of leaves plant^{-1} was earlier observed by Kandpal *et al.* (2003), Nair and Medhi (2002) and Sane and Gowada (2001).

5.1.3. Leaf Length

Highest mean leaf length was recorded in variety Beaudine (38.17 cm) and lowest in Esmara (23.14 cm). Ahlavath *et al.* (2011) reported that growth parameters show variations due to varietal characters. Similar results regarding mean leaf length were also obtained by Dhane *et al.* (2004), Sema *et al*. (2010) and Sarmah *et al.* (2014)

5.1.4. Leaf Breadth

In the present study, variability expressed in leaf breadth can be pointed as varietal character as all the plants were given uniform cultural management. Leaves with highest mean breadth were found in Ruble (11.61 cm) and leaf breadth was lowest for Orinaco (7.73 cm). Wankhade and Gajbhiye (2013) also reported variations in leaf breadth among gerbera varieties.

5.1.5. Number of Suckers Plant^{-1}

Sucker production was relatively low in all the varieties, and Jinx produced highest number of suckers (3.87). Mean Sucker production was high for varieties Esmara (3.68) and Palm beach (3.25). Lowest sucker production was recorded in Ballroom (1.00). Kumar *et al*. (2014a) suggested that diversion of more food material to flowering attributes like flower number, stalk length etc might be the

cause for less number of suckers per plant under poly house as compared to field conditions.

Analysis of flowering behavior of different varieties indicated the fact that, varieties which produced more flowers were likely to produce less number of suckers. At the same time, in variety Beaudine, sucker and flower production were seen to be more or less balanced (mean number of suckers: 3.13, number of flowers produced: 23.50)

5.2. FLOWERING CHARACTERS

5.2.1. Number of Days for First Flowering

Significant variations were observed among varieties for number of days for first flowering. Aragon took lowest mean number of days for first flowering (47.50 days) and Palm beach took 129.75 days. Variation among varieties for days required for flowering might be due to inherent genetic characters and environmental influences. Similar findings were obtained by Wankhede and Gajbhiye (2013) and Sane and Gowada (2001)

5.2.2. Number of Days from Bud Opening to Harvest

Not much variation was observed among varieties in general for number of days from bud opening to harvest. Variety Jinx took lowest days (7.00 days) followed by Orinaco (7.33 days). However the variety Esmara recorded highest number of days from bud opening to maturity (13.12 days). Variation in period required for flower development was greatly influenced by individual varietal characters (Wankhede and Gajbhiye, 2013). Similar observations were recorded by Kumar and Kumar (2001).

5.2.3. Total Number of Flowers Produced

The study revealed that mean flower production was highest for Double date (26.64) and lowest number of flowers were produced in variety Mammut (11.38). Barooah and Choudhury (2009) evaluated gerbera varieties under Assam conditions and found that number of flowers plant^{-1} varied among varieties. Ahlavath *et al.* (2011) also reported variation in yield meter^{-2} among varieties.

5.2.4. Peak Flowering Period

Peak flowering period varied among varieties and most of the varieties had their production peak during rainy season. Drop in temperature and light intensity inside the rain shelter during rainy season might have favorably influenced production of flowers. The varieties such as Mammut, Mariata, Ruble, Jinx, Lexington, Atletico, Canzone, Orinaco, Double date, Ballroom and Louvre which yielded more during rainy season can be recommended for shaded conditions as these varieties can perform well under reduced light intensity and temperature.However Beaudine (14.10) and Carrera (14.33) yielded more during summer.

5.2.5. Longevity of Flower in Plant

In the present study, mean life of flower in plant varied from 8.70 days in variety Lexington to 5.75 days in Atletico. This was in conformity with earlier study by Wankhede and Gajbhiye (2013), who evaluated gerberas under shade net and reported that longevity of flowers in plant was a varietal character.

5.3. FLOWER QUALITY PARAMETERS

5.3.1. Flower Diameter

In the present study, diameter of flower was clearly expressed as a varietal character under uniform conditions of rain shelter. Beaudine produced flowers with highest mean diameter (11.55 cm) followed by Mammut (11.06 cm). Lowest mean diameter for flower was recorded in variety Ballroom (8.64 cm). Varieties like Ballroom, Palm beach and Aragon constantly produced flowers with lower diameter over mean diameter. On the other hand, varieties like Beaudine and Mammut were seen to be clearly superior, producing flowers with higher mean diameter.

