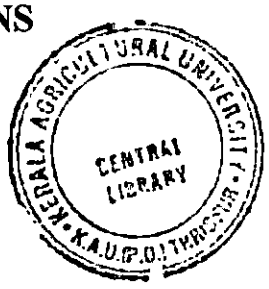
PERFORMANCE OF AFRICAN MARIGOLD (*Tagetes erecta* L.) UNDER DIFFERENT GROWING CONDITIONS



by

NIMISHA AUGUSTINE

(2014 – 12 – 105)

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 HORTICULTURE

VELLANIKKARA, THRISSUR – 680 656

KERALA, INDIA

2016

DECLARATION

I, Nimisha Augustine (2014-12-105) hereby declare that this thesis entitled **"PERFORMANCE OF AFRICAN MARIGOLD (*Tagetes erecta* L.) UNDER DIFFERENT GROWING CONDITIONS"** is a bonafide record of research work done by me during the course of research and 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.

Vellanikkara

Date: 04/11/2016

NIMISHA AUGUSTINE

(2014– 12– 105)

CERTIFICATE

Certified that this thesis entitled **"PERFORMANCE OF AFRICAN MARIGOLD (*Tagetes erecta* L.) UNDER DIFFERENT GROWING CONDITIONS"** is a record of research work done independently by **Ms. Nimisha Augustine**, under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

4/11/16

Vellanikkara

Date: 04/11/2016

Dr. A. Sobhana

(Chairperson, Advisory Committee)
Professor (Horticulture)
Cashew Research Station
Madakkathara
Thrissur

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms. Nimisha Augustine,** a candidate for the degree of Master of Science in Horticulture, with major in Pomology and Floriculture, agree that the thesis entitled **"PERFORMANCE OF AFRICAN MARIGOLD (*Tagetes erecta* L.) UNDER DIFFERENT GROWING CONDITIONS"** may be submitted by **Ms. Nimisha Augustine,** in partial fulfilment of the requirement for the degree.

4/11/16

Dr. A. Sobhana

(Chairperson, Advisory Committee)
Professor (Horticulture)
Cashew Research Station
Madakkathara

4-11-2016

Dr. C. K. Geetha

(Member, Advisory Committee)
Professor and Head
Department of Pomology and Floriculture
College of Horticulture, Vellanikkara

Dr. Mini Sankar

(Member, Advisory Committee)
Assistant Professor
Department of Pomology and Floriculture
College of Horticulture, Vellanikkara

S. K 4/11/16

Dr. S. Krishnan

(Member, Advisory Committee)
Professor and Head
Department of Agricultural Statistics
College of Horticulture, Vellanikkara

4/11/16

EXTERNAL EXAMINER

Dr. M. Ganga
Assistant Professor (Horticulture)
TNAU, Coimbatore

Acknowledgement

First and foremost I bow my head before the ***Almighty God*** *for all the blessings showered upon me to successfully complete my thesis work in time.*

And, so comes the time to look back on the path traversed during the endeavour and to remember the faces behind the action with a sense of gratitude. Nothing of significance can be accomplished without the acts of assistance, words of encouragement and gestures of helpfulness from others.

It is with immense pleasure, I avail this opportunity to express my deep sense of reverence gratitude and indebtedness to my major advisor ***Dr. A. Sobhana,*** *Professor (Horticulture), Cashew Research Station, Madakkathara and Chairperson of my Advisory Committee for her sustained and valuable guidance, constructive suggestions, unfailing patience, friendly approach, constant support and encouragement during the course of the research work and preparation of this thesis. She has been a support to me during each step of this venture. I really consider myself being greatest fortunate in having her guidance for my research work and will be remembered forever.*

I deeply express my heartfelt gratitude to ***Dr. C. K. Geetha,*** *Professor and Head, Department of Pomology and Floriculture, College of Horticulture and member of my Advisory Committee for her affectionate advice, valuable suggestions, constant support and encouragement throughout the course of study. She has been a constant support during each step of the way and I owe a deep sense of gratitude to her.*

I convey my deepest gratitude to ***Dr. S. Krishnan,*** *Professor and Head, Department of Agricultural Statistics, College of Horticulture and member of my Advisory committee for his expert advice, valuable suggestions and support rendered during the statistical analysis of data and interpretation of the results without whom I am sure that the venture would not be successful at all.*

I wish to express my sincere gratitude to ***Dr. Mini Sankar,*** *Assistant Professor, Department of Pomology and Floriculture, College of Horticulture and member of my*

Advisory Committee for her valuable advice, critical evaluation and constant inspiration rendered during the course of study.

I wish to extend my heartfelt thanks to my beloved teachers Dr. K. Ajithkumar, Dr. Jyothi Bhaskar, Dr. P. K. Sudhadevi, Dr. P. K. Rajeevan, Dr. P. K. Valsalakumari, Dr. N. Parameswaran, Dr.T. Radha, Dr. K. Lila Mathew of our Department of Pomology and Floriculture for their encouragement, valuable help, and friendly suggestions rendered during the course of study.

I thankfully acknowledge Dr. P. Anitha, Dr. R. Ushakumari and Dr. Latha Bastine C. of College of Horticulture for their encouragement and valuable guidance during the period of my work.

I sincerely express my thanks to Dr. P. K. Sushama, Dr. C. George Thomas, Dr. S. Beena and Dr. K. Nandini all other teaching and non-teaching staff of College of Horticulture for their meticulous help during course of my thesis work.

I am happy to place on record my sincere thanks to all the non-teaching staff of Cashew Research Station, Madakkathara who helped me in nursery raising and maintenance of plants in the nursery.

I wish to thank Devan chetan, Sasi chetan, Vasantha chechi and other labours in the Department of Agronomy for their help in land preparation and planting.

I place my sincere thanks to Sindhu miss, Arun sir and Rajkumar chettan of Department of Soil science and Agricultural chemistry for their valuable guidance and kind cooperation during the analysis of my samples.

I am thankful to Uthaman sir, Santhosh chettan, Preman chettan, Varghese chettan, Pushpa chechi, Abitha chichi, Rajani chechi and all other non-teaching staff of the Department of Pomology and Floriculture for their sincere help and valuable cooperation during investigation period.

With pleasure I express my heartfelt gratitude to my classmates (Andrew, Arathi, Aslam, Jyolsna, Sameer and Sanjay), seniors and juniors whose constant support and encouragement could never be forgotten. I also express my thankfulness to my dear friends for their great understanding and constant support throughout my research period.

I wish to express my sincere thanks to our librarian **Dr. A. T. Francis** *and other staffs of the college and university library for their patience, guidance, consideration and immense help rendered to me.*

I wish to express my thanks to **Kerala Agricultural University** *for the financial attention offered during the study period.*

On my personal ground, I cannot forget the fondness, constant support and encouragement showered by my loving family. I deeply express my special whole hearted thanks to my loving **mother** *and my dearest brother (***Subin Augustine***) and sister (***Lidiya Augustine***) for their everlasting support, sacrifice, prayers and blessings, without them, this would not have been a success. Deep from the heart, I would like to express my sincere thanks to my dad in heaven for his blessings. I convey my affection and heartfelt gratitude to them who supported me a lot in my long journey of research.*

It would be impossible to list out all those who have helped me in one way or another, for the completion of my work. I once again express my heartfelt thanks to all those who helped me in completing my work on time.

Nimisha Augustine

Dedicated to my

Major Advisor (Dr. A. Sobhana)

and my Family

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Introduction

1. INTRODUCTION

Marigold (*Tagetes* spp.) is one of the most commercially exploited annual flower crops much acclaimed for its exquisite flower heads. It belongs to family Asteraceae with its origin in South and Central America (Mexico). In India, marigold ranks next to jasmine in terms of production and occupies prominent position as a traditional loose flower (Meena *et al.*, 2015). It is estimated that the crop is being grown in an area of 42,880 ha with production of 3,60,000 MT (NHB 2012–13). In India, a major share of its commercial cultivation is limited to the states Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal. Apart from these states, marigold is also cultivated in Punjab, Himachal Pradesh, Rajasthan, Haryana, and Uttar Pradesh.

The genus *Tagetes* consists of about 33 species, out of which the African marigold (*Tagetes erecta* L.) and the French marigold (*Tagetes patula*) are of great horticultural importance. The French marigold is mostly dwarf, has its native home in Mexico. The African marigold plants are vigorous and tall growing (about 150 cm in height) producing single to double flowers of excellent keeping quality. It is commercially cultivated for the majestic blooms having wide spectrum of colours, size and shape. The flower colour varies from lemon yellow, golden yellow, brightly yellow, primrose or orange. There are also the nearest-to-white marigolds though not pure white. Propagation of marigold is through seeds which can be sown directly in the soil. The cultivation of the crop is popular among the small and marginal farmers of our country because of the easiness in cultivation, long duration of flowering as well as due to the wide adaptability of the crop to varying soil and climatic conditions.

African marigold is predominantly used as a garden plant, both in urban and rural areas for bedding purpose and for growing in pots. The crop is popular with landscape designers because of its suitability to shrubberies and herbaceous borders due to varied plant height and flower colours. The flowers are used as loose flowers, also for making garlands, for beautification of *mandaps* and for decoration of vehicles during festival seasons and religious ceremonies. Some

African marigold cultivars having globular flowers and straight stalk are used as a cut flower in interior decorations. The cultivation of marigold is quite remunerative to the farmers, on account of its various commercial uses. The acreage under commercial cultivation of marigolds in India has grown up dramatically.

The research inventions carried out in marigolds have brought about a good fillip to its utility in different domains. Recently, marigolds have emerged as natural source of carotenoid pigments which are commercially used in pharmaceuticals, food supplements, animal feed additives and as colourants in food and cosmetics. The major carotenoid pigment present in marigold is xanthophyll. Marigold petals are the most concentrated source of xanthophylls as well as lutein (80-90%). The purified extract of marigold petals, mainly containing xanthophyll dipalmitate is marketed under the trade name 'Adaptional' as an ophthalmological agent. Lutein is another carotenoid pigment found mostly in marigold flowers. About 90 per cent (w/w) of carotenoids are present in the dry petals of marigold (Kumar and Sharma, 2013). Presently the use of natural lutein is increasing worldwide, because it protects the skin from sun damage, prevents LDL cholesterol from oxidizing and lowers the risks of heart diseases. Lutein also prevents blockage of arteries, delays lung ageing and protects eyes by decreasing night blindness and increasing vision ability (Singh and Karki, 2006). The dye obtained from the flowers is widely used in poultry feeds to improve the pigmentation of poultry skin and eggs. The plants are being used as an antagonistic crop for suppressing nematode population. Aromatic sulphur containing secondary metabolite known as triophenes produced in the roots of the plants has been found effective in keeping the nematode population under control. They are also used as a trap crop in vegetable fields, especially to control fruit borer in tomato.

In Kerala, the crop is mostly cultivated in homestead gardens but the commercial cultivation is quite limited due to lack of awareness among the farmers. Marigold flowers have a steady demand throughout the year in the state whereas, the demand for the flowers during festival seasons like *Onam* and

Navarathri is very high. The flowers for meeting this demand are mostly coming from the neighbouring states namely Karnataka and Tamil Nadu.

Intense rainfall and high relative humidity during the South–West monsoon season impede the cultivation of marigold during that period in Kerala. This makes difficulty in managing the crop and the quality of the blooms gets affected. The opportunity for environmental control is limited in traditional cultivation practices, in addition the productivity of the crop is not fully attained. In this situation, cultivation under protected structures has got much significance. Since protected condition provides a favourable environment for plant growth, the crop is preferably being grown under protected conditions in order to meet the quality standards. Cultivation under protected conditions results in high yield of flowers with better quality. Hence, there exists a scope for growing marigold under rain shelter conditions.

The performance of marigold is greatly affected by the genotypes, growing conditions and seasons. Changes in planting time will cause variations in weather parameters, which in turn influence the crop performances (Ramesh and Singh, 2008). Planting during different seasons will alter the growth, flowering, yield and quality of flowers due to climatic variations. Maximum flower yield can be achieved only when the crop is exposed to optimum climatic conditions.

Hence, the investigations to evaluate the performance of African marigold cultivars under protected structures have got much relevance. Considering all these aspects the present study was undertaken with the following objectives,

1. To compare the performance of African marigold cultivars under open and polyhouse conditions.
2. To compare the effect of growing seasons on performance of African marigold cultivars grown under open and polyhouse conditions.

Review of Literature

2. REVIEW OF LITERATURE

African marigold (*Tagetes erecta* L.) is one of the most important annual flower crops having immense value both as a loose flower and garden flower. It has huge demand in the domestic market. The crop is mainly cultivated by the small and marginal farmers in India due to its easiness in cultivation, wide adaptability and short term profitable returns. Flowers are used for making garlands in religious and social functions and for xanthophyll extraction also. The demand for marigold flowers is very high during festive seasons like *Onam* and *Navarathri* in Kerala. Even though there is an increased demand, the production from our state is very less and the requirement is met from our neighbouring states namely Tamil Nadu and Karnataka.

The growth and flowering in African marigold is influenced by seasons and growing conditions. The available information on the effect of growing conditions on the growth and flowering of African marigold is very limited. So far no such studies were conducted in Kerala with respect to protected cultivation of marigold.

Literature relating to the performance of flower crops under different growing conditions and growing seasons are reviewed here. Since reports on the performance of African marigold under different growing conditions and growing seasons are meager, the works in related crops have also been cited.

2.1 VARIETAL EVALUATION

The phenolic biosynthesis in African marigold varieties African Giant Double Yellow and African Giant Double Orange in relation to moisture stress conditions was studied by Kurup *et al.* (1994). The varieties showed significant difference on peroxidase activity during transplanting and pre-blooming stages which was due to the variation in inherent capacity among the varieties to respond to stress. At the transplanting stage the variety African Giant Double Yellow accumulated more phenols (0.691 mg/g fresh wt) when compared to African Giant Double Orange (0.579 mg/g fresh wt).

A stability analysis of 15 genotypes of African marigold, over three different environments for growth, yield and flower colour was conducted by Naik *et al.* (2005) at University of Agricultural Sciences, Dharwad. Significantly higher flower yield (16.47 t/ha), petal meal (14.13 q/ha) and xanthophyll yield (23.67 kg/ha) and excellent vegetative parameters were reported in the genotype African Marigold Orange compared to the local control Orange Double. They also recommended African Marigold Orange as a more stable genotype to suit most of the agro-climatic conditions.

Rao *et al.* (2005) conducted a study in 10 cultivars of African marigold to screen those cultivars for flower yield and carotenoid pigments. Better plant growth was reported in Orange Double cultivar with the highest plant height (84.00 cm), leaf area (3762.00 cm^2) and dry matter yield (42.96 g). The highest total carotenoid per gram fresh weight of flower petals was observed in the cultivar Pusa Narangi Gainda (2.69 mg/g) followed by Orange Double (2.66 mg/g). The cultivar Orange Double recorded the highest fresh flower yield (295.8 g). Maximum flowering duration was observed in cultivar Orange Double (44 days) followed by Pusa Basanti Gainda (38 days). Cultivar Orange Double recorded maximum seed yield (1183.41 kg/ha) followed by Pusa Narangi Gainda (715.48 kg/ha).

Singh and Singh (2006) evaluated the performance of 29 genotypes of African marigold under Uttaranchal conditions. Maximum number of primary branches per plant, number of flowers per plant and dry weight of leaf was recorded in the genotype TEG 16. TEG 17 reported maximum flower longevity (66.00 days) and dry weight of flower (6.68 g), whereas maximum duration of flowering (135.33 days) was recorded in TEG 13.

Singh *et al.* (2008) evaluated 29 genotypes of African marigold in different parts of Uttarakhand. TEG 26 recorded the maximum plant height, leaf biomass per plant, flower diameter, weight of seeds per peduncle and seed yield per plant. Maximum number of secondary branches per plant, number of petals per flower and individual fresh flower weight were observed in TEG 17. Maximum 1000 seed weight was reported in TEG 28 among all the 29 genotypes of marigold.

According to Narsude *et al.* (2010), among the 10 African marigold genotypes evaluated during their study, the genotype Tuljapur Local – 1 recorded maximum number of branches (21.46). Significantly superior performance in terms of number of flowers (71.00), flower yield per plant (630.48 g) and yield per hectare (24.67 MT) was also showed by Tuljapur Local – 1.

An evaluation of 17 African marigold genotypes for their morphological characters was carried out by Pramila *et al.* (2011). All marigold genotypes possessed shades of yellow and orange colour, but the genotypes Coorg L-1 (light yellow), Coorg L-2 (dark yellow) and Sirsi Local (medium orange) could be very easily identified. Sierra Yellow recorded the highest seed weight (3.62 g) and Atlantis Gold recorded the lowest (2.16 g).