Malik *et al.* (2013) and Singh and Ramachandran (2002) suggested that the bigger size of flowers was due to larger ray florets and inherent characters of individual flowers. Gotz (1983) reported large differences among varieties for diameter when they were grown in green house.

5.3.2. Disc Diameter

In the present study, men disc diameter was highest for variety Esmara (4.75 cm) and lowest mean disc diameter was observed for Jinx (2.20 cm). Varieties producing higher flower diameter like Beaudine and Mammut also recorded higher mean disc diameter. However in general, in varieties with medium sized flowers, size of disc was not always in proportion with flower diameter. Visual appeal of flowers was found to be better in case of flowers with disc diameter of 2 to 2.3 cm. Uniform distribution of ray florets around the disc was related to size of disc. Those flowers where disc diameter was significantly higher, distribution of ray florets was not always uniform.

5.3.3. Number of Ray Florets

Significant variations were observed for number of ray florets among varieties. Highest number of ray florets was recorded in Ruble (75.71) which was a multi whorled type flower. Lowest number of ray florets was observed in Palm beach (43.38). This clearly indicated that number of ray florets was always dependent on nature of variety (multi whorled or single whorled). Nair and Medhi (2002) also reported variation in number of ray florets among gerbera varieties.

5.3.4. Length and Width of Ray Florets

Ray floret length ranged from 4.81 cm in Beaudine to 3.25 cm in Ballroom. Width of ray florets was highest for Aquamelone which produced ray florets of 1.10 cm and lowest width was observed for variety Esmara (0.66 cm).

5.3.5. Length and Girth of Flower Stalk

Stalk length is an important character in grading of cut flowers for marketing. Evaluated varieties showed significant difference in stalk characters. Beaudine produced flowers with longest stalk (57.48 cm) followed by Lexington (57.28 cm). Lowest stalk length was recorded for ballroom (37.13 cm). Sarkar and Ghimiray (2004) opined that stalk length is a genetic factor and expected to vary among the cultivars. According to Malik *et al*. (2013), more reserved food will be present in the long stalk which will later be available to the flower for longer time

period. The results were in accordance with the findings of Kandpal *et al.* (2003), who reported a variation in stalk length among genotypes and opined that this variation might be due to the genetic characters of particular genotypes.

Stalk girth plays an important role in the post harvest vase life of cut flowers. It has been found that as the diameter of the stalk increases the carbohydrates content of the stalk also increases which helps in increasing the stability of vase life of the cut flowers thereby prolonging the vase life of cut flowers. In the present study, highest stalk girth was observed in Mammut (2.34 cm) and lowest in Ruble (2.02 cm). Sankar (2003) also reported variations in stalk girth and length among varieties.

5.3.6. Colour of Disc and Ray Florets

For attractiveness of a flower, colour of disc and ray florets plays a critical role. Colour of disc and ray florets should complement each other. In the present study, Colour of disc and ray florets showed wide variations. Colour of flower disc ranged from green to yellowish green and black. Ray florets of various shades of red, pink, orange, cream, yellow, white were observed for different varieties. Visual appeal was highest for Beaudine, which had a black disc and red ray florets, and Mammut, having greenish yellow disc and cream coloured ray florets.

5.3.7. Visual Appeal

As stated earlier, a colour combination is essential for visual appeal. Delicate colouring of petal coupled with large flower size contributed to high visual appeal for variety Mammut. Contrasting colors of ray and disc florets (red and black respectively) in variety Carrera enhanced the beauty of flowers. Palm beach scored very low in visual appeal due to small size and erratic arrangement of ray florets. According to Pattanashetti (2009), Size and quality of the gerbera were dependent on differences in the cultivars, environments and the seasonal conditions.

5.3.8. Market Preference of Flowers

Market preference of flowers changes with visual appeal and purpose for which the flower is used. For large arrangements, usually flowers with large size and long flower stalk are preferred. Varieties such as Beaudine, Mammut and Carrera are preferred for large floral arrangements and stage decorations. Medium sized flowers with attractive colour and medium stalk length are preferred for small flower arrangements in vases and bouquets. Medium flowered varieties such as Aquamelone, Ruble and Mariata are preferred for these purposes.

5.4. YIELD PARAMETERS

Varieties exhibited variations for number of flowers produced year^{-1}. The mean yield was lowest for Mammut (11.38). Highest number of flowers was recorded in Double date (26.65) might be attributed to the greater leaf area and more number of leaves per plant as well as plant spread resulted in production and accumulation of maximum photosynthates, which led to production of more number of flowers with bigger size. The results are similar to the findings of Nair and Medhi (2002), who studied gerbera under protected conditions and also to the findings of Naik *et al.* (2006), who evaluated gerbera varieties under naturally ventilated poly house and Ambad *et al*. (2001) who observed difference in flower yield among varieties under low cost poly house. Barooah and Choudhury (2009) evaluated gerbera varieties under Assam conditions and found that number of flowers plant^{-1} varied among varieties. Ahlavat *et al.* (2011) also reported variation in yield meter^{-2} among varieties.

5.5. VASE LIFE

Significant differences were observed for vase life among varieties. Mariata and Aragon recorded highest vase life of 10.75 days and lowest vase life was obtained for Orinaco and Louvre (6.25 days). When stalk length increased, vase life also increased. As stalk length Increases stalk girth was found increasing proportionately. Jong (1985) suggested that variation in vase life among cultivars may be attributed to variations in genetic makeup. Ferrante *et al*. (2007) reported

that vase life of gerbera flowers may vary with cultivar, and range between 5 and 24 days. Singh and Srivastava (2008) also observed variation among varieties for vase life of eight gerbera cultivars grown in a low cost poly house. According to Malik *et al.* (2013), vase life of the cut blooms terminated when the flower heads start drooping, followed by discoloration and petal fall. Kumar *et al.* (2014b) opined that the variation in vase-life among different varieties might be due to structural difference in xylem and phloem vessels of the flower stalk.

5.6. GENETIC VARIABILITY

Crop improvement programmes depend greatly on the magnitude of genetic variability present in a germplasm. All the characters studied exhibited a phenotypic coefficient of variation higher than genotypic coefficient of variation. A higher value for PCV than GCV is an indication of environmental influence on expression of that particular character. Kumari *et al*. (2013), Chobe *et al.* (2010b), and Nair and Shiva (2003), reported similar results in gerbera and Jhon *et al.* (2002) and Misra and Salini (1990) in gladiolus.

Highest GCV and PCV were noticed for yield in summer season followed by number of suckers plant^{-1}, number of days for first flowering, and yield in rainy season. Chobe *et al.* (2010b) also obtained high GCV and PCV for number of suckers plant^{-1} in gerbera. This indicated that in this flower crop, selection for number of suckers plant^{-1} can be done on the basis of phenotypic performance.

Difference between phenotypic and genotypic coefficients of variation was highest for number of suckers plant^{-1} and number of leaves plant^{-1}. Number of days for first flowering, yield in summer season, yield in rainy season, number of ray florets, and plant spread showed very low difference. Therefore, the variation observed among these characters might be due to genetic makeup of varieties and less influence of environment.

5.7. HERITABILITY AND GENETIC ADVANCE

Transmissibility of a character from one generation to other can be estimated by heritability which provides a measure of the value of selection for

different attributes. But heritability does not necessarily mean a high genetic advance for a particular character (Allard, 1960). For prediction of resultant effect of a selection, heritability along with genetic advance is more useful than heritability alone (Johnson *et al*., 1955)

In the present study, highest value for heritability was recorded for number of days for first flowering followed by yield in summer and yield in rainy season. Plant spread, disc diameter, number of flowers plant^{-1} year^{-1} , number of ray florets and number of days from bud initiation to harvest also recorded high heritability. High heritability indicated that substantial improvement of these characters can be made by using standard selection criteria. Less weightage should be given to those characters with low heritability while fixing selection criteria.

High genetic advance was observed in characters like yield in summer season, number of suckers plant^{-1}, number of days for first flowering, yield in rainy season, plant spread, disc diameter, number of days from bud initiation to harvest, vase life in distilled water, number of ray florets, number of flowers plant^{-1} year^{-1}, total number of flowers produced and width of ray florets.

Chobe *et al.* (2010b) also reported high heritability coupled with high genetic advance for number of days to first flowering, leaf area, vase life, number of ray florets, and number of flowers plant^{-1}. They also noticed highest genetic advance for number of flowers plant^{-1}. High heritability along with high genetic gain indicated in these characters was due to considerable additive gene effects (Panse and Sukhatme, 1957). Plant spread and number of flowers plant^{-1} obtained high heritability with medium genetic advance as per cent of mean indicating the presence of dominant and epistatic gene effects, and these characters can be improved through hybridization (Kumar, 2013)

Girth of flower stalk, flower diameter, number of leaves plant^{-1}, and life of flower in plant were found to have lowest genetic advance. Hence these characters cannot be considered as dependable criteria for further selection.