Kumar and Sharma (2013) evaluated the effect of farm yard manure, vermicompost, and drying methods on flower yield and carotenoid contents in two varieties of African marigold. A significant response was observed in vegetative and flowering characters except carotenoid content in Pusa Basanti Gainda with respect to Pusa Narangi Gainda. The variety Pusa Basanti Gainda recorded the highest plant height (47.46 cm), more number of flower buds per plant (23.19), maximum flower diameter (6.68 cm), dry weight of single flower (1.38 g) and enhanced flower yield (204.64 q/ha). However, Pusa Narangi Gainda recorded maximum plant spread (24.98 cm), early flower bud initiation (35.67 days), increased carotenoid content in fresh petals (285.84 µg/g) and dried petals (30.47 µg/g) and highest dried petal yield (11.98 q/ha).

In a comparative study with two African marigold varieties for their performance in terms of growth and flowering under drought stress, maximum plant height was recorded in Super Giant (33.9 cm). The average number of leaves was found highest in Inca F1 (16.5) on all drought treatments compared to Super Giant (12.6). The variety Inca F1 showed higher value for water use efficiency on average than that of Super Giant (Riaz *et al.,* 2013).

Choudhary *et al.* (2014) evaluated the performance of 28 genotypes of African marigold and two genotypes of French marigold under semi-arid conditions of Haryana. Best performance of the crop in terms of plant spread (217.10 cm^2), number of secondary branches per plant (150.97) number of flower buds (217.10/plant) and flower yield per plot (20.99 kg) were recorded in the genotype Hisar Jaffri–2.

Six different varieties of African marigold were grown in artificially prepared saline soil conditions to evaluate the effect of salinity on nutrient content in leaves (Singh *et al.,* 2014). Pusa Narangi Gainda was found to have maximum nitrogen, potassium and calcium content in leaves, which was significantly superior over other varieties. The variety Pusa Narangi Gainda also maintained a significantly higher level of phosphorous content over other varieties while minimum was observed in the variety Sunset Giant.

The response of African marigold to different levels of nitrogen and phosphorous nutrition was studied by Polara *et al.* (2015). The variety Pusa Narangi Gainda recorded the maximum flower diameter (6.20 cm), highest number of flowers per plant (56.34), highest flower yield (183 q/ha), maximum leaf area (13.89 cm^2) and total chlorophyll content (1.43 mg/g) in leaves.

2.2 EFFECT OF GROWING CONDITIONS

According to Attavar (1993), protected cultivation enables quality improvement and productivity enhancement in flower crops which aids to compete in the global market. The cultivation of crops under protected condition provides a favourable environment for plant growth by providing protection against heavy winds, pests, diseases and other climatic conditions (Khan, 1995). In ornamental plants, protected cultivation provides higher yield and better quality flowers. Most of the growth attributes in flower crops were influenced by the growing conditions (Pattanashetti, 2009).

2.2.1 Effect of Growing Conditions on Marigold

The response of French marigold under greenhouse condition to day and night and temperature fluctuations were studied by Blanchard and Runkle (2011). Dole (2015) conducted an experiment in ten specialty cut flowers under greenhouse condition and reported that the *Tagetes erecta* L. was found to be a facultative long day plant. Under all the photoperiods tried (8 h, 12 h and 16 h), *Tagetes* produced stems long enough to meet the minimum harvest length (45 cm).

2.2.2 Effect of Growing Conditions on Other Crops

In chrysanthemum, polyhouse planting exhibited significantly better growth and flower yield (35-40% more) compared to open field planting (Gaikwad and Dumbre-Patil, 2001). Maximum flower size, spray stalk length and number of flowers per spray were recorded from polyhouse condition.

Talukdar *et al.* (2006) evaluated the performance of 18 standard chrysanthemum cultivars under open and rain shelter conditions. The earliest cultivar was Bolare Deo, which bloomed earlier inside rain shelter (70.33 days) compared to open condition (79.67 days). The blooming period was observed highest in the cultivar Snow Ball which bloomed for additional five days inside rain shelter (33.33 days) compared to open condition (27.67 days). The variety Snow Ball exhibited maximum vase life which was enhanced by four days inside rain shelter (20 days) compared to open condition (16 days).

Open and low cost polyhouse conditions had significant influence on all the growth and flowering parameters of chrysanthemum cultivars (Swaroop *et al.*, 2006). Maximum flower diameter (10.83 cm) was recorded in the cultivar Snow Don grown under polyhouse condition. The highest flower yield was recorded in cultivar Thai Chen Queen grown under polyhouse condition. Most of the characters performed better under polyhouse condition as compared to open condition.

Twelve chrysanthemum cultivars were grown under open and plastic house conditions by Budiarto and Marwoto (2009) for evaluating the production and quality of chrysanthemum cuttings obtained. The average number of cuttings produced per plant and the quality of cuttings produced by chrysanthemum mother plants grown in the open condition was inferior to those obtained from plastic house condition.

An experiment conducted by Gantait and Pal (2011) to study the performance of 15 spray chrysanthemum cultivars under open and polyhouse conditions at different dates of planting showed that, the highest flower yield was recorded in cultivar Arati (794.94 g/plant) in 30th July planting under polyhouse. Under polyhouse condition, the maximum flower diameter (4.67 cm) and individual flower weight (1.88 g) were found under 30th July planting. The plants grown under polyhouse condition exhibited better shelf life and vase life of flowers compared to those grown in the open field condition.

Singh and Ramachandran (2002) made a comparative study on the performance of gerbera under different growing conditions and reported that better growth, yield and quality of gerbera flowers were noticed under protected condition. Gerbera grows faster, produces large green leaves with high dry matter content which resulted in more flower yield under protected condition. Dhane *et al.* (2004) evaluated the performance of 11 gerbera cultivars under naturally ventilated polyhouse condition and the highest plant height was recorded in cultivar Yanara (39.20 cm). Maximum flower diameter was recorded in cultivar Sunway (2.02 cm).

A study was conducted by Singh and Srivastava (2008) to evaluate the performance of eight gerbera cultivars under low cost polyhouse and shade net (50 per cent) conditions in the Model Floriculture Center, Uttarakhand. The low cost polyhouse planting recorded better growth and yield compared to shade net condition. Maximum plant height (35.7 cm), flower diameter (9.90 cm), flower stalk length (58.18 cm), duration of flowering (18 days) and vase life (10 days) were reported by cultivars grown under low cost polyhouse condition.

The performance of ten gerbera cultivars under protected conditions was evaluated by Pattanashetti (2009) at UAS, Dharwad. The plants grown under naturally ventilated polyhouse showed superiority in growth and flowering characters during rainy and winter seasons. Under polyhouse and shade house conditions during both seasons, the cultivars Dino and Hope took less number of days from flower bud initiation to flowering.

Gerbera cultivars when grown under naturally ventilated polyhouse showed a significant variation amongst the cultivars for number of flowers per meter square per year and their vase life (Ahlawat *et al.*, 2012). The cultivar Winter Queen produced maximum number of flowers (396) followed by Dalma (324). Maximum vase life was observed in cultivar Avant Garde (11.8 days) which was statistically on par with Winter Queen (11.7 days), Essence (11.4 days) and Doni (11.0 days).

Seventeen gerbera cultivars were evaluated for their performance under cost effective polyhouse by Kumar and Deka (2012). The cultivar Mayonaise recorded maximum number of leaves per plant (16.66) while, maximum leaf breadth (13.87 cm) was reported in cultivar Fenna. Number of flowers/plant/month (3.69) and number of suckers/plant/year (5.0) were recorded highest in cultivar Lion.

Gerbera can be cultivated in moderately warmer areas in open sunny conditions but, its performance is enhanced when grown under protected or semi-protected structures (Hedau *et al.*, 2012). According to Kumar (2013) gerbera should preferably be grown under protected conditions in order to meet the quality standards.

Mahmood *et al.* (2013) made a comparative evaluation of the growth and flowering characters of various gerbera cultivars under protected condition. The longest spike length was recorded in the cultivar Alberino (60.3 cm) followed by Lexus (59.0 cm). The cultivar Avemaria recorded the maximum number of flowers per meter square (135).

In a field study conducted in gerbera (Wankhede and Gajbhiye, 2013) thirteen cultivars were planted under shade net and tested for various characters related to growth and flowering. Maximum plant height was observed in the cultivar Charmander (45 cm) followed by Savannah (44.23 cm). The cultivar Charmander also recorded maximum life span of flower on plant (16.6 days).

According to Bhalla *et al.* (2006), greenhouse provides the plants with optimum conditions of light, humidity, temperature and carbon dioxide which stimulates proper growth and production of quality flowers in carnation. Ryagi *et al.* (2007) reported that the carnation needs to be grown under cover to produce quality flowers. It is necessary to grow carnation under polyhouse conditions for obtaining quality flowers (Gharge *et al.,* 2009). Poor quality flowers were produced by carnation plants grown under open field condition due to deviation in environmental conditions and by various pest and disease incidence (Singh *et al.,* 2013).

In an experiment conducted by Gharge *et al.* (2011) the performance of ten standard carnation varieties under naturally ventilated polyhouse was studied. The variety Diana was the earliest to open its buds (88.54 days) and showed maximum duration of flowering (180 days) compared to others.

The spikes obtained from gladiolus plants grown under 100 micron polyethylene were free from cold injury and of good quality compared to the spikes obtained from open field condition (Chadha *et al.*, 1992). According to Mukherjee (1992), early flowering was observed in gladiolus variety Aldebaran grown under greenhouse condition compared to outdoor condition. Faster spike growth was also recorded in plants under greenhouse condition (2.34 cm/day) compared to outdoor condition (2.03 cm/day).

In an experiment conducted by Simmy (2015) at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, the performance of three gladiolus varieties under open and rain shelter conditions was evaluated during two seasons. Better spike length, rachis length, spike diameter, number of

florets per spike, longer blooming period and corm yield were recorded in the rain shelter grown plants.

2.3 EFFECT OF SEASONS

2.3.1 Effect of Seasons on Marigold

A comparative study on the influence of short day conditions on various marigold species by Tsukamoto *et al.* (1971) reported that the maximum short day requirement was exhibited by *T. tenuifolia* and the minimum by *T. erecta*. The species *T. patula* appeared to be intermediate in response. The flowering in main shoot as well as secondary and tertiary shoots was enhanced by favourable photoperiod conditions. At high temperatures, the flower buds were formed only in short days whereas at low temperatures, flower buds were formed both in long days and short days.

An experiment was conducted by Samantaray *et al.* (1999) to evaluate the effect of planting time and spacing on African marigold. Since May planting resulted in continued vegetative growth for a longer period and reduced flower yield, it was found not beneficial for Bhubaneswar conditions. For maximizing the yield, September planting closely followed by July planting were found as the best times for planting. January and November plantings gave an early flower bud appearance. Maximum flower production was recorded during September and October months, which coincided with the short day conditions. March planting resulted in highest plant dry matter content but, lowest flower yield. In cultivar Pusa Narangi Gainda, planting during June resulted in highest flower yield and seed yield.

Another study conducted by Singh (2001) to evaluate the effect of season of planting on herbage, oil yield and oil quality in *Tagetes minuta* reported significantly higher herbage and oil yield during autumn planting. According to Ismail *et al.* (2013), planting during April month resulted in maximum production of fresh herb, dry herb and essential oil in *Tagetes lucida*.

Rao and Reddy (2002) reported a reduction in the number of days for flower opening from August to February because of short day length and low light intensity. Because of short day length and low night temperature, the number of days required for flower opening in African marigold was reduced from April to August sowing. But in March sowing delayed flower opening was reported due to high fluctuation in diurnal temperature, long day length, low light intensity, frequent rains and cloudiness (Rao and Moon, 2003).

According to Ritu and Gupta (2004), February planting resulted in maximum flower size (6.70 cm), number of flowers per plant (53.33) and flower yield per plant (296.10 g) in African marigold. Whereas, planting during July resulted in maximum plant height (108.30 cm), plant spread (41.85 cm) and seed yield per plant (23.12 g). In French marigold, the highest flower yield was obtained from June planting (Raju *et al.*, 2006). But, the maximum flower weight and flower diameter were recorded from August planting.

In a field study conducted by More *et al.* (2006), nine elite lines of marigold were evaluated for quality seed production during spring (July – November), winter (September – February) and summer (February – June) seasons. Greatest seed weight (3.20 g), seed germination (57.97%), seedling height (13.01 cm) and vigour index (134.93) were recorded in the spring planting.

Sreekanth *et al.* (2006) reported the maximum flower diameter, flower yield per plant and flower yield per hectare in African marigold during October planting. In another study by Sreekanth *et al.* (2008) maximum plant height, plant spread and number of lateral branches were recorded during November planting in African marigold.

According to Ghosh and Pal (2008) plant height, number of primary branches, flower diameter, individual flower weight and flower yield were influenced by the planting time in African marigold. Maximum plant height (89.29 cm) was recorded in April planting and August planting recorded the maximum number of primary branches. Maximum flower diameter (5.80 cm), individual

flower weight (5.29 g) and flower yield per unit area (20.01 kg/5.76 sqm) were reported in October planting.

The different planting times coincided with changes in weather parameters, which in turn attributed to the variation in crop performances (Ramesh and Singh, 2008). In *Tagetes minuta*, delayed planting reduced the crop duration from vegetative to reproductive phase.

Pramila *et al.* (2011) reported maximum plant height, number of primary branches and number of flowers per plant during *kharif* season in African marigold. Whereas, in a study conducted by Mohanty *et al.* (2015), November planting was found beneficial for improving flower diameter, flower number, weight of flowers per plot and flower yield per hectare in African marigold.

In a field study conducted by Pramila *et al.* (2012) on African marigold to evaluate the influence of seasons on seed yield and quality, more plant height (90.80 cm), number of primary branches (11.00), number of flowers (32.00/plant) and seed yield per flower (14.51 g) were recorded during the *kharif* season. Maximum flower size (6.55 cm) and highest seed germination (88.40%) were recorded during *rabi* season.

Another study on African marigold by Chauhan *et al.* (2014) reported maximum plant height in April planting (126.58 cm) followed by March planting (106.63 cm). The maximum plant spread was found in April planting (54.23cm). The earliest flowering (68.88 days) was observed in October planting, whereas maximum number of flowers per plant (34.67) was obtained from March planting. Maximum flower yield per plant (142.15 g) and maximum flower yield per square meter were recorded in April planting.

In an experiment conducted by Lakshmi *et al.* (2014) in African marigold, October planting resulted in statistically higher number of primary branches per plant (16.89), plant spread (48.33 cm), flower diameter (6.89 cm), number of flowers per plant (50.10), weight of flowers per plant (466.35 g), flower yield per plot (20.97 kg) and flower yield per hectare (25903.31 kg). In October planting, the

moderate temperature and short day conditions prevailed during the crop growing period resulted in increased flower yield.

A study on African marigold cultivar Siracole, conducted in the Indo-gangetic plains of West Bengal reported maximum plant height (96.93 cm) in June planting (Joshna and Pal, 2015). Minimum days for bud emergence to full bloom (20.16 days) and maximum flower diameter (3.99 cm) were reported in April planting. The individual flower weight was maximum (2.55 g) in October planting and the maximum number of flowers per plot (7434.67) was recorded from May planting.

In African marigold cultivar Pusa Narangi Gainda, the maximum days to first flowering (104.42 days) was recorded in November planting, whereas the minimum (59.46 days) was recorded in September planting due to low temperature coupled with low light intensity. The better environmental conditions resulted in highest number of flowers per plant (37.27) and number of branches per plant (18.79) in October planting (Meena *et al.*, 2015).

In a study conducted in the Department of Pomology and Floriculture, College of Agriculture, Padannakkad, two varieties of African marigold were evaluated for finding the effect of seasons and pinching on growth and flower yield, by Prakash (2015). The study was undertaken in three seasons namely pre monsoon (January sown), monsoon (May sown) and post monsoon (September sown) with Pusa Narangi Gainda and Pusa Basanti Gainda varieties of African marigold. The variety Pusa Narangi Gainda sown during May without pinching recorded the maximum plant height (124.86 cm). Maximum number of flowers (125.16) was recorded in January sown crop of Pusa Narangi Gainda with pinching. Pusa Basanti Gainda sown during January with pinching recorded the maximum flower yield (626.66 g/plant).

Mohanty *et al.* (2016) evaluated the influence of different sources of fertilizers on growth of African marigold during three growing seasons (*kharif*, *rabi* and summer). They reported higher plant spread during *kharif* season,

followed by *rabi* season. They also reported that the better vegetative growth in marigold plants during *kharif* and *rabi* seasons might be due to high relative humidity coupled with low rate of evapotranspiration.

2.3.2 Effect of Seasons on Other Crops

The planting dates had direct influence on bud appearance and flower yield in chrysanthemum cultivar Chandrama (Barman *et al.,* 1993). A study conducted in chrysanthemum cultivar Chandrama showed significant variation in plant height, leaf area, length of flower stalk, number of flowers per plant, and individual flower weight with regard to the difference in planting seasons (Barman *et al.*, 1997). Maximum number of flowers with longest stems and longest flowering duration were observed in July planting.

In chrysanthemum, maximum plant height, peduncle length and number of branches per plant were obtained when the transplanting was done on 5th and 15th October (Jane *et al.,* 2001). According to Kulkarni and Reddy (2010), highest flower yield was recorded in chrysanthemum planted during April (135.16 g/plant) followed by May (134.16 g/plant) while, it was lowest in December planting (20.19 g/plant). The flower size was found better when planting was done in April (4.99 cm) and May (5.04 cm).

A study conducted by Anjum *et al.* (2007) in Pakistan reported prolonged blooming period and greater number of flowers with extended vase life, in early planted chrysanthemum. Early planting (February) resulted in increased plant height, more number of branches per plant and higher flower yield in chrysanthemum due to prolonged period of photosynthetic activity (Nawaz *et al.*, 2009).

As per the study of Kulkarni and Reddy (2008) in chrysanthemum, the flowering duration decreased gradually from April planting (65.67 days) to December planting (13.67 days). Early flowering was observed in December planting (42.93 days after planting) due to exposure of plants to short day and low temperature conditions during growth period.

According to Laxmi and Pratap (2011) July planting resulted in maximum plant height (25.89 cm), plant spread (21.37 cm), number of branches per plant (13.25), flower diameter (3.88 cm), duration of flowering (58.67 days), flower yield per plant (157.94 g) and flower yield per plot (6.02 kg) in chrysanthemum. A field experiment on chrysanthemum by Sharma *et al.* (2015) reported maximum plant height (120.29 cm), early flowering (95.08 days), more duration of flowering (41.43 days), number of flowers per stem (21.98), number of heads per plant (308) and number of seeds per head (243.95) when planting was done on 17th September.

Jane and Kawarkhe (2002) reported increase in plant height, number of branches per plant, plant spread, flower diameter, 100 flower weight and number of flowers per plant during October planting in China aster and the number of days taken for flower bud initiation was reduced. The planting dates had direct influence on the performance of China aster. Prasad and Reddy (2003) reported highest flower yield during October and November plantings in China aster. Seeds sown on 6th April gave better plant height, plant spread, number of flowering stems per plant, number of flowers per plant and yield of flowers per stem in China aster (Kaushal *et al.,* 2014).

In China aster, maximum capitulum diameter (4.31 cm), capitulum weight (1.42 g) and number of capitula per plant (15.25) were observed in October planting (Mathad *et al.,* 2008). October planting also improved the filled seed weight per capitulum (0.20 g), seed weight per capitulum (0.25 g), 1000 seed weight (1.68 g) and seed yield per plant (3.82 g).

Parthasarathy and Nagaraju (2003) evaluated the performance of gerbera through a three year trial and reported that the flower bud initiation, growth, development and flowering were faster during warmer period (April – May and June – July), while the flower longevity was more during October to November. The performance of gerbera varied significantly with differences in planting time, due to variation in soil moisture content (Sartaj, 2014). However, the best response of the crop in terms of number of leaves per plant (15.96), leaf area (138.78 cm^2),

plant height (27.09 cm), flower size (9.12 cm), number of flowers (220.10/m^2) and flower yield (2.95 kg/m^2) were obtained from June planting.

In an experiment on the effect of seasonal variation on flower yield of carnation, maximum plant height, stem length, number of flowers per plant and flower yield per square meter were reported in October planted crop, by Verma and Sharma (2002). They also reported early flower bud formation and flower opening in February planted crop. In carnation, maximum plant height, stem length and flower yield were observed in December planted crop (Dilta *et al.*, 2006). Earliest flower bud formation and flower opening were recorded in March planted crop whereas, maximum days for flower bud formation and flower opening was reported in December planted crop.

Planting gladiolus during October, November and June appeared to be best for getting quality flowers (Bankar and Mukhopadhyay, 1980). Early flowering (61.70 days) was observed in corms planted during June while those planted in February took maximum number of days (93.30 days). According to Sharma and Talukdar (2002) early shoot emergence, spike emergence and first flower opening in gladiolus were obtained from early planting (15th October and 5th November). The values for sprouts per corm, plant height, number of leaves, leaf length, florets per spike, spike length, floret size and shelf life of spike were also found highest in early planted crop.

Shiva and Dadlani (2002) conducted an experiment to study the effect of planting time on growth and flowering of gladiolus under greenhouse and open field conditions. They reported that, under greenhouse and open field conditions, earliest planting resulted in the best performance of gladiolus. Bagde *et al.* (2009) reported that gladiolus variety White Prosperity showed maximum spike length (104.20 cm), rachis length (52.40 cm), number of spikes per plant (1.53) and florets per spike (15.20) in 13th October planting.

The maximum plant height (119.12 cm), spike length (98.06 cm), number of florets per spike (13.20) and floret diameter (9.77 cm) were recorded in

gladiolus when planting was done on 31st March, due to occurrence of optimum temperature for plant growth (Sheikh and Jhon, 2005). Kumari *et al.* (2011) reported earliest sprouting of gladiolus corms in early planting *i.e.*, on 25th October. Maximum plant height, leaf area per plant, early spike emergence, number of spikes per plant, spike length, number of florets per spike and flowering duration were also observed in 25th October planting.

A field experiment conducted by Rathod *et al.* (2011) reported that the growth, flowering, quality and yield attributes of gladiolus were significantly increased by planting during first week of October as compared to first week of August and November. Saaie *et al.* (2012) reported significantly highest percentage of sprouting, leaf area, number of days for spike emergence, number of florets per spike, spike length, diameter of floret and weight of corms from gladiolus planted during August to November.

Materials and Methods

3. MATERIALS AND METHODS

The experiment was conducted during the year 2015-16, at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. The objective of the experiment was to study the growth and flowering of African marigold cultivars under open and polyhouse conditions. The details of the materials used and methods adopted for the study are discussed in this chapter.

3.1 LOCATION, CLIMATE AND SOIL OF THE SITE

The experiment was laid out in the open field of the orchard of Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. The area is located at 10°32' North latitude and 76°16' East longitude at an elevation of 22.5 m above the mean sea level.

The experimental area enjoys a tropical monsoon climate with warm and humid weather. The weather conditions that prevailed in the area during the experimental period are presented in Appendices 1 to 4. The soil of the site is sandy loam and acidic in reaction with a pH of 5.8, organic carbon content 0.40 per cent, available N 100.50 kg/ha, available P_2O_5 20.00 kg/ha and available K_2O 84.00 kg/ha.

3.2 TREATMENTS

3.2.1 Cultivars

The following cultivars of African marigold were used in the study.

i) Sonata Orange
ii) Sonata Yellow
iii) Biocarve Orange
iv) Biocarve Yellow
v) Local Orange
vi) Local Yellow
vii) Sierra Yellow
viii) Orange Giant

3.2.2 Growing Conditions

i) Open field (G1)

ii) Rain shelter (G2)

3.3 SEASON

The experiment was conducted in two different seasons, from July – November 2015 (Season I or rainy season) and from January – April 2016 (Season II or winter sowing).

3.4 EXPERIMENTAL DESIGN

The experiment was laid out in Randomised Block Design (RBD) with three replications having two beds per replication in both the seasons. The layout of the open field and rain shelter conditions are presented in Figs 1 to 4.

3.5 PLANTING MATERIAL

Seeds were purchased from Namdhari Seeds Private Ltd. and local cultivars were collected from Cashew Research Station, Madakkathara. Biocarve Orange, Biocarve Yellow and Sierra Yellow are hybrids. Seeds were sown in the nursery beds of size 1 m × 1 m, for each cultivar during June for the first season crop and in December for second season crop. One month old healthy seedlings were transplanted in the main field.

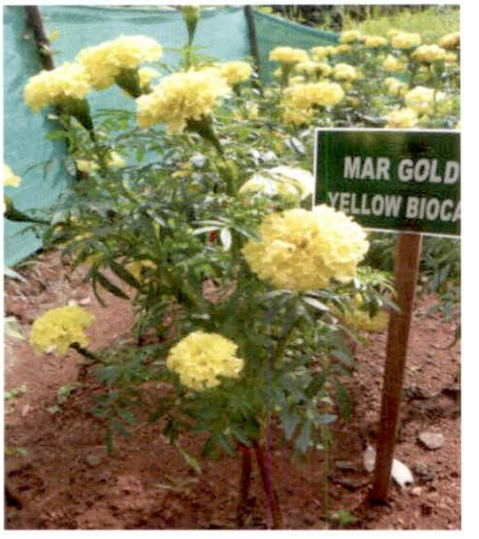
3.6 RAIN SHELTER

The structure (rain shelter) for the experiment was made using bamboo poles and covered with UV sheet of 200 micron thickness. The size of the structure was 28 m × 7 m. The sides of both rain shelter and open field were covered with green shade nets to protect the crop from peacock, wild boar, rabbit *etc.*

Sonata Orange

Sonata Yellow

Biocarve Orange

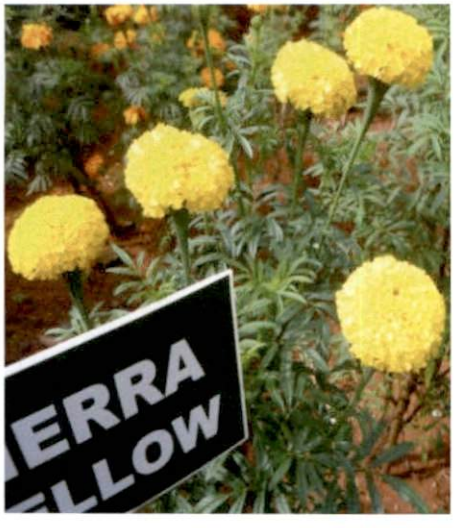


Biocarve Yellow

Plate 1. African marigold cultivars

Local Orange

Local Yellow



Sierra Yellow

Orange Giant

Plate 2. African marigold cultivars (contd..)

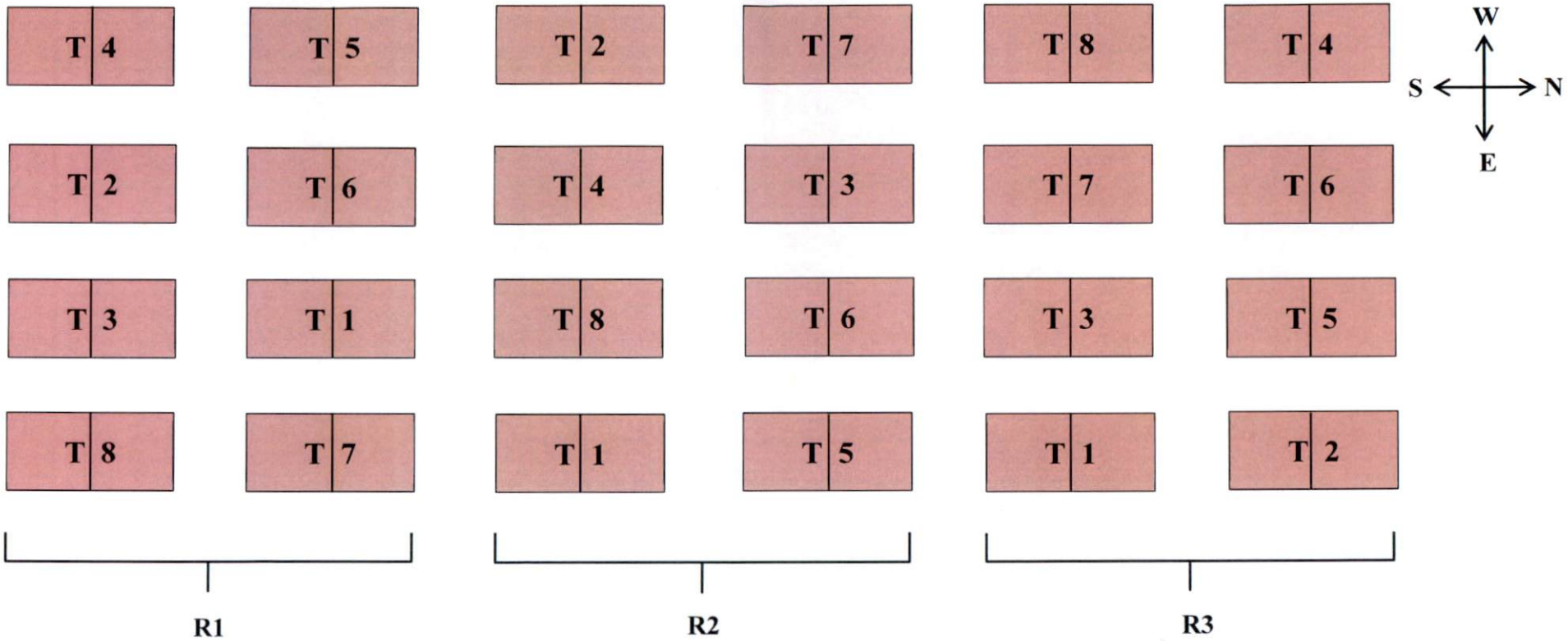
Open field

Rain shelter

Plate 3. Growing conditions

Seedlings raised in the nursery

Plate 4. Seedlings in nursery



Growing conditions : 2

No. of cultivars : 8

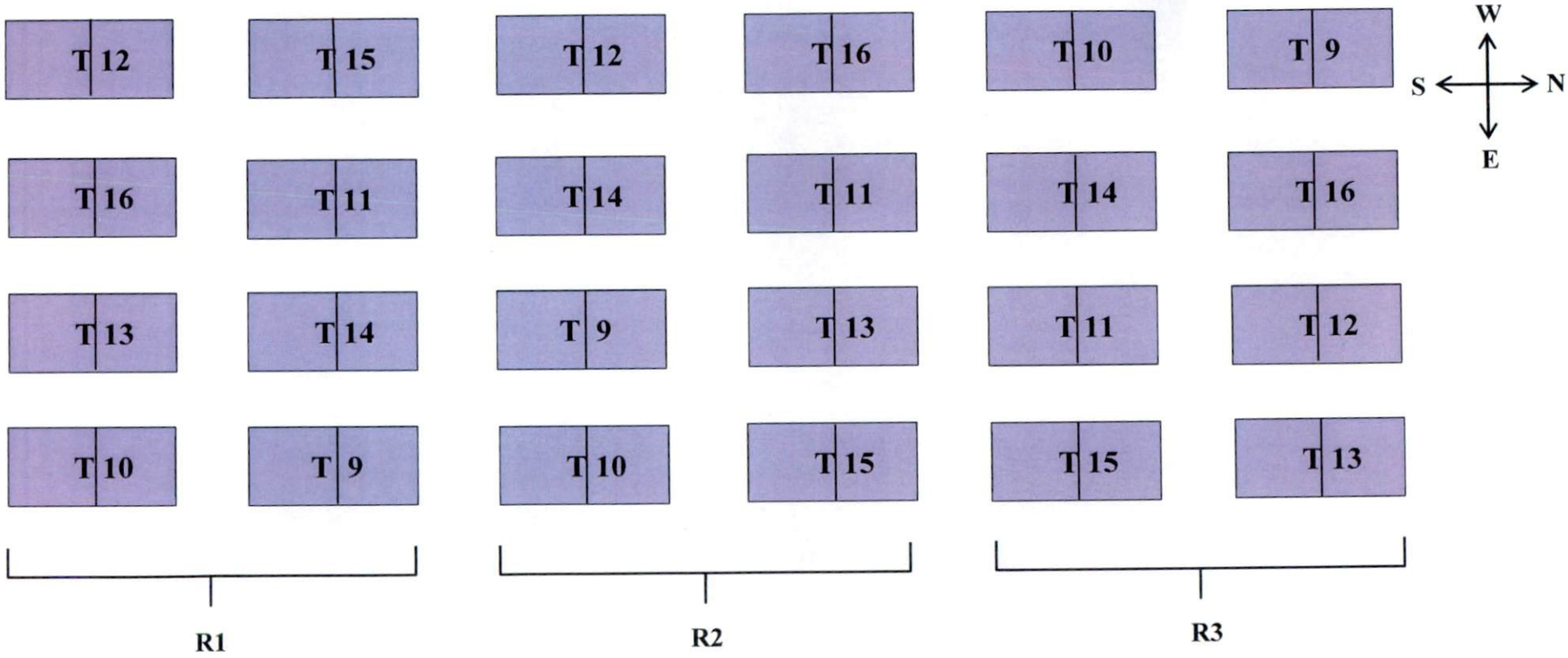
No. of treatments : 16

No. of replications : 3

No. of beds/replication : 2

Design : RBD

Fig 1. Layout of the open field (G1) condition for the first season (July – November)