5.8. CORRELATION

The degree and direction of association between characters could be better under stood by correlation analysis. The analysis measures the mutual relationship between various characters and help to determine those characters on which selection can be based for improvement. This also provides information on nature and extend of relationship between characters. Genotypic correlation provides a reliable measure of genetic association between characters and help to differentiate the vital association useful in breeding (Falconer, 1981).

5.8.1 Phenotypic Correlation

Highly significant and positive phenotypic correlation was obtained for flower diameter with length of ray florets (0.7364). Flower diameter was found to have highly significant and negative correlation with yield in rainy season (0.5966). Number of days from bud initiation to harvest showed a positive correlation with disc diameter (0.4780). Significant positive correlation was also found between leaf length and length of ray florets (0.4963). Length of ray florets also exhibited significant positive correlation with width of ray florets (0.5002).

Yield in summer season exhibited a significant negative correlation with number of days for first flowering (-0.5186). But it exhibited significant positive correlation with total number of flowers produced (0.5018) and number of flowers plant $^{-1}$(0.5018). Highly significant negative correlation was found between yield in summer season and yield in rainy season (-0.5666).

5.8.2 Genotypic Correlation

Number of leaves was positively correlated with number of suckers plant^{-1} (0.5004) and negatively correlated with length of flower stalk (-0.5473). Magar *et al*. (2010) also reported positive correlation between number of leaves and number of suckers plant^{-1} in gerbera. However, this result was in contrast with earlier result by Kumari *et al*. (2013) who reported positive correlation between number of leaves and stalk length in gerbera. Leaf length showed significant

positive correlation with disc diameter (0.5052). Girth of flower stalk was found to have highly significant negative correlation with leaf length (-0.6346).

Number of days from bud initiation to harvest showed positive correlation with flower diameter (0.5357) and highly significant association with disc diameter (0.5763), but negative correlation was obtained with yield in rainy season (-0.4788).

Highly significant positive correlation was obtained for length of ray florets with leaf length (0.6183) and flower diameter (0.7229). Significant association between disc diameter and ray floret length was also noticed. Life of flower in plant exhibited positive correlation with width of ray florets (0.4658). Length of flower stalk showed positive and significant correlation with number of ray florets (0.4868).

Highly significant negative correlation was obtained for yield in rainy season with flower diameter (-0.7996) and length of ray florets (-0.5656). Yield in summer season was found to have significant positive correlation with total number of flowers produced (0.4945), flower diameter (0.4466) and number of ray florets (0.4599). Kumari *et al*. (2013) also reported positive but non significant correlation between yield and flower diameter. Highly significant negative correlation was exhibited by yield in summer season (-0.6180) with yield in rainy season. Number of days for first flowering showed significant negative correlation (-0.5265) with yield in summer season. Number of ray florets showed significant positive correlation (0.4717) with vase life of flowers in distilled water.

For most of the characters studied, genotypic correlation coefficient was higher than phenotypic correlation coefficient. Similar results were also obtained earlier by Raghav *et al.* (1992) in chrysanthemum and Magar *et al.* (2010) in gerbera. Correlation between characters indicates that selection based on any one of the characters will result in the improvement of other and degree of

improvement depend upon the magnitude of correlation between the characters (Kumari *et al*., 2013).

Further studies can be conducted on standardization of agro techniques, and integrated nutrient management for quality improvement in gerbera using promising varieties of this study.

Summary

6. SUMMARY

The present investigation entitled Evaluation of gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation" was conducted at department of Pomology and Floriculture, College of Agriculture; Vellayani from January 2015 to June 2016 with an objective to evaluate varieties/accessions of *Gerbera jamesonii* Bolus for growth, yield and floral attributes under rain shelter for selecting promising varieties for commercial cultivation under Kerala conditions.

Varieties evaluated were Aragon, Mammut, Bismark, Aviance, Mariata, Ruble, Jinx, Lexington, Aquamelone, Palm beach, Atletico, Canzone, Orinaco, Esmara, Double date, Ballroom, Carrera, Poseidon, Louvre, and Beaudine. Evaluated varieties showed significant variation in growth, flowering and yield attributes.