Growing conditions : 2

No. of cultivars : 8

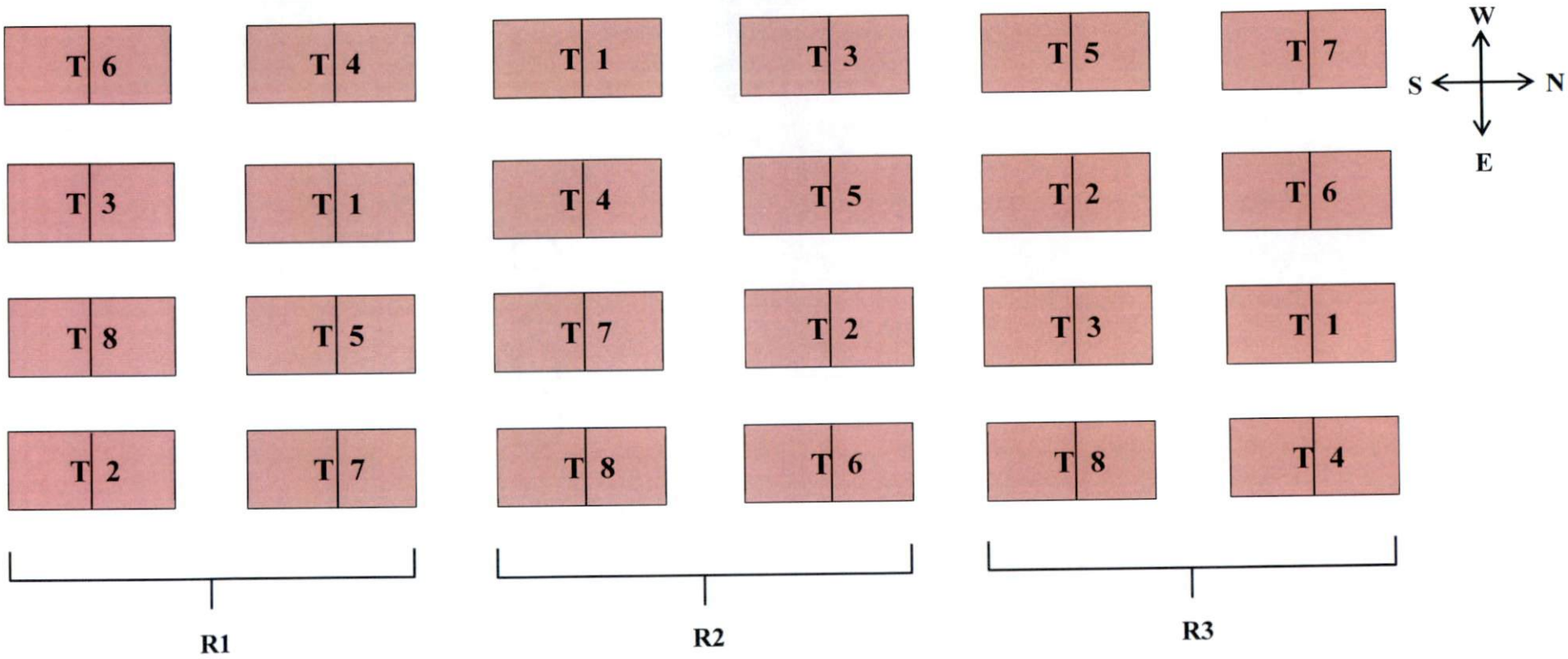
No. of treatments : 16

No. of replications : 3

No. of beds/replication : 2

Design : RBD

Fig 2. Layout of the rain shelter (G2) condition for the first season (July – November)



Growing conditions : 2

No. of cultivars : 8

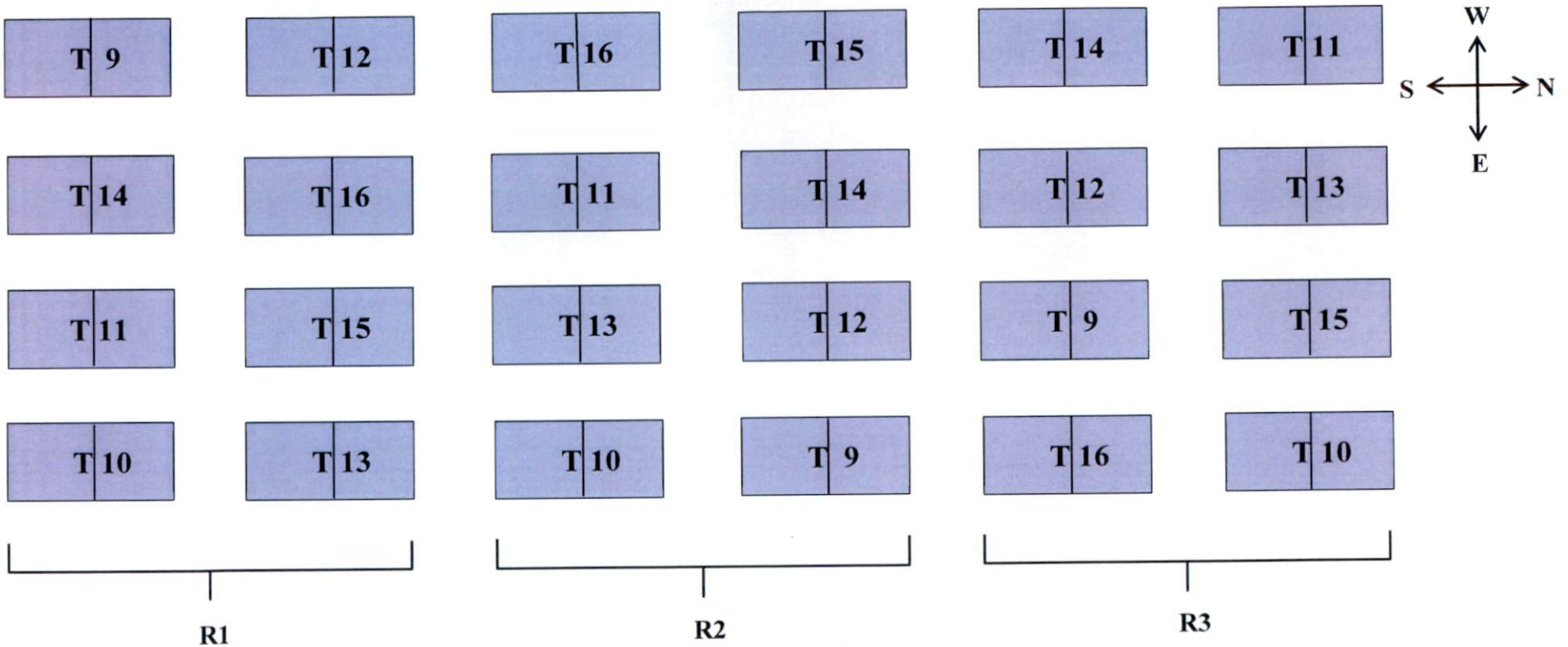
No. of treatments : 16

No. of replications : 3

No. of beds/replication : 2

Design : RBD

Fig 3. Layout of the open field (G1) condition for the second season (January – April)



Growing conditions : 2

No. of cultivars : 8

No. of treatments : 16

No. of replications : 3

No. of beds/replication : 2

Design : RBD

Fig 4. Layout of the rain shelter (G2) condition for the second season (January – April)

3.7 LAND PREPARATION AND PLANTING

The area for the experiment was selected and cleared, levelled and ploughed to a fine tilth. Raised beds of size 2 m × 1 m were taken and the seedlings were transplanted on the beds at a spacing of 45 cm × 45 cm. Thus, there were 48 beds each in the rain shelter and open field conditions.

3.8 CARE AND MANAGEMENT

Uniform management practices as per Package of Practices Recommendations: Crops (KAU, 2011) were followed in all the treatments.

3.8.1 Application of Fertilizers

Well rotten farm yard manure was incorporated into the beds at the rate of 20 t/ha. Recommended dose of 225:60:60 kg N, P_2O_5, K_2O per ha was applied in the form of Urea, Diammonium Phosphate and Muriate of Potash respectively. Half the dose of N, full doses of P_2O_5 and K_2O were applied at the time of planting. Remaining half dose of N was applied one month after transplanting as top dressing, after pinching.

3.8.2 Cultural Operations

Immediately after planting, the beds were irrigated and daily irrigation was continued for the crop under rain shelter condition during first season. During second season, daily irrigation was done for crop grown under both growing conditions. During both the seasons, periodic hand weeding was undertaken as and when necessary. Earthing up was done along with top dressing. Pinching of the plants was done one month after transplanting. Staking was given at the time of flowering, to avoid lodging.

3.8.3 Plant Protection

Appropriate plant protection measures were taken up to protect the plants from incidence of pests and diseases. Bacterial wilt was noticed in some of the plants during both the seasons. In the first crop (rainy season), as a control measure

against bacterial wilt, alternate application of the plants with Streptocyclin (3 g/10L), COC (3 g/L) and Kocide (2 g/L) was done. The beds were also drenched with Chlorpyriphos (2.5 ml/L) against termite attack. Prophylactic drenching of the beds with Streptocyclin (3 g/10L) was done to protect the plants from bacterial wilt during second season.

3.9 HARVESTING

Individual flowers were harvested when they opened fully and attained full size. Harvested flowers were used for recording the post–harvest observations and shelf life studies. Flowers for seed extraction were harvested when they dried on the plant and seeds matured.

3.10 OBSERVATIONS

3.10.1 Vegetative Characters

Observations on vegetative parameters were recorded just before flowering. Eight plants were selected in each replication and observations on various vegetative and floral characters were recorded. The following vegetative characters were recorded during the study.

3.10.1.1 Plant Height

Plant height in centimeters was measured from the collar region to the tip of the topmost leaf in the plant.

3.10.1.2 Plant Spread

The spread of the plant in north–south and east–west directions was measured in centimeters and the mean values were calculated.

3.10.1.3 Number of Primary Branches

The number of primary branches arising from the main stem was recorded. The average number of primary branches per plant was worked out.

3.10.1.4 Number of Secondary Branches

The total number of secondary branches arising from all the primary branches in a plant was counted and the mean number of secondary branches per plant was worked out.

3.10.1.5 Leaf Colour

Visual differences in leaf colour were recorded.

3.10.1.6 Leaf Length

Four functional leaves from the basal 2^{nd} to 4^{th} nodes were selected from each plant. The leaf length in centimeters was measured and mean length worked out.

3.10.1.7 Leaf Breadth

The breadth of the selected leaves in centimeters was measured and mean leaf breadth worked out.

3.10.1.8 Leaf Area

Leaf area was calculated using the following formula and was expressed in cm^2.

$$\text{Leaf area} = 0.22 \times \text{Length} \times \text{Breadth}$$

The statistical package of non-linear regression was used in deriving the leaf area constant.

3.10.1.9 Petiole Length

The petiole length in centimeters was measured from the selected leaves and mean petiole length worked out.

3.10.1.10 Internodal Length

The internodal length between the 2^{nd} and 3^{rd} node from the base of the plants was measured in centimeters.

3.10.1.11 Stem Girth

Stem girth 10 cm above the base of the plant was measured in centimeters.

3.10.1.12 Crop Duration

The number of days from date of transplanting to the complete death of the plant was recorded.

3.10.1.13 Incidence of Pests and Diseases

Observations were recorded on the pest attack and disease incidence during the crop growing period.

3.10.2 Floral Characters

3.10.2.1 Days to First Flowering

The number of days taken for commencement of flowering was worked out by counting the days from transplanting to the opening of first flower and expressed as number of days.

3.10.2.2 Days to 50 per cent Flowering

The number of days taken for 50 per cent flowering of the plants was calculated by counting the days from transplanting to 50 per cent flowering and expressed as number of days.

3.10.2.3 Flower Diameter

Diameter of five randomly selected fully opened flowers from each of the selected plants was measured in centimeters and mean flower diameter was calculated.

3.10.2.4 Flower Length

The flower length of the five randomly selected fully opened flowers was measured from the base of the stalk to the top of the flower and expressed in centimeters.

3.10.2.5 Pedicel Length

The pedicel length of five randomly selected flowers was measured in centimeters and mean pedicel length was worked out.

3.10.2.6 Individual Flower Weight

The individual flower weight of five selected flowers was measured, the average flower weight worked out and expressed in gram.

3.10.2.7 Number of Flowers per Plant

The number of flowers harvested from the selected plants in each replication was counted. The mean number of flowers from each replication was worked out and expressed in number of flowers per plant.

3.10.2.8 Flower Colour

Visual differences in flower colour were identified with the help of Royal Horticultural Society (RHS) Colour Chart.

3.10.2.9 Total Flower Yield

The flower yield obtained from the selected plants was recorded separately and mean flower yield was worked out in grams per plant.

3.10.2.10 Marketable Flower Yield

The marketable flower yield was recorded after sorting out the damaged/ bruised flowers. The mean flower yield after sorting was calculated and expressed in grams per plant.

3.10.2.11 Duration of Flowering

The number of days taken from opening of first flower to the death of last flower in the selected plants was recorded and expressed as number of days.

3.10.2.12 Shelf Life

Eight flowers from the selected plants in each replication were kept in ambient atmospheric conditions in the laboratory. The number of days taken for more than 50 per cent of the flowers to show wilting and discolouration was counted in each replication and expressed as number of days.

3.10.3 Seed Characters

3.10.3.1 Seed Yield per Flower

Five dried flowers from each plant were selected randomly, the weight of seeds obtained from individual flower was recorded and mean seed yield expressed in gram per flower.

3.10.3.2 Seed Germination

Fifty seeds taken from flowers of each replication were sown in beds and mean percentage of seed germination was calculated.

3.10.4 Biochemical Analysis

3.10.4.1 Chlorophyll Content in Leaf

The chlorophyll a, chlorophyll b and total chlorophyll content in the leaves of each cultivar was found out separately by the method proposed by Starner and Hardley (1967) using 80% acetone. To every 100 mg leaf sample taken, 10 ml 80% acetone was poured and macerated well using pestle and mortar. This was then centrifuged at 3000 rpm for 10 minutes. The supernatant was filtered and the final volume made up to 25 ml. The chlorophyll content of the sample was estimated spectrophotometrically at two different wavelengths (645 nm and 663

nm). The chlorophyll content in leaf samples was calculated using the formula given below. The results obtained were expressed in mg g^{-1} fresh wt of the sample.

Chlorophyll a = $[(12.7 \times A_{663}) - (2.69 \times A_{645})] \times V/1000 \times W$

Chlorophyll b = $[(22.9 \times A_{645}) - (4.68 \times A_{663})] \times V/1000 \times W$

Total chlorophyll = $[(20.2 \times A_{645}) + (8.02 \times A_{663})] \times V/1000 \times W$

Where,

A – Absorbance at given wavelength

V – Volume of supernatant solution made up

W – Weight of the sample

3.10.4.2 Xanthophyll Content in Flower

The xanthophyll content in flowers was estimated as per the procedure suggested by Neogy *et al.* (2001). For the estimation of xanthophyll, 250 mg sample (flower petals) was taken in a pestle and mortar, into which 20 ml of 80% acetone was added and macerated well. The extract was centrifuged for 15 minutes at 3000 rpm. The reextraction of the residue was carried out twice using 80% acetone and the supernatant collected. The acetone extract was transferred to a separating funnel and shaken well after adding equal volume of hexane into it. The combined hexane fractions were washed with equal volume of distilled water. The hexane fraction was washed repeatedly with 90% methanol in order to extract xanthophyll from carotenoids. The methanol fraction containing xanthophyll was collected and the absorbance measured at 450 nm in a Spectrophotometer. The xanthophyll content was calculated using the following formula and result expressed as mg $100g^{-1}$ fresh wt of the sample.

$$\text{Xanthophyll content in } \mu g\ g^{-1} \text{ fresh wt of the sample} = \frac{\text{Absorbance at 450 nm}}{\text{Weight of the sample (g)}}$$

3.10.4.3 Flavonoid Content in Flower

Estimation of flavonoid content in flowers was carried by the method of Mirecki and Teramura (1984). A sample of 100 mg was taken in a beaker, into which 20 ml 80% acidified methanol (methanol, water and HCl in 79:20:1 ratio) was added and kept overnight in the darkness. The sample was filtered and absorbance at 300 nm was read in a Spectrophotometer. The flavonoid content was calculated using the formula given below and expressed in A_{300} g^{-1} fresh wt of the sample.

$$Y = 16.05 \times A$$

Where,

Y – Concentration of the UV-B absorbing compound equivalent to coumaric acid

A – Absorbance at 300 nm

3.10.5 Meteorological Data

Temperature and relative humidity of both open field and rain shelter were recorded daily between 10.00 a.m. and 12.00 p.m. daily and the monthly mean was calculated. Light intensity was also recorded daily at 12.00 noon. The data on sunshine hours (monthly mean) and rainfall (monthly mean) were collected from the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara. The recorded weather data for the period under study are included in Appendices 1 to 4.

3.10.6 Economics of Cultivation

3.10.6.1 BC Ratio

Benefit – cost ratio worked out using the cost of making rain shelter, cost of cultivation, marketable flower yield and the price of flowers.

3.11 TABULATION AND STATISTICAL ANALYSIS

Observations on different characters were tabulated and statistically analysed using the M STAT–C package. Correlation analysis was conducted for finding out the relationship between various vegetative and floral characters.

Results

4. RESULTS

Experiment was conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during the year 2015-16, to study the performance of African marigold cultivars under open field and rain shelter conditions. The crop was planted during two seasons, from July – November 2015 (Season I) and from January – April 2016 (Season II), and the performance evaluated with respect to various vegetative and floral characters.

The data were statistically analysed as a two factor RBD for all the characters observed. The results of the experiment are presented in this chapter under four major headings,

1. Vegetative characters
2. Floral characters
3. Seed characters
4. Biochemical attributes

The results obtained from the recorded observations on various characters in open field and rain shelter conditions during the first and second season are separately presented here.

4.1 VEGETATIVE CHARACTERS

Observations related to various vegetative characters in the open field and rain shelter conditions during both the seasons are presented in Table 1(a) to Table 3(j).

4.1.1 Plant Height

Data pertaining to the plant height of different cultivars during the first season are presented in Table 1(a) and that of second season in Table 1(b).

Open field

Rain shelter

Plate 5. General view of experimental plot during first season (July – Nov.)

Open field

Rain shelter

Plate 6. General view of experimental plot during second season (Jan. – April)

Season I

Since the interaction effect was not significant, only the cultivar means and growing condition means were taken into consideration, during the first season. In general, significant difference could be noticed with respect to plant height among the different cultivars and better plant height was observed in rain shelter than in open field condition. Irrespective of growing conditions, the cultivar Orange Giant recorded the highest plant height (113.00 cm) and was significantly superior to all other cultivars. This was followed by Local Orange (104.17 cm), Sonata Orange (102.08 cm) and Local Yellow (100.13 cm) which were on par with one another. Biocarve Yellow recorded the least plant height (52.66 cm) which was on par with Sonata Yellow (56.69 cm) and Biocarve Orange (59.32 cm).

Season II

Sonata Orange recorded the highest plant height (48.40 cm) in open field condition, which was significantly superior to all other cultivars. This was followed by Local Yellow (44.33 cm), Local Orange (44.27 cm), Sonata Yellow (42.47 cm) and Orange Giant (42.20 cm) which were statistically on par with one another. Lowest plant height was observed in Biocarve Yellow (22.20 cm) which was significantly different from all the cultivars.

Highest plant height under rain shelter condition was recorded in Sonata Orange (47.53 cm), which was significantly superior to all other cultivars. This was followed by Orange Giant (44.93 cm). Plant height of the cultivars Local Yellow (42.73 cm) and Local Orange (42.20 cm) were on par with one another. Least plant height was recorded in Biocarve Yellow (24.13 cm).

Irrespective of cultivars, there was no significant difference between the growing conditions with regard to plant height. Among the cultivars, Sonata Orange recorded significantly highest plant height (47.97 cm), regardless of growing conditions. This was followed by Orange Giant (43.57 cm), Local Yellow (43.53 cm) and Local Orange (43.23 cm) which were on par with one another. The cultivar Biocarve Yellow recorded the least plant height (23.17 cm).

4.1.1.1 Effect of Seasons on Plant Height

The plant height of all the cultivars were significantly influenced by the seasons both under open field and rain shelter conditions (Table 1(c) & Table 1(d)). The plant height recorded during first season was more compared to the second season irrespective of the cultivars, in the open field condition (Table 1(c)). The cultivar Orange Giant grown during first season recorded the highest plant height (109.79 cm) which was followed by Local Orange (103.11 cm).

Under rain shelter condition also higher plant height was recorded during first season (rainy season) compared to second season (winter sowing) in all the cultivars (Table 1(d)). The cultivar Orange Giant grown during first season recorded the highest plant height (116.20 cm) among all the cultivars.

4.1.2 Plant Spread

Significant difference could be found in plant spread for all the cultivars, irrespective of the growing conditions during both the seasons (Tables 1(a) and 1(b)).

4.1.2.1 Plant Spread (North-South)

Season I

During the first season, no significant interaction effect between cultivars and growing conditions was observed. Even though higher plant spread (NS) was observed in plants grown in the open field condition compared to rain shelter condition, there was no significant difference between the growing conditions with regard to the plant spread (NS), regardless of cultivars. Among the cultivars, Local Orange recorded highest plant spread (NS) both in open field (52.11 cm) and rain shelter (47.70 cm) conditions. Irrespective of growing conditions, Local Orange (49.91 cm) recorded the highest plant spread (NS). This was followed by Local Yellow (48.27 cm) which was on par with Local Orange. Least plant spread (NS) was recorded in Biocarve Yellow (26.92 cm).

Table 1(a). Effect of growing conditions on plant characters in African marigold cultivars during first season (July – November)

Cultivars	Plant height (cm)			Plant spread (cm)						Stem girth (cm)			Internodal length (cm)		
				NS			EW								
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	96.08	108.08	102.08	45.33	40.92	43.13	34.04	29.50	31.77	3.95	3.44	3.69	5.36	4.60	4.98
Sonata Yellow	54.63	58.75	56.69	30.38	34.71	32.55	22.53	27.94	25.24	3.06	3.20	3.13	3.44	3.04	3.24
Biocarve Orange	60.27	58.38	59.32	32.29	32.25	32.27	26.25	25.29	25.77	3.08	2.66	2.87	3.90	3.87	3.88
Biocarve Yellow	51.67	53.66	52.66	26.16	27.67	26.92	19.98	19.58	19.78	2.57	2.54	2.55	2.81	3.08	2.95
Local Orange	103.11	105.23	104.17	52.11	47.70	49.91	40.64	38.53	39.58	4.47	3.69	4.08	3.43	4.80	4.12
Local Yellow	99.75	100.50	100.13	51.58	44.96	48.27	42.38	38.13	40.25	4.49	3.48	3.98	4.34	5.43	4.89
Sierra Yellow	68.94	75.38	72.16	31.91	33.68	32.80	25.65	27.68	26.66	2.97	2.68	2.82	4.13	3.63	3.88
Orange Giant	109.79	116.20	113.00	47.83	39.08	43.46	37.04	27.54	32.29	3.90	3.13	3.52	8.12	7.93	8.02
Mean	80.53	84.52		39.70	37.62		31.06	29.27		3.56	3.10		4.44	4.55	
CD (0.05) (Cultivars)	7.02			4.51			3.67			0.25			0.61		
CD (0.05) (Growing conditions)	3.51			NS			NS			0.13			NS		
CD (0.05) (Interaction)	NS			NS			5.20			0.36			0.86		

G1 – Open field condition G2 – Rain shelter condition NS : North-South EW : East-West

Table 1(b). Effect of growing conditions on plant characters in African marigold cultivars during second season (January – April)

Cultivars	Plant height (cm)			Plant spread (cm)						Stem girth (cm)			Internodal length (cm)		
				NS			EW								
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	48.40	47.53	47.97	24.73	24.20	24.47	19.07	21.07	20.07	2.37	2.17	2.27	3.02	3.67	3.34
Sonata Yellow	42.47	40.33	41.40	20.67	25.47	23.07	16.87	17.87	17.37	1.77	2.23	2.00	3.69	4.08	3.89
Biocarve Orange	27.93	30.67	29.30	14.60	15.53	15.07	11.73	11.87	11.80	1.25	1.48	1.36	3.52	3.85	3.69
Biocarve Yellow	22.20	24.13	23.17	12.00	13.00	12.50	9.40	10.52	9.96	1.32	1.42	1.37	3.65	3.63	3.64
Local Orange	44.27	42.20	43.23	24.60	22.60	23.60	21.73	18.33	20.03	2.47	1.91	2.19	3.66	3.48	3.57
Local Yellow	44.33	42.73	43.53	26.07	24.47	25.27	20.87	20.67	20.77	2.49	2.46	2.47	3.07	3.13	3.10
Sierra Yellow	38.60	39.93	39.27	18.93	17.47	18.20	14.27	13.60	13.93	2.17	1.59	1.88	4.04	4.09	4.06
Orange Giant	42.20	44.93	43.57	22.00	17.93	19.97	16.53	13.87	15.20	2.48	2.33	2.40	4.21	4.27	4.24
Mean	38.80	39.06		20.45	20.08		16.31	15.97		2.04	1.95		3.61	3.77	
CD (0.05) (Cultivars)	1.53			1.43			1.85			0.17			0.29		
CD (0.05) (Growing conditions)	NS			NS			NS			0.09			0.14		
CD (0.05) (Interaction)	2.17			2.03			NS			0.24			NS		

G1 – Open field condition G2 – Rain shelter condition NS : North-South EW : East-West

Table 1(c). Effect of seasons on plant characters of African marigold cultivars in open field condition

Cultivars	Plant height (cm)		Plant spread (cm)			
			NS		EW	
	S1	S2	S1	S2	S1	S2
Sonata Orange	96.08	48.40	45.33	24.73	34.04	19.07
Sonata Yellow	54.63	42.47	30.38	20.67	22.53	16.87
Biocarve Orange	60.27	27.93	32.29	14.60	26.25	11.73
Biocarve Yellow	51.67	22.20	26.16	12.00	19.98	9.40
Local Orange	103.11	44.27	52.11	24.60	40.64	21.73
Local Yellow	99.75	44.33	51.58	26.07	42.38	20.87
Sierra Yellow	68.94	38.60	31.91	18.93	25.65	14.27
Orange Giant	109.79	42.20	47.83	22.00	37.04	16.53
CD (0.05)	7.70		5.31		4.92	

S1 – 1st season (July – November) NS : North-South

S2 – 2nd season (January – April) EW: East-West

Table 1(d). Effect of seasons on plant characters of African marigold cultivars under rain shelter condition

Cultivars	Plant height (cm)		Plant spread (cm)			
			NS		EW	
	S1	S2	S1	S2	S1	S2
Sonata Orange	108.08	47.53	40.92	24.20	29.50	21.07
Sonata Yellow	58.75	40.33	34.71	25.47	27.94	17.87
Biocarve Orange	58.38	30.67	32.25	15.53	25.29	11.87
Biocarve Yellow	53.66	24.13	27.67	13.00	19.58	10.52
Local Orange	105.23	42.20	47.70	22.60	38.53	18.33
Local Yellow	100.50	42.73	44.96	24.47	38.13	20.67
Sierra Yellow	75.38	39.93	33.68	17.47	27.68	13.60
Orange Giant	116.20	44.93	39.08	17.93	27.54	13.87
CD (0.05)	5.04		4.10		3.20	

S1 – 1st season (July – November) NS : North-South

S2 – 2nd season (January – April) EW: East-West

Season II

The highest plant spread (NS) in the open field condition was recorded in cultivar Local Yellow (26.07 cm). This was followed by Sonata Orange (24.73 cm) and Local Orange (24.60 cm) which were on par with Local Yellow. There was no significant difference between Orange Giant (22.00 cm) and Sonata Yellow (20.67 cm) with regard to plant spread (NS). Lowest plant spread (NS) was recorded in cultivar Biocarve Yellow (12.00 cm).

Under rain shelter condition, highest plant spread (NS) was observed in cultivar Sonata Yellow (25.47 cm). This was followed by Local Yellow (24.47 cm) and Sonata Orange (24.20 cm) which were on par with Sonata Yellow. While the lowest plant spread (NS) was recorded in cultivar Biocarve Yellow (13.00 cm).

Even though better plant spread (NS) was observed in the open field condition compared to rain shelter condition, irrespective of cultivars, there was no significant difference between the plant spread (NS) recorded under the two growing conditions, during the second season also. Among the cultivars, Local Yellow (25.27 cm) recorded the highest plant spread (NS) regardless of growing conditions. This was followed by Sonata Orange (24.47 cm) which was on par with Local Yellow. The cultivar Biocarve Yellow (12.50 cm) recorded the least plant spread (NS) which was significantly different from all the cultivars.

4.1.2.1.1 Effect of Seasons on Plant Spread (North-South)

Season had significant influence on plant spread (NS) of all the cultivars both under open field and rain shelter conditions (Table 1(c) and Table 1(d)). More plant spread (NS) was recorded during the first season compared to second season irrespective of the cultivars in the open field condition. Highest plant spread in the open field condition was recorded in cultivar Local Orange (52.11 cm) planted during the first season (Table 1(c)).

Under rain shelter condition also all the cultivars recorded higher plant spread (NS) during first season compared to second season. The cultivar Local

Orange (47.70 cm) grown during the first season recorded highest plant spread (Table 1(d)).

4.1.2.2 Plant Spread (East-West)

Season I

As indicated in Table 1(a), highest plant spread (EW) in the open field condition was observed in cultivar Local Yellow (42.38 cm). This was followed by Local Orange (40.64 cm) which was statistically on par with Local Yellow. The plant spread (EW) of the cultivars Orange Giant (37.04 cm) and Sonata Orange (34.04 cm) were on par with each other. Least plant spread (EW) was recorded in cultivar Biocarve Yellow (19.98 cm) which was on par with Sonata Yellow (22.53 cm).

Under rain shelter condition, highest plant spread (EW) was recorded in Local Orange (38.53 cm) which was significantly superior to all other cultivars except Local Yellow (38.13 cm). The plant spread (EW) of all other cultivars except Biocarve Yellow were on par with one another. Lowest plant spread (EW) was recorded in cultivar Biocarve Yellow (19.58 cm).

Thus, it was apparent from the data that the plant spread (EW) of the cultivars was significantly influenced by the growing conditions during the first season. Irrespective of cultivars, growing condition had no significant influence on plant spread (EW). Among the cultivars, Local Yellow (40.25 cm) recorded the highest plant spread (EW) irrespective of growing conditions. This was followed by Local Orange (39.58 cm) which was on par with Local Yellow. The least plant spread was recorded in cultivar Biocarve Yellow (19.78 cm).

Season II

During second season, the growing condition had no significant influence on plant spread (EW) of the evaluated cultivars. Even though better plant spread (EW) was observed in open field condition than in the rain shelter condition, there was no significant difference between the growing condition means. Irrespective of

growing conditions, the cultivar Local Yellow (20.77 cm) recorded the highest plant spread (EW). This was followed by Sonata Orange (20.07 cm) and Local Orange (20.03 cm) which were on par with Local Yellow. Least plant spread (EW) was recorded in cultivar Biocarve Yellow (9.96 cm) which was on par with Biocarve Orange (11.80 cm).

4.1.2.2.1 Effect of Seasons on Plant Spread (East-West)

Data included in Table 1(c) and Table 1(d) revealed that the plant spread (EW) was significantly influenced by the growing seasons in all cultivars grown under open field and rain shelter conditions. In the open field condition, better plant spread (EW) was observed during the first season compared to second season. The highest plant spread (EW) in the open field condition was observed in cultivar Local Yellow (42.38 cm) grown during the first season (Table 1(c)).

Under rain shelter condition also the cultivars grown during first season recorded more plant spread (EW) compared to second season. The cultivar Local Orange (38.53 cm) planted during first season recorded highest plant spread (EW) among all the cultivars (Table 1(d)).

4.1.3 Stem Girth

Data pertaining to the stem girth of different cultivars grown under open field and rain shelter conditions during the first season are presented in Table 1(a) and that of second season are presented in Table 1(b).

Season I

Highest stem girth in the open field condition was recorded in cultivar Local Yellow (4.49 cm) which was significantly superior to all other cultivars except Local Orange (4.47 cm). Sonata Orange (3.95 cm) and Orange Giant (3.90 cm) were on par with each other with respect to the stem girth. Lowest stem girth was recorded in Biocarve Yellow (2.57 cm) among all the cultivars.

Table 1(e). Effect of seasons on plant characters of African marigold cultivars in open field condition

Cultivars	Stem girth (cm)		Internodal length (cm)	
	S1	S2	S1	S2
Sonata Orange	3.95	2.37	5.36	3.02
Sonata Yellow	3.06	1.77	3.44	3.69
Biocarve Orange	3.08	1.25	3.90	3.52
Biocarve Yellow	2.57	1.32	2.81	3.65
Local Orange	4.47	2.47	3.43	3.66
Local Yellow	4.49	2.49	4.34	3.07
Sierra Yellow	2.97	2.17	4.13	4.04
Orange Giant	3.90	2.48	8.12	4.21
CD (0.05)	0.37		0.73	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 1(f). Effect of seasons on plant characters of African marigold cultivars under rain shelter condition

Cultivars	Stem girth (cm)		Internodal length (cm)	
	S1	S2	S1	S2
Sonata Orange	3.44	2.17	4.60	3.67
Sonata Yellow	3.20	2.23	3.04	4.08
Biocarve Orange	2.66	1.48	3.87	3.85
Biocarve Yellow	2.54	1.42	3.08	3.63
Local Orange	3.69	1.91	4.80	3.48
Local Yellow	3.48	2.46	5.43	3.13
Sierra Yellow	2.68	1.59	3.63	4.09
Orange Giant	3.13	2.33	7.93	4.27
CD (0.05)	0.20		0.62	

S1 –1st season (July – November) S2 – 2nd season (January – April)

Highest stem girth under rain shelter condition was noticed in Local Orange (3.69 cm). This was followed by Local Yellow (3.48 cm) and Sonata Orange (3.44 cm) which were on par with Local Orange. Least stem girth was observed in Biocarve Yellow (2.54 cm) which was on par with Biocarve Orange (2.66 cm) and Sierra Yellow (2.68 cm).