Varieties differed significantly with respect to plant spread. Beaudine recorded highest mean plant spread throughout the growing period. Lowest plant spread was obtained for Bismark.

Mean number of leaves was highest for Aragon after 5 months. Double date produced lowest mean number of leaves. There were no significant differences among varieties for number of leaves at 2, 8 and 11 MAP.

Leaf length showed significant difference among evaluated varieties. Highest mean leaf length was observed in Beaudine. Leaf length was lowest for Esmara. Mean leaf breadth was highest for Ruble and it was lowest in Orinaco.

Varieties exhibited significant variation in sucker production. At 2 MAP, mean sucker production was highest in variety Esmara. Jinx recorded highest mean number of suckers at 5, 8 and 11 MAP. Ballroom produced lowest maen number of suckers at 5 and 11 MAP.

Lowest mean number of days for flowering was taken by Aragon followed by Esmara. Palm beach recorded highest mean number of days for first flowering.

Significant difference was observed in mean number of days from bud opening to harvest among varieties. Jinx took lowest number of days from bud opening to harvest maturity. Esmara recorded highest number of days from bud initiation to maturity.

Varieties differed significantly for number of flowers produced per plant. Highest number of flowers was produced in Double date. Mean flower production plant^{-1} was lowest for Mammut.

Most of the evaluated varieties showed their peak flower production during rainy season. Mammut, Mariata, Ruble, Jinx, Lexington, Atletico, Canzone, Orinaco, Double date, Ballroom and Louvre produced highest number of flowers in rainy season whereas Beaudine and Carrera yielded highest in summer. Mammut was the variety in which lowest yield was recorded in both seasons.

Mean life of flower in plant was highest for Lexington and it was lowest for Atletico.

Significant differences were observed for flower diameter among evaluated varieties. Flowers with highest mean diameter were produced by Variety Beaudine. Lowest mean diameter was recorded for Aragon. Mean disc diameter was highest for Esmara. Lowest disc diameter was observed in Jinx.

Highest mean number of ray florets was recorded for variety Ruble and it was lowest in Palm beach.

Flower disc colour varied among the varieties from greenish yellow to yellow and black. Varieties exhibited wide variation in colour of ray florets, ranging from white to cream, Pink to purple, and orange to dark red. Bi-coloured ray florets with light coloured tips were also noticed.

Mean ray floret length was highest for variety Beaudine. Ballroom recorded lowest ray floret length. Variety Aquamelone produced flowers with highest mean ray floret width. Lowest mean ray floret width was observed in Esmara.

Significant differences were noticed for flower stalk characters among evaluated varieties. Highest mean length of flower stalk was recorded in Beaudine. Flowers with lowest mean stalk length were observed in Ballroom. Mean stalk girth was highest for Mammut. Lowest stalk girth was recorded in variety Ruble.

Beaudine, Mammut, Carrera, Mariata and Aquamelone obtained highest score and had best quality flowers, with good appearance, size, and proper and uniform color development. Palm beach, Ball room, Canzone, and Aragon obtained lowest scores for visual appeal.

Double date produced highest mean number of flowers year^{-1}. Mean flower production was lowest for variety Mammut.

Flower yield varied among the varieties during rainy and summer seasons. Double date produced highest number of flowers during rainy season. Highest yield in summer was obtained from variety Carrera.

Evaluated varieties exhibited significant difference in vase life. Highest vase life was recorded for varieties Mariata and Aragon and it was lowest for Orinaco and Louvre.

Mite infestation was observed in the experimental field during the study. More than 50 per cent of plants were infested in varieties Ballroom, Double date, Atletico, Lexington, and Orinaco. Minor infestation by snails were also noticed.

Environmental parameters such as temperature, relative humidity, and light intensity were recorded and these parameters showed significant association with total flower yield. Mite infestation was more with high relative humidity inside the structure.

Highest BC ratio was recorded for double date and ballroom followed by Aquamelone, Louvre, Ruble and Beaudine. Mammut recorded lowest BC ratio.

For all the observed characters, phenotypic coefficient of variability (PCV) was slightly higher than genotypic coefficient of variability (GCV). Highest GCV and PCV were noticed for yield in summer season. Girth of flower stalk recorded

lowest GCV and PCV. Difference between phenotypic and genotypic coefficients of variation was highest for number of suckers per plant and number of leaves per plant.

High heritability was noticed for number of days for first flowering, yield in summer season, yield in rainy season, disc diameter, number of flowers plant^{-1} year^{-1} , number of ray florets, number of days from bud initiation to harvest and plant spread. Number of leaves per plant recorded lowest value for heritability.

High genetic advance was observed in characters like yield in summer season, number of sucker per plant, number of days for first flowering, yield in rainy season, disc diameter, number of days from bud initiation to harvest, vase life in distilled water, Plant spread, number of ray florets, number of flowers plant^{-1} year^{-1}, total number of flowers produced and width of ray florets.

Significant positive phenotypic correlation was obtained for flower diameter with length of ray florets, Number of days from bud initiation to harvest with disc diameter, leaf length with length of ray florets, length of ray florets with width of ray florets and yield in summer season with total number of flowers produced and number of flowers plant $^{-1}$.

Flower diameter with yield in rainy season and summer season with number of days for first flowering were found to have significant and negative phenotypic correlation.

Significant positive genotypic correlations were observed for plant spread with flower diameter, number of leaves with number of suckers Plant^{-1} Leaf length with disc diameter, number of days from bud initiation to harvest with flower diameter and disc diameter, length of ray florets with leaf length and flower diameter, life of flower in plant with width of ray florets, length of flower stalk with number of ray florets, yield in summer season with total number of flowers produced, flower diameter with number of ray florets, and number of ray florets with vase life of flowers in distilled water.

Significant negative genotypic correlations were observed for number of leaves with length of flower stalk, number of days for first flowering with yield in summer season, yield in rainy season with flower diameter and length of ray florets, disc diameter with ray floret length, number of days from bud initiation to harvest with yield in rainy season, and girth of flower stalk with leaf length.

Future lines of work include standardization of agro techniques for gerbera under rain shelter and integrated nutrient management of gerbera, using promising varieties of this study.

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Appendices

Appendix I. Scoring of gerbera varieties for visual appeal

Variety	General appearance				Size of flower				Colour development				Average
	1	2	3	4	1	2	3	4	1	2	3	4	
Aragon	3	3	4	4	3	3	3	3	4	4	4	3	3.41
Mammut	5	5	5	5	5	5	5	5	4	5	5	5	4.91
Bismark	4	4	4	3	4	5	4	4	4	3	4	3	3.83
Aviance	4	3	3	4	3	4	4	4	4	4	4	4	3.75
Mariata	5	5	5	5	5	5	4	5	5	5	5	4	4.83
Ruble	5	4	5	5	4	5	5	4	5	5	5	5	4.75
Jinx	3	4	3	3	3	3	3	3	4	4	4	4	3.41
Lexington	4	4	4	3	3	3	4	3	3	4	3	4	3.50
Aquamelone	5	5	5	5	5	4	5	4	5	5	5	5	4.83
Palm beach	3	3	3	3	3	3	3	3	4	4	4	4	3.33
Atletico	3	3	4	4	4	5	4	3	3	3	3	3	3.50
Canzone	3	4	4	3	3	3	3	4	3	4	4	4	3.50
Orinaco	4	4	3	3	3	4	3	3	3	4	4	3	3.41
Esmara	4	4	5	5	4	4	5	4	5	4	5	4	4.41
Double date	3	4	3	3	3	4	4	3	3	3	4	4	3.41
Ballroom	4	3	3	4	4	3	4	4	4	5	4	4	3.83
Carrera	5	5	4	5	5	5	5	5	5	5	5	4	4.83
Posidon	4	5	4	4	5	4	4	4	4	4	5	5	4.33
Louvre	4	3	4	4	4	3	4	4	4	4	4	3	3.75
Beaudine	5	5	4	5	5	5	5	5	5	5	5	5	4.91

Score distribution: 1-3: Average 3.1-3.5: Good 3.6 -4.75: Very good 4.76-5: Excellent

Appendix II. Environmental parameters

Month	Temperature (^{0}C)		Relative humidity (%)	Light intensity (K. lux)
	Max. temp	Min. temp		
May (2015)	31.33	25.33	94.00	66.5
June	29.33	25.33	90.00	63.1
July	34.33	27	82.25	67.5
August	39.33	25.67	88.20	60.3
September	41.67	27.5	82.00	62.8
October	39.67	24.33	89.00	68.5
November	42.67	24.33	87.00	66.4
December	41.67	24	81.00	70.1
January (2016)	41.66	25.67	87.25	67.8
February	40.33	24.33	88.75	65.3
March	41.33	24	84.55	64.2
April	41.67	23.33	81.25	68.4
May	39.55	24	91.25	62.4