It is evident that the stem girth of all the cultivars were significantly influenced by the growing conditions. The plants recorded significantly highest stem girth in the open field condition compared to rain shelter conditions, irrespective of cultivars. Among the cultivars, Local Orange recorded highest stem girth (4.08 cm), regardless of growing conditions. This was followed by Local Yellow (3.98 cm), which was on par with Local Orange. The least stem girth was observed in cultivar Biocarve Yellow (2.55 cm).

Season II

In the open field condition, highest stem girth was observed in cultivar Local Yellow (2.49 cm). The stem girth recorded in Orange Giant (2.48 cm), Local Orange (2.47 cm) and Sonata Orange (2.37 cm) were on par with Local Yellow. The least stem girth was recorded in cultivar Biocarve Orange (1.25 cm) which was on par with Biocarve Yellow (1.32 cm).

Under rain shelter condition also, highest stem girth was recorded in Local Yellow (2.46 cm). This was followed by Orange Giant (2.33 cm) and Sonata Yellow (2.23 cm) which were on par with Local Yellow. The least stem girth was observed in Biocarve Yellow (1.42 cm) which was statistically on par with Biocarve Orange (1.48 cm).

It could be seen that the stem girth was significantly influenced by the growing conditions in all the cultivars. During second season also plants in the open field condition recorded significantly highest stem girth, regardless of cultivars. Highest stem girth was recorded in cultivar Local Yellow (2.47 cm), irrespective of growing conditions. This was followed by Orange Giant (2.40 cm)

which was on par with Local Yellow. Biocarve Orange recorded the least stem girth (1.36 cm), which was on par with Biocarve Yellow (1.37 cm).

4.1.3.1 Effect of Seasons on Stem Girth

The stem girth of all the cultivars were significantly influenced by the growing seasons both in open field condition (Table 1(e)) and under rain shelter condition (Table 1(f)). The plants grown during first season recorded higher stem girth than the plants grown during second season in the open field condition (Table 1(e)). Among the cultivars Local Yellow (4.49 cm) grown during the first season recorded highest stem girth which was followed by Local Orange (4.47 cm).

Higher stem girth under rain shelter condition was also recorded during the first season (Table 1(f)) in all the eight cultivars. Highest stem girth was observed in the cultivar Local Orange (3.69 cm) grown during first season.

4.1.4 Internodal Length

Data pertaining to internodal length of the cultivars grown under the two growing conditions during the two seasons are presented in Table 1(a) & Table 1(b).

Season I

During the first season, highest internodal length in the open field condition was recorded in Orange Giant (8.12 cm) which was significantly superior to all other cultivars. This was followed by the cultivars Sonata Orange and Local Yellow which recorded an internodal length of 5.36 cm and 4.34 cm respectively. The least internodal length was recorded in Biocarve Yellow (2.81 cm) which was on par with Local Orange (3.43 cm) and Sonata Yellow (3.44 cm).

Under rain shelter condition also Orange Giant recorded the highest internodal length (7.93 cm) which was significantly superior to all other cultivars. This was followed by Local Yellow (5.43 cm), Local Orange (4.80 cm) and Sonata Orange (4.60 cm) which were on par with one another. Sonata Yellow recorded the

least internodal length (3.04 cm) which was on par with the remaining cultivars, Biocarve Yellow (3.08 cm), Sierra Yellow (3.63 cm) and Biocarve Orange (3.87 cm).

The data revealed that growing conditions exerted significant influence on the internodal length of the cultivars evaluated. Even though the growing condition had no significant influence on internodal length, irrespective of cultivars, the plants grown under rain shelter condition recorded higher internodal length compared to open field condition. Among the cultivars, Orange Giant recorded significantly highest internodal length (8.02 cm), regardless of growing conditions. The cultivar Biocarve Yellow recorded the least internodal length (2.95 cm) which was on par with Sonata Yellow (3.24 cm).

Season II

Since the interaction effect was not significant, the growing condition had no significant influence on internodal length of the cultivars during the second season. Regardless of cultivars, planting under rain shelter condition resulted in significantly higher internodal length compared to open field condition. Irrespective of growing conditions, the cultivar Orange Giant recorded highest internodal length (4.24 cm). This was followed by Sierra Yellow (4.06 cm) which was on par with Orange Giant. Least internodal length was recorded in cultivar Local Yellow (3.10 cm) which was on par with Sonata Orange (3.34 cm).

4.1.4.1 Effect of Seasons on Internodal Length

The seasons have significant influence on the internodal length of all the cultivars under both growing conditions (Table 1(e) and Table 1(f)). In the open field condition, the plants showed better internodal length during first season. Among the cultivars, Orange Giant (8.12 cm) grown during first season recorded the highest internodal length (Table 1(e)).

Under rain shelter condition also higher internodal length in most of the cultivars was recorded during the first season. The cultivar Orange Giant (7.93 cm)

grown during first season recorded the highest internodal length under rain shelter condition (Table 1(f)).

4.1.5 Number of Primary Branches

The data pertaining to the number of primary branches per plant of different cultivars during first season are presented in Table 2(a) and that of second season are presented in Table 2(b).

Season I

During first season, the growing condition had no significant influence on the number of primary branches per plant of the cultivars since, the interaction effect was not significant. From the recorded data, it is evident that the number of primary branches per plant varied significantly with respect to growing conditions, irrespective of cultivars. More number of primary branches per plant was observed in plants grown under rain shelter condition than in the open field condition. Regardless of growing conditions, the cultivar Local Orange recorded highest number of primary branches per plant (8.92). This was followed by Sonata Yellow (8.73), Local Yellow (8.52), Biocarve Orange (8.08) and Orange Giant (7.52) which were on par with Local Orange. Sierra Yellow recorded the least number of primary branches per plant (5.42) which was on par with Biocarve Yellow (6.02).

Season II

The highest number of primary branches per plant in the open field condition was recorded in Local Yellow (8.67) which was significantly superior to all other cultivars except Local Orange (8.33). The number of primary branches per plant observed in the cultivars Sonata Yellow, Sonata Orange, Orange Giant and Biocarve Orange were 7.20, 6.80, 6.73 and 6.67 respectively which were statistically on par with one another. Least number of primary branches per plant was recorded in cultivar Biocarve Yellow (5.00).

Under rain shelter condition also, Local Yellow recorded the highest number of primary branches per plant (8.53). This was followed by Sonata Yellow (8.27)

which was statistically on par with Local Yellow. The number of primary branches per plant observed in cultivars Sonata Orange (7.60) and Local Orange (7.33) were on par with each other. Under rain shelter condition also Biocarve Yellow recorded the least number of primary branches per plant (5.60).

It could be seen that growing condition had significant influence on number of primary branches per plant for all the evaluated cultivars. Irrespective of cultivars, the growing condition had no significant influence on the number of primary branches per plant. Among the cultivars, Local Yellow (8.60) maintained superiority for number of primary branches per plant, irrespective of growing conditions. The cultivar Biocarve Yellow recorded the least number of primary branches per plant (5.30).

4.1.5.1 Effect of Seasons on Number of Primary Branches

The growing season had no significant influence on the number of primary branches per plant, both under open field and rain shelter conditions (Table 2(c) and Table 2(d)). Highest number of primary branches was noticed in cultivar Local Yellow (8.67) grown during the second season (Table 2(c)).

Under rain shelter condition, the cultivar Local Orange (9.99) grown during first season recorded the highest number of primary branches per plant (Table 2(d)).

4.1.6 Number of Secondary Branches

The number of secondary branches per plant was significantly influenced by the growing conditions during both seasons in all the cultivars (Tables 2(a) and 2(b)).

Season I

It was found that, the interaction effect of growing conditions on cultivars was not significant with regard to the number of secondary branches per plant during first season. But irrespective of cultivars, the growing condition had a

Table 2(a). Effect of growing conditions on plant characters in African marigold cultivars during first season (July – November)

Cultivars	No. of primary branches			No. of secondary branches		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	6.21	8.50	7.35	29.00	32.88	30.94
Sonata Yellow	7.78	9.68	8.73	24.20	36.51	30.35
Biocarve Orange	7.58	8.58	8.08	20.50	25.38	22.94
Biocarve Yellow	6.29	5.76	6.02	11.54	18.21	14.88
Local Orange	7.85	9.99	8.92	31.04	39.08	35.06
Local Yellow	8.13	8.92	8.52	29.20	41.00	35.10
Sierra Yellow	4.89	5.96	5.42	12.89	22.63	17.76
Orange Giant	6.79	8.25	7.52	36.17	34.58	35.38
Mean	6.94	8.21		24.32	31.28	
CD (0.05) (Cultivars)	1.55			4.94		
CD (0.05) (Growing conditions)	0.77			2.47		
CD (0.05) (Interaction)	NS			NS		

G1 – Open field condition G2 – Rain shelter condition

Table 2(b). Effect of growing conditions on plant characters in African marigold cultivars during second season (January – April)

Cultivars	No. of primary branches			No. of secondary branches		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	6.80	7.60	7.20	23.07	22.80	22.93
Sonata Yellow	7.20	8.27	7.73	16.20	23.80	20.00
Biocarve Orange	6.67	6.53	6.60	5.47	9.87	7.67
Biocarve Yellow	5.00	5.60	5.30	6.47	6.73	6.60
Local Orange	8.33	7.33	7.83	20.40	19.00	19.70
Local Yellow	8.67	8.53	8.60	23.53	19.67	21.60
Sierra Yellow	6.00	6.40	6.20	13.40	18.20	15.80
Orange Giant	6.73	6.73	6.73	21.87	17.20	19.53
Mean	6.93	7.13		16.30	17.16	
CD (0.05) (Cultivars)	0.48			1.99		
CD (0.05) (Growing conditions)	NS			NS		
CD (0.05) (Interaction)	0.68			2.82		

G1 – Open field condition G2 – Rain shelter condition

Table 2(c). Effect of seasons on plant characters of African marigold cultivars in open field condition

Cultivars	No. of primary branches		No. of secondary branches	
	S1	S2	S1	S2
Sonata Orange	6.21	6.80	29.00	23.07
Sonata Yellow	7.78	7.20	24.20	16.20
Biocarve Orange	7.58	6.67	20.50	5.47
Biocarve Yellow	6.29	5.00	11.54	6.47
Local Orange	7.85	8.33	31.04	20.40
Local Yellow	8.13	8.67	29.20	23.53
Sierra Yellow	4.89	6.00	12.89	13.40
Orange Giant	6.79	6.73	36.17	21.87
CD (0.05)	NS		6.04	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 2(d). Effect of seasons on plant characters of African marigold cultivars under rain shelter condition

Cultivars	No. of primary branches		No. of secondary branches	
	S1	S2	S1	S2
Sonata Orange	8.50	7.60	32.88	22.80
Sonata Yellow	9.68	8.27	36.51	23.80
Biocarve Orange	8.58	6.53	25.38	9.87
Biocarve Yellow	5.76	5.60	18.21	6.73
Local Orange	9.99	7.33	39.08	19.00
Local Yellow	8.92	8.53	41.00	19.67
Sierra Yellow	5.96	6.40	22.63	18.20
Orange Giant	8.25	6.73	34.58	17.20
CD (0.05)	NS		4.34	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

significant influence on the number of secondary branches per plant. Better number of secondary branches was noticed in plants grown under rain shelter condition compared to open field condition. Among the cultivars, the cultivar Orange Giant recorded highest number of secondary branches per plant (35.38), regardless of growing conditions. This was followed by Local Yellow (35.10), Local Orange (35.06) and Sonata Orange (30.94) which were on par with Orange Giant. The least number of secondary branches per plant was noticed in cultivar Biocarve Yellow (14.88).

Season II

In the open field condition, highest number of secondary branches per plant was recorded in cultivar Local Yellow (23.53). This was followed by Sonata Orange (23.07) and Orange Giant (21.87) which were statistically on par with Local Yellow. The least number of secondary branches per plant was recorded in Biocarve Orange (5.47) which was on par with Biocarve Yellow (6.47).

Under rain shelter condition, the highest number of secondary branches per plant was observed in cultivar Sonata Yellow (23.80) which was superior to all other cultivars except Sonata Orange (22.80). The number of secondary branches per plant recorded in the cultivars Local Yellow (19.67), Local Orange (19.00), Sierra Yellow (18.20) and Orange Giant (17.20) were on par with one another. Least number of secondary branches per plant was observed in Biocarve Yellow (6.73).

In general, growing condition had a significant influence on the number of secondary branches per plant in all the cultivars evaluated. But, irrespective of cultivars, growing conditions had no significant influence on the number of secondary branches per plant. Among the cultivars, highest number of secondary branches was recorded in Sonata Orange (22.93) regardless of growing conditions. This was followed by Local Yellow (21.60), which was on par with Sonata Orange. Biocarve Yellow recorded the least number of secondary branches per plant (6.60) which was on par with Biocarve Orange (7.67).

4.1.6.1 Effect of Seasons on Number of Secondary Branches

Significant influence of growing seasons on the number of secondary branches per plant could be observed in all the cultivars grown under open field and rain shelter conditions (Table 2(c) and Table 2(d)). In the open field condition, all the cultivars recorded higher number of secondary branches during the first season compared to the second season. Highest number of secondary branches was recorded in cultivar Orange Giant (36.17) grown during the first season (Table 2(c)).

Under rain shelter condition also, plants grown during the first season recorded higher number of secondary branches per plant (Table 2(d)). The cultivar Local Yellow (41.00) grown during first season recorded the highest number of secondary branches per plant.

4.1.7 Leaf Length

The data presented in Table 3(a) and Table 3(b) revealed that the leaf length of the cultivars was significantly influenced by growing conditions during both the seasons.

Season I

Highest leaf length in the open field condition was recorded in Sonata Orange (11.92 cm). This was followed by Local Yellow (11.56 cm), Biocarve Yellow (11.30 cm), Local Orange (10.99 cm), Sierra Yellow (10.39 cm) and Orange Giant (10.27 cm) which were statistically on par with Sonata Orange. The cultivar Sonata Yellow recorded the lowest leaf length (9.38 cm) which was on par with Biocarve Orange (9.86 cm).

Under rain shelter condition, Local Orange recorded the highest leaf length (12.23 cm). The leaf length of the cultivars Sonata Orange (11.36 cm), Sonata Yellow (11.19 cm), Sierra Yellow (11.01 cm) and Orange Giant (10.57 cm) were on par with Local Orange. The least leaf length was observed in Biocarve Yellow

(9.06 cm) which was on par with Local Yellow (9.93 cm) and Biocarve Orange (10.20 cm).

There was no significant difference among the cultivars with regard to leaf length, irrespective of growing conditions. Even though higher leaf length was observed in plants grown in the open field condition, regardless of cultivars, there was no significant difference between the growing conditions on leaf length of the plants. Among the cultivars, Sonata Orange recorded the highest leaf length (11.64 cm), regardless of growing conditions.

Season II

In the open field condition, highest leaf length was recorded in Local Yellow (12.64 cm) which was significantly superior to all other cultivars. The leaf length recorded in the cultivars Local Orange (10.28 cm) and Sonata Orange (10.03 cm) were statistically on par with each other. Lowest leaf length was observed in cultivar Biocarve Yellow (5.85 cm) which was significantly different from all other cultivars.

Under rain shelter condition also the cultivar Local Yellow recorded significantly highest leaf length (12.45 cm). This was followed by Local Orange (9.83 cm). The cultivars Sonata Orange (8.63 cm) and Sonata Yellow (8.56 cm) were performed on par with respect to their leaf length. Biocarve Yellow recorded the least leaf length (5.31 cm) and was significantly different from all other cultivars.

Irrespective of cultivars, significantly highest leaf length was recorded in plants grown in the open field condition compared to rain shelter condition. Regardless of growing conditions, the cultivar Local Yellow recorded significantly highest leaf length (12.55 cm). This was followed by Local Orange (10.06 cm). The least leaf length was recorded in Biocarve Yellow (5.58 cm).

4.1.7.1 Effect of Seasons on Leaf Length

Season had significant influence on the leaf length of all the cultivars grown in the open field and rain shelter conditions (Table 3(c) and Table 3(d)). In the open field condition, higher leaf length in most of the cultivars was recorded during the first season. Highest leaf length was recorded in cultivar Local Yellow (12.64 cm) grown during the second season (Table 3(c)).

Under rain shelter condition also most of the cultivars recorded higher leaf length during the first season compared to the second season. Among all the cultivars, Local Yellow (12.45) grown during second season recorded the highest leaf length (Table 3(d)).

4.1.8 Leaf Breadth

Data pertaining to the leaf breadth of plants, grown under the two growing conditions during both the seasons are presented in Table 3(a) and Table 3(b).

Season I

The growing condition had no significant influence on the leaf breadth of the cultivars. But there was significant difference between the cultivar means and growing condition means. The plants in the open field condition recorded higher leaf breadth compared rain shelter condition, regardless of cultivars. Among the cultivars, Local Orange (6.56 cm) recorded highest leaf breadth irrespective of growing conditions. This was followed by Local Yellow (5.81 cm) which was on par with Local Orange. The cultivar Orange Giant (4.33 cm) recorded the least leaf breadth which was on par with Biocarve Orange (4.67 cm), Sonata Orange (4.69 cm) and Sonata Yellow (5.13 cm).

Season II

Highest leaf breadth in open field condition was noticed in cultivar Local Yellow (5.04 cm). This was closely followed by Sonata Yellow (5.02 cm) and Sonata Orange (4.98 cm) which were on par with Local Yellow. The leaf breadth

recorded in the cultivars Local Orange (4.66 cm) and Orange Giant (4.41 cm) were statistically on par. The cultivar Biocarve Orange recorded lowest leaf breadth (3.18 cm).

Under rain shelter condition, Sonata Yellow recorded highest leaf breadth (5.27 cm) and was significantly superior to all other cultivars. This was followed by Local Yellow (4.94 cm). The cultivars Local Orange and Orange Giant recorded the same leaf breadth (4.51 cm). The least leaf breadth was observed in Biocarve Orange (3.60 cm) which was statistically on par with Biocarve Yellow (3.63 cm).

It can be concluded that, a significant influence of growing conditions on leaf breadth of all the cultivars was observed during the second season. Irrespective of cultivars, growing condition had no significant influence on the leaf breadth of the plants. Among the cultivars Sonata Yellow (5.14 cm) recorded the highest leaf breadth, regardless of growing conditions. This was followed by Local Yellow (4.99 cm) which was on par with Sonata Yellow. The cultivar Biocarve Orange recorded the least leaf breadth (3.39 cm) which was significantly different from all others.

4.1.8.1 Effect of Seasons on Leaf Breadth

The leaf breadth of all the cultivars were significantly influenced by the seasons both under open field and rain shelter conditions (Table 3(c) and Table 3(d)). In general, the plants grown during first season recorded higher leaf breadth in the open field condition (Table 3(c)). Highest leaf breadth in the open field condition was noticed in cultivar Local Yellow (6.39 cm) grown during the first season.

Under rain shelter condition also, higher leaf breadth was observed in plants grown during the first season. The cultivar Local Orange (7.12 cm) grown during first season recorded the highest leaf breadth among all other cultivars (Table 3(d)).

Table 3(a). Effect of growing conditions on leaf characters in African marigold cultivars during first season (July – November)

Cultivars	Leaf length (cm)			Leaf breadth (cm)			Leaf area (cm^2)			Petiole length (cm)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	11.92	11.36	11.64	5.16	4.22	4.69	13.52	10.65	12.09	1.74	1.65	1.69
Sonata Yellow	9.38	11.19	10.29	5.18	5.07	5.13	10.69	12.51	11.60	0.91	1.26	1.09
Biocarve Orange	9.86	10.20	10.03	4.90	4.44	4.67	10.79	10.04	10.42	1.33	1.34	1.33
Biocarve Yellow	11.30	9.06	10.18	5.54	4.84	5.19	13.78	9.68	11.73	1.80	1.14	1.47
Local Orange	10.99	12.23	11.61	6.00	7.12	6.56	14.54	19.20	16.87	1.39	1.11	1.25
Local Yellow	11.56	9.93	10.74	6.39	5.22	5.81	16.72	11.42	14.07	1.40	1.12	1.26
Sierra Yellow	10.39	11.01	10.70	5.43	5.00	5.22	12.40	12.20	12.30	1.39	1.50	1.44
Orange Giant	10.27	10.57	10.42	4.70	3.95	4.33	10.84	9.25	10.05	1.42	1.44	1.43
Mean	10.71	10.69		5.42	4.98		12.91	11.87		1.42	1.32	
CD (0.05) (Cultivars)	NS			0.85			3.27			0.26		
CD (0.05) (Growing conditions)	NS			0.43			NS			NS		
CD (0.05) (Interaction)	1.66			NS			NS			0.36		

G1 – Open field condition G2 – Rain shelter condition

Table 3(b). Effect of growing conditions on leaf characters in African marigold cultivars during second season (January – April)

Cultivars	Leaf length (cm)			Leaf breadth (cm)			Leaf area (cm^2)			Petiole length (cm)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	10.03	8.63	9.33	4.98	3.89	4.43	10.99	7.38	9.18	1.33	1.12	1.22
Sonata Yellow	8.39	8.56	8.48	5.02	5.27	5.14	9.26	9.92	9.59	1.09	1.16	1.13
Biocarve Orange	6.40	5.94	6.17	3.18	3.60	3.39	4.48	4.68	4.58	1.19	1.18	1.19
Biocarve Yellow	5.85	5.31	5.58	3.63	3.63	3.63	4.67	4.24	4.45	1.22	1.23	1.22
Local Orange	10.28	9.83	10.06	4.66	4.51	4.59	10.55	9.76	10.15	1.55	1.28	1.41
Local Yellow	12.64	12.45	12.55	5.04	4.94	4.99	14.03	13.55	13.79	1.41	1.19	1.30
Sierra Yellow	7.95	7.93	7.94	3.64	3.93	3.79	6.37	6.86	6.62	0.94	1.05	1.00
Orange Giant	7.70	8.21	7.95	4.41	4.51	4.46	7.47	8.15	7.81	1.11	1.17	1.14
Mean	8.66	8.36		4.32	4.29		8.48	8.07		1.23	1.17	
CD (0.05) (Cultivars)	0.22			0.22			0.45			0.06		
CD (0.05) (Growing conditions)	0.11			NS			0.23			0.03		
CD (0.05) (Interaction)	0.30			0.31			0.64			0.08		

G1 – Open field condition G2 – Rain shelter condition

Table 3(c). Effect of seasons on leaf characters of African marigold cultivars in open field condition

Cultivars	Leaf length (cm)		Leaf breadth (cm)	
	S1	S2	S1	S2
Sonata Orange	11.92	10.03	5.16	4.98
Sonata Yellow	9.38	8.39	5.18	5.02
Biocarve Orange	9.86	6.40	4.90	3.18
Biocarve Yellow	11.30	5.85	5.54	3.63
Local Orange	10.99	10.28	6.00	4.66
Local Yellow	11.56	12.64	6.39	5.04
Sierra Yellow	10.39	7.95	5.43	3.64
Orange Giant	10.27	7.70	4.70	4.41
CD (0.05)	1.49		1.00	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 3(d). Effect of seasons on leaf characters of African marigold cultivars under rain shelter condition

Cultivars	Leaf length (cm)		Leaf breadth (cm)	
	S1	S2	S1	S2
Sonata Orange	11.36	8.63	4.22	3.89
Sonata Yellow	11.19	8.56	5.07	5.27
Biocarve Orange	10.20	5.94	4.44	3.60
Biocarve Yellow	9.06	5.31	4.84	3.63
Local Orange	12.23	9.83	7.12	4.51
Local Yellow	9.93	12.45	5.22	4.94
Sierra Yellow	11.01	7.93	5.00	3.93
Orange Giant	10.57	8.21	3.95	4.51
CD (0.05)	0.84		0.69	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

4.1.9 Leaf Area

Data pertaining to leaf area of the cultivars grown under open field and rain shelter conditions during the two seasons are presented in Table 3(a) and Table 3(b).

Season I

The growing condition had no significant influence on the leaf area of the cultivars since the interaction effect was not significant. Even though the plants grown in open field condition recorded higher leaf area compared to rain shelter grown plants, regardless of cultivars, there was no significant difference between the growing conditions with regard to leaf area. Irrespective of growing conditions, the cultivar Local Orange (16.87 cm^2) recorded the highest leaf area. This was followed by Local Yellow (14.07 cm^2) which was on par with Local Orange. Among the cultivars, Orange Giant (10.05 cm^2) recorded the least leaf area.

Season II

The cultivar Local Yellow recorded significantly highest leaf area (14.03 cm^2) in the open field condition and was superior to all other cultivars. This was followed by Sonata Orange (10.99 cm^2) and Local Orange (10.55 cm^2) which were on par with each other. Least leaf area was noticed in Biocarve Orange (4.48 cm^2) which was on par with Biocarve Yellow (4.67 cm^2).

The cultivar Local Yellow recorded significantly highest leaf area (13.55 cm^2) under rain shelter condition also. The leaf area observed in the cultivars Sonata Yellow (9.92 cm^2) and Local Orange (9.76 cm^2) were on par with each other. Lowest leaf area was observed in cultivar Biocarve Yellow (4.24 cm^2) which was statistically on par with Biocarve Orange (4.68 cm^2).

Irrespective of cultivars, significantly higher leaf area was observed in the open field condition rather than rain shelter condition. Among the cultivars, Local Yellow recorded the highest leaf area (13.79 cm^2) regardless of growing conditions, which was followed by Local Orange (10.15 cm^2). The cultivar

Biocarve Yellow recorded the least leaf area (4.45 cm^2) which was on par with Biocarve Orange (4.58 cm^2).

4.1.9.1 Effect of Seasons on Leaf Area

In the open field condition, the season had no significant influence on the leaf area of the cultivars (Table 3(e)). But, the leaf area of the cultivars grown under rain shelter condition was significantly influenced by the growing seasons (Table 3(f)). In the open field condition, highest leaf area was observed in cultivar Local Yellow (16.72 cm^2) grown during the first season.

Under rain shelter condition also, most of the cultivars recorded higher leaf area during the first season compared to the second season. Highest leaf area was recorded in cultivar Local Orange (19.20 cm^2) grown during the first season (Table 3(f)).

4.1.10 Petiole Length

Data pertaining to petiole length of different cultivars grown during first season are presented in Table 3(a) and that of second season are presented in Table 3(b).

Season I

In the open field condition, highest petiole length was recorded in Biocarve Yellow (1.80 cm) which was significantly superior to all other cultivars except Sonata Orange (1.74 cm). The petiole length recorded in the cultivars Orange Giant, Local Yellow, Local Orange, Sierra Yellow and Biocarve Orange were 1.42 cm, 1.40 cm, 1.39 cm, 1.39 cm and 1.33 cm respectively, which were statistically on par with one another. Lowest petiole length was noticed in cultivar Sonata Yellow (0.91 cm) which was significantly different from all other cultivars.

Sonata Orange recorded the highest petiole length (1.65 cm) under rain shelter condition among all the cultivars. This was followed by Sierra Yellow (1.50 cm), Orange Giant (1.44 cm) and Biocarve Orange (1.34 cm) which were

statistically on par with Sonata Orange. The least petiole length was noticed in cultivar Local Orange (1.11 cm) which was on par with Local Yellow (1.12 cm), Biocarve Yellow (1.14 cm) and Sonata Yellow (1.26 cm).

It could be seen that the growing condition exerted significant influence on petiole length of all the cultivars evaluated. Even though there was no significant difference between the growing conditions with regard to petiole length, better petiole length was observed in the open field condition compared to rain shelter condition. Irrespective of growing conditions, Sonata Orange recorded the highest petiole length (1.69 cm). This was followed by Biocarve Yellow (1.47 cm), Sierra Yellow (1.44 cm) and Orange Giant (1.43 cm) which were on par with Sonata Orange. The cultivar Sonata Yellow (1.09 cm) recorded the least petiole length which was on par with Local Orange (1.25 cm), Local Yellow (1.26 cm) and Biocarve Orange (1.33 cm).

Season II

Highest petiole length in the open field condition was observed in Local Orange (1.55 cm) which was significantly superior to all other cultivars. This was followed by Local Yellow (1.41 cm) and Sonata Orange (1.33 cm) which were on par with each other. The petiole length recorded in the cultivars Biocarve Yellow (1.22 cm) and Biocarve Orange (1.19 cm) were on par with each other. The cultivar Sierra Yellow recorded the least petiole length (0.94 cm) which was significantly different from all other cultivars.

Under rain shelter condition, highest petiole length was observed in the cultivar Local Orange (1.28 cm). This was followed by Biocarve Yellow (1.23 cm) which was on par with Local Orange. The petiole length recorded in the cultivars Local Yellow (1.19 cm), Biocarve Orange (1.18 cm), Orange Giant (1.17 cm) and Sonata Yellow (1.16 cm) were statistically on par with one another. Least petiole length was noticed in cultivar Sierra Yellow (1.05 cm) which was on par with Sonata Orange (1.12 cm).

Table 3(e). Effect of seasons on leaf characters of African marigold cultivars in open field condition

Cultivars	Leaf area (cm^2)		Petiole length (cm)	
	S1	S2	S1	S2
Sonata Orange	13.52	10.99	1.74	1.33
Sonata Yellow	10.69	9.26	0.91	1.09
Biocarve Orange	10.79	4.48	1.33	1.19
Biocarve Yellow	13.78	4.67	1.80	1.22
Local Orange	14.54	10.55	1.39	1.55
Local Yellow	16.72	14.03	1.40	1.41
Sierra Yellow	12.40	6.37	1.39	0.94
Orange Giant	10.84	7.47	1.42	1.11
CD (0.05)	NS		0.23	

S1 –1st season (July – November) S2 – 2nd season (January – April)

Table 3(f). Effect of seasons on leaf characters of African marigold cultivars under rain shelter condition

Cultivars	Leaf area (cm^2)		Petiole length (cm)	
	S1	S2	S1	S2
Sonata Orange	10.65	7.38	1.65	1.12
Sonata Yellow	12.51	9.92	1.26	1.16
Biocarve Orange	10.04	4.68	1.34	1.18
Biocarve Yellow	9.68	4.24	1.14	1.23
Local Orange	19.20	9.76	1.11	1.28
Local Yellow	11.42	13.55	1.12	1.19
Sierra Yellow	12.20	6.86	1.50	1.05
Orange Giant	9.25	8.15	1.44	1.17
CD (0.05)	2.34		0.26	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

It is evident from the data that significant difference in petiole length was observed among cultivars with respect to the growing conditions. Irrespective of cultivars, significantly higher petiole length was observed in the open field condition compared to rain shelter condition. Regardless of growing conditions, Local Orange recorded significantly highest petiole length (1.41 cm). The cultivar Sierra Yellow recorded the least petiole length (1.00 cm).

4.1.10.1 Effect of Seasons on Petiole Length

Data presented in Table 3(e) and Table 3(f) revealed that the seasons have a significant influence on petiole length of the cultivars in the open field and rain shelter conditions. In general, the plants grown during first season recorded higher petiole length than the plants grown during second season, in the open field condition (Table 3(e)). Biocarve Yellow grown during first season recorded the highest petiole length (1.80 cm).

Under rain shelter condition also, plants grown during the first season recorded higher petiole length (Table 3(f)). Highest petiole length was recorded in the cultivar Sonata Orange (1.65 cm) grown during first season.

4.1.11 Leaf Colour

Data presented in Table 3(g) shows the variation in leaf colour of all the cultivars grown in the open field and rain shelter conditions during both the seasons. The leaf colour of the cultivars varied from light green to dark green colour under open field and rain shelter conditions during both the growing seasons.

4.1.12 Crop Duration

Data pertaining to the crop duration of the cultivars grown under open field and rain shelter conditions during the two seasons are presented in Table 3(h) and Table 3(i).

Season I

During first season, greater crop duration was observed in all the cultivars grown under rain shelter condition compared to the open field condition. Among the cultivars, Orange Giant grown under rain shelter condition recorded the highest crop duration (123.58 days) during first season (Table 3(h) and Table 3(i)).

Season II

During second season, most of the cultivars recorded higher crop duration when grown under rain shelter condition compared to open field condition. The cultivar Local Yellow grown under rain shelter condition recorded the highest crop duration (106.67 days) among all other cultivars during second season (Table 3(h) and Table 3(i)).

4.1.12.1 Effect of Seasons on Crop Duration

The cultivars in general recorded more crop duration during the first season compared to second season under both the growing conditions. During second season, the cultivars completed their growth within a short duration. In the open field condition, highest crop duration was recorded in cultivar Sonata Orange grown during first season. Highest crop duration under rain shelter condition was recorded in Orange Giant grown during first season.

4.1.13 Incidence of Pests and Diseases

Season I

The plants in the open field condition were affected with termites during the first season, while under rain shelter condition all the plants were found free of termite attack. The termite attack was prevalent during the establishment stage of the transplanted seedlings.