Appendix III. Month wise total yield of flowers from 320 plants of gerbera

Month	Total yield of flowers
May (2015)	0
June	77
July	92
August	157
September	273
October	277
November	272
December	205
January (2016)	96
February	95
March	91
April	95
May	128

Appendix IV. Classification of evaluated gerbera varieties based on peak flowering season

Varieties having peak flower production during rainy season	Aragon Bismark Aviance Mammut Mariata Ruble Jinx Lexington Aquamelone Palm beach Atletico Canzone Orinaco Esmara Double date Ballroom Poseidon Louvre
Varieties having peak flower production during summer season	Beaudine Carrera

Abstract

ABSTRACT

The study entitled 'Evaluation of Gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation' was conducted in the Department of Pomology and Floriculture, College of Agriculture, Vellayani during 2015-2016 with the objective of evaluating varieties/ accessions of *Gerbera jamesonii* Bolus for growth, yield and floral attributes under rain shelter for selecting promising varieties for commercial cultivation.

The experiment was laid out in completely randomized design with four replications. One month old tissue culture plantlets of twenty varieties of gerbera *viz.,* Aragon, Mammut, Bismark, Aviance, Mariata, Ruble, Jinx, Lexington, Aquamelone, Palm beach, Atletico, Canzone, Orinaco, Esmara, Double date, Ballroom, Carrera, Poseidon, Louvre, and Beaudine were planted and evaluated for various growth, yield and floral parameters.

Vegetative parameters of the plant were studied and Beaudine recorded highest mean plant spread (187.61 cm) and leaf length (38.17 cm). Number of leaves (14.50) and sucker production (3.87) were highest in variety Jinx. Ruble was found to have highest leaf breadth (11.61cm).

Significant differences were noticed among varieties for flowering characters. Double date produced highest number of flowers (19.98) during rainy season and highest mean yield in summer was obtained from variety Carrera (14.32). Mammut was the low yielder in both the seasons. Lowest number of days for flowering (47.50 days) was taken by Aragon followed by Esmara (49.87 days). Jinx took lowest number of days from bud opening to harvest maturity (7.00 days). Esmara recorded highest number of days from bud opening to maturity (13.12 days). Palm beach recorded highest number of days for first flowering (129.75 days). Mean yield plant^{-1} year^{-1} was highest for Double date (26.64). Flowers of Lexington were found to have longest life in plant (8.70 days).

Flower quality also differed significantly among the varieties. Beaudine recorded highest length of flower stalk (57.47 cm), flower diameter (11.55 cm), and ray floret length (4.81 cm). Disc diameter was highest for Esmara (4.75 cm). Ruble recorded highest number of ray florets (75.70). Aquamelone produced

flowers with highest mean ray floret width (1.09 cm). Highest stalk girth was observed in Mammut (2.33 cm). Varieties exhibited wide variation in colour of ray florets. Flower disc colour varied from greenish yellow to yellow and black. Highest vase life was recorded for Mariata and Aragon (10.75 days) and was lowest for Orinaco and Louvre (6.25 days). Beaudine, Mammut, Carrera, Mariata and Aquamelone obtained highest score (4.87) for visual appeal. Palm beach, Ball room, Canzone, and Aragon, obtained lowest score.

For all the observed characters, phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV). Highest GCV and PCV were noticed for yield in summer season. Difference between phenotypic and genotypic coefficients of variation was highest for number of suckers plant^{-1}. High heritability coupled with high genetic advance was observed in characters like yield in summer season, number of days for first flowering and yield in rainy season. Highly significant and positive phenotypic correlation was obtained for flower diameter with length of ray florets. Yield in summer season exhibited significant positive correlation with total number of flowers produced and number of flowers plant $^{-1}$.

Twenty varieties of gerbera were evaluated under rain shelter and observed significant differences for various growth, yield, and floral attributes. Beaudine was the best performed variety with good vegetative growth, highest flower diameter and stalk length which are important characters for a commercial cut flower. Peak flowering in this variety was observed during summer. Beaudine, Mariata, Carrera, Ruble and Aquamelone can be recommended for commercial cultivation under rain shelter as these performed well under rain shelter and produced good quality flowers, and obtained high BC ratios. Further studies can be conducted on standardization of agro techniques, and integrated nutrient management for quality improvement in gerbera using promising varieties of this study.