Symptoms: A complete wilting of the affected plants was first noticed in the field. The basal portion of the seedling plants was eaten away by the termites. As a

Table 3(g). Effect of growing conditions on leaf colour of African marigold cultivars during the two seasons

Cultivars	Leaf colour			
	Season I (July – November)		Season II (December – April)	
	Open field	Rain shelter	Open field	Rain shelter
Sonata Orange	Green	Dark green	Dark green	Dark green
Sonata Yellow	Dark green	Green	Green	Green
Biocarve Orange	Green	Green	Light green	Light green
Biocarve Yellow	Green	Green	Light green	Light green
Local Orange	Light green	Light green	Green	Dark green
Local Yellow	Light green	Green	Green	Green
Sierra Yellow	Green	Green	Green	Green
Orange Giant	Green	Dark green	Dark green	Dark green

Table 3(h). Crop duration of African marigold cultivars grown in the open field condition during the two seasons

Cultivars	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sonata Orange												
Sonata Yellow												
Biocarve Orange												
Biocarve Yellow												
Local Orange												
Local Yellow												
Sierra Yellow												
Orange Giant												

Crop duration during first season (July –November) Crop duration during second season (January–April)

Table 3(i). Crop duration of African marigold cultivars grown under rain shelter condition during the two seasons

Cultivars	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sonata Orange												
Sonata Yellow												
Biocarve Orange												
Biocarve Yellow												
Local Orange												
Local Yellow												
Sierra Yellow												
Orange Giant												

Crop duration during first season (July –November) Crop duration during second season (January–April)

result, the seedlings when pulled out came out easily from the soil. The presence of the pest was observed in soil surrounding the basal region of the plant.

Control: Soil drenching was done with Chlorpyriphos (Radar 20 EC) at the rate of 2.5ml/L of water at one week interval and further attack of the pest was controlled.

A few plants of the cultivar Local Orange under rain shelter condition were attacked by thrips.

Symptoms: The upward curling of the leaves was noticed in the affected plants. The growth of the plants reduced.

Control: Spraying of the plants with Quinalphos (Ekalux 25 EC) at the rate of 2ml/L of water was done in order to control the pest.

Some minor pests like plant hoppers (Fulgoridae), long horned grass hoppers and beetles were also noticed during the first season.

A major problem resulted in destruction of many plants in the field was the incidence of bacterial wilt. The disease incidence was started one month after transplanting of plants, before the commencement of flowering. The incidence of the disease was first noticed in the open field plants and was a serious problem in the open field. While under rain shelter condition only a few plants got affected.

Symptoms: At the beginning only a branch of the plant started wilting but the complete wilting of the plants was observed by the next day. The affected plants were pulled out from the beds and subjected to the ooze test. Bacterial ooze came out from the cut stem, thus confirmed bacterial infection.

Control: As a primary control measure, soil drenching was carried out using Kocide (DuPont Kocide 2000) at the rate of 2g/L of water, application was repeated at fortnightly intervals. The beds were also alternately drenched with COC (3g/L). Cloth bags containing bleaching powder were put in the channels between the beds to avoid infection through the irrigation water. Since the

Thrips attack

Plant hopper (Fulgoridae)

Long horned grasshopper

Beetle

Plate 7. Incidence of pests

Fungal infection in flower

Flower rot

Bacterial wilt

Plate 8. Incidence of diseases

complete control of the disease was not ensured another application with Streptocyclin (Tagmycin) at the rate of 3g/10L of water was given and thus the disease spread was completely controlled.

Season II

During the second season, Streptocyclin (3g/10L of water) was applied in the field as a prophylactic control measure against bacterial wilt. A little incidence of bacterial wilt was noticed in the field during second season also. But, the spread of the disease was less when compared to the first season. In general, the incidence of pests and diseases was found less under rain shelter condition compared to the open field condition.

4.2 FLORAL CHARACTERS

Data pertaining to various floral characters in open field and rain shelter were statistically analysed and presented in Table 4(a) to Table 6(i).

4.2.1 Days to First Flowering

Data on days to first flowering of plants grown under open field and rain shelter conditions during both the seasons are presented in Tables 4(a) and 4(b).

Season I

The data presented in Table 4(a) shows that the cultivar Biocarve Orange took the least number of days to first flowering (44.42 days) in the open field condition, which was significantly different from all other cultivars. This was followed by Biocarve Yellow (48.00 days). The cultivar Local Yellow took significantly highest number of days (76.08 days) for first flowering, among all the cultivars.

Under rain shelter condition, earliest flowering was observed in cultivar Biocarve Orange (43.42 days) followed by Biocarve Yellow (46.50 days). The number of days for first flowering recorded in the cultivars Sonata Orange (55.75 days), Local Orange (54.92 days) and Orange Giant (54.75 days) were statistically

on par with one another. Local Yellow took significantly highest number days (71.83 days) for first flowering, among all the cultivars.

Hence, the growing conditions significantly influenced the number of days for first flowering in the cultivars evaluated. Irrespective of cultivars, there was significant difference between the number of days taken for first flowering, in plants grown under open field and rain shelter conditions. The plants under rain shelter condition took less number of days for first flowering compared to open field condition. Among the cultivars, Biocarve Orange (43.92 days) flowered earlier, regardless of growing conditions. The cultivar Local Yellow took significantly highest number of days for first flowering (73.96 days).

Season II

In the open field condition, the cultivar Biocarve Yellow took the least number of days for first flowering (33.93 days), which was significantly different from all other cultivars. This was followed by Biocarve Orange (37.07 days) and Sonata Orange (43.87 days). The number of days for first flowering recorded in the cultivars Sonata Yellow (48.53 days) and Orange Giant (48.87 days) were on par with each other. However, significantly highest number of days for first flowering was observed in cultivar Local Orange (60.33 days).

Under rain shelter condition also the cultivar Biocarve Yellow took the least number of days for first flowering (30.67 days), which was significantly different from all other cultivars. This was followed by Biocarve Orange (33.47 days). More number of days for first flowering under rain shelter condition also was observed in cultivar Local Orange (55.26 days) which was significantly higher than all other cultivars.

The mean number of days taken for first flowering of plants grown in the open field condition was significantly higher compared to the rain shelter condition, regardless of cultivars. Among the cultivars, Biocarve Yellow recorded least number of days for first flowering (32.30 days) whereas Local Orange (57.80

days) recorded more number of days for first flowering, irrespective of growing conditions, which were significantly different from all other cultivars.

4.2.1.1 Effect of Seasons on Days to First Flowering

The seasons have significant influence on days to first flowering in all the cultivars under the two growing conditions (Table 4(c) and Table 4(d)). All the cultivars took lesser number of days for first flowering during second season compared to first season in the open field condition (Table 4(c)). The cultivar Biocarve Yellow grown during second season flowered in least number of days (33.93 days), among all the cultivars.

Under rain shelter condition, all the cultivars except Local Orange took lesser number of days for first flowering when grown during the second season (Table 4(d)). Among the cultivars, Biocarve Yellow grown during second season recorded the least number of days for first flowering (30.67 days).

4.2.2 Days to 50 per cent Flowering

Data on days for 50 per cent flowering recorded from all the cultivars under open field and rain shelter conditions during the two seasons are presented in Table 4(a) and Table 4(b).

Season I

In the open field condition, Biocarve Orange recorded least number of days for 50 per cent flowering (52.92 days). The cultivar Biocarve Yellow took 56.33 days which was on par with Biocarve Orange. Significantly highest number of days for 50 per cent flowering was observed in cultivar Local Yellow (86.58 days).

The cultivar Biocarve Orange took the least number of days for 50 per cent flowering (59.25 days) under rain shelter condition which was statistically on par with Biocarve Yellow (61.58 days). The number of days for 50 per cent flowering observed in the cultivars Orange Giant (65.67 days), Sonata Yellow (65.83 days) and Local Orange (68.75 days) were on par with one another. Significantly highest

Table 4(a). Effect of growing conditions on days to flowering in African marigold cultivars during first season (July – November)

Cultivars	Days to first flowering (days)			Days to 50% flowering (days)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	57.42	55.75	56.58	68.75	73.17	70.96
Sonata Yellow	51.83	51.42	51.63	65.00	65.83	65.42
Biocarve Orange	44.42	43.42	43.92	52.92	59.25	56.08
Biocarve Yellow	48.00	46.50	47.25	56.33	61.58	58.96
Local Orange	72.48	54.92	63.70	82.95	68.75	75.85
Local Yellow	76.08	71.83	73.96	86.58	80.75	83.67
Sierra Yellow	54.50	53.25	53.88	67.17	70.17	68.67
Orange Giant	57.92	54.75	56.33	73.08	65.67	69.38
Mean	57.83	53.98		69.10	68.15	
CD (0.05) (Cultivars)	1.66			2.41		
CD (0.05) (Growing conditions)	0.83			NS		
CD (0.05) (Interaction)	2.34			3.41		

G1 – Open field condition G2 – Rain shelter condition

Table 4(b). Effect of growing conditions on days to flowering in African marigold cultivars during second season (January – April)

Cultivars	Days to first flowering (days)			Days to 50% flowering (days)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	43.87	40.87	42.37	50.20	48.40	49.30
Sonata Yellow	48.53	42.86	45.70	57.07	46.93	52.00
Biocarve Orange	37.07	33.47	35.27	43.13	38.33	40.73
Biocarve Yellow	33.93	30.67	32.30	39.07	36.60	37.83
Local Orange	60.33	55.26	57.80	72.40	66.47	69.43
Local Yellow	59.80	54.07	56.93	69.47	64.87	67.17
Sierra Yellow	46.73	42.87	44.80	55.20	50.27	52.73
Orange Giant	48.87	44.80	46.83	55.53	52.26	53.90
Mean	47.39	43.11		55.26	50.52	
CD (0.05) (Cultivars)	0.69			1.76		
CD (0.05) (Growing conditions)	0.35			0.88		
CD (0.05) (Interaction)	0.98			2.48		

G1 – Open field condition G2 – Rain shelter condition

Table 4(c). Effect of seasons on days to flowering of African marigold cultivars in open field condition

Cultivars	Days to first flowering (days)		Days to 50% flowering (days)	
	S1	S2	S1	S2
Sonata Orange	57.42	43.87	68.75	50.20
Sonata Yellow	51.83	48.53	65.00	57.07
Biocarve Orange	44.42	37.07	52.92	43.13
Biocarve Yellow	48.00	33.93	56.33	39.07
Local Orange	72.48	60.33	82.95	72.40
Local Yellow	76.08	59.80	86.58	69.47
Sierra Yellow	54.50	46.73	67.17	55.20
Orange Giant	57.92	48.87	73.08	55.53
CD (0.05)	2.02		2.71	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 4(d). Effect of seasons on days to flowering of African marigold cultivars under rain shelter condition

Cultivars	Days to first flowering (days)		Days to 50% flowering (days)	
	S1	S2	S1	S2
Sonata Orange	55.75	40.87	73.17	48.40
Sonata Yellow	51.42	42.86	65.83	46.93
Biocarve Orange	43.42	33.47	59.25	38.33
Biocarve Yellow	46.50	30.67	61.58	36.60
Local Orange	54.92	55.26	68.75	66.47
Local Yellow	71.83	54.07	80.75	64.87
Sierra Yellow	53.25	42.87	70.17	50.27
Orange Giant	54.75	44.80	65.67	52.26
CD (0.05)	1.47		3.34	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

number of days for 50 per cent flowering was observed in cultivar Local Yellow (80.75 days).

In general, the days for 50 per cent flowering in all the cultivars were significantly influenced by the growing conditions. Even though lesser number of days for 50 per cent flowering was recorded under rain shelter condition compared to open field condition, regardless of cultivars, there was no significant difference. Irrespective of growing conditions, Biocarve Orange took the least number of days for 50 per cent flowering (56.08 days) which was significantly different from all other cultivars. Significantly highest number of days for 50 per cent flowering was recorded in cultivar Local Yellow (83.67 days).

Season II

In the open field condition, Biocarve Yellow took the least number of days for 50 per cent flowering (39.07 days) which was significantly different from all other cultivars. This was followed by Biocarve Orange (43.13 days). The number of days for 50 per cent flowering recorded in cultivar Local Yellow was 69.47 days. The cultivar Local Orange recorded the highest number of days for 50 per cent flowering (72.40 days) among all the cultivars.

Under rain shelter condition, Biocarve Yellow recorded the least number of days for 50 per cent flowering (36.60 days) which was on par with Biocarve Orange (38.33 days). Highest number of days to 50 per cent flowering was observed in cultivar Local Orange (66.47 days), which was on par with Local Yellow (64.87 days).

Significant difference was observed among cultivars with respect to the number of days for 50 per cent flowering under different growing conditions. Regardless of cultivars, the plants grown under rain shelter condition took lesser number of days for 50 per cent flowering, which was significantly different from the open field condition. Irrespective of growing conditions, the cultivar Biocarve Yellow recorded the least number of days for 50 per cent flowering (37.83 days).

Significantly highest number of days for 50 per cent flowering was recorded in cultivar Local Orange (69.43 days).

4.2.2.1 Effect of Seasons on Days to 50 per cent Flowering

The days for 50 per cent flowering in all the cultivars were significantly influenced by the seasons under both growing conditions (Table 4(c) and 4(d)). In the open field condition, all the cultivars grown during second season took lesser number of days for 50 per cent flowering compared to the first season (Table 4(c)). The cultivar Biocarve Yellow (39.07 days) grown during second season recorded the least number of days for 50 per cent flowering among all the cultivars.

Under rain shelter condition also all the cultivars grown during second season took lesser number of days for 50 per cent flowering compared to first season. Among the cultivars, Biocarve Yellow grown during second season recorded the least number of days (36.60 days) for 50 per cent flowering (Table 4(d)).

4.2.3 Flower Diameter

Data pertaining to flower diameter of the cultivars during first season are presented in Table 5(a) and that of second season are presented in Table 5(b).

Season I

In the open field condition, Orange Giant recorded the highest flower diameter (6.74 cm) which was significantly superior to all other cultivars except Local Yellow (6.05 cm). The flower diameter recorded in the cultivars Local Orange (5.68 cm), Sonata Orange (5.67 cm) and Sonata Yellow (5.40 cm) were on par with one another. Least flower diameter was observed in cultivar Biocarve Orange (4.29 cm) which was statistically on par with Biocarve Yellow (4.59 cm) and Sierra Yellow (4.65 cm).

Highest flower diameter under rain shelter condition was recorded in Sonata Orange (6.87 cm). This was followed by Orange Giant (6.38 cm) and Sonata

Yellow (6.09 cm) which were on par with Sonata Orange. The least flower diameter was recorded in Local Orange (4.70 cm), which was on par with Biocarve Orange (4.73 cm), Biocarve Yellow (4.84 cm) and Sierra Yellow (4.86 cm).

The cultivars in general had a differential performance with respect to growing conditions, as the interaction effect was significant for flower diameter. Even though, the growing conditions had no significant influence on the flower diameter, the plants recorded higher flower diameter when grown under rain shelter condition compared to the open field condition. Among the cultivars, Orange Giant recorded highest flower diameter (6.56 cm) irrespective of growing conditions. This was followed by Sonata Orange (6.27 cm) and Local Yellow (5.98 cm) which were on par with Orange Giant. Least flower diameter was recorded in Biocarve Orange (4.51 cm) which was on par with Biocarve Yellow (4.72 cm) and Sierra Yellow (4.76 cm).

Season II

Highest flower diameter in the open field condition was noticed in Sonata Yellow (4.49 cm). The flower diameter of Sonata Orange (4.26 cm) and Orange Giant (4.20 cm) were on par with Sonata Yellow. Biocarve Yellow recorded the least flower diameter (3.24 cm) which was on par with Biocarve Orange (3.50 cm).

Under rain shelter condition, Sonata Yellow recorded the highest flower diameter (4.76 cm). This was followed by Orange Giant (4.37 cm), Sonata Orange (4.31 cm) and Sierra Yellow (4.27 cm) which were on par with one another. Biocarve Orange recorded the least flower diameter (3.92 cm) and was statistically on par with Biocarve Yellow (3.94 cm), Local Orange (3.95 cm) and Local Yellow (4.06 cm).

Flower diameter of all the cultivars was significantly influenced by the growing conditions. Significantly higher flower diameter was recorded under rain shelter condition, irrespective of the cultivars. Regardless of growing conditions, the cultivar Sonata Yellow recorded significantly highest flower diameter (4.63

cm). Least flower diameter was recorded in cultivar Biocarve Yellow (3.59 cm) which was on par with Biocarve Orange (3.71 cm).

4.2.3.1 Effect of Seasons on Flower Diameter

The flower diameter recorded in all the cultivars was significantly influenced by the seasons under both open field and rain shelter conditions (Table 5(c) and Table 5(d)). In general, better flower diameter was recorded in the plants grown during first season compared to second season, in the open field condition (Table 5(c)). Highest flower diameter was recorded in the cultivar Orange Giant (6.74 cm) grown during the first season.

Under rain shelter condition also greater flower diameter in all the cultivars was recorded during the first season (Table 5(d)). The cultivar Sonata Orange grown during first season recorded the highest flower diameter (6.87 cm) followed by Orange Giant (6.38 cm) grown during the same season.

4.2.4 Flower Length

Data pertaining to flower length of the cultivars grown under open field and rain shelter conditions, during the two seasons are presented in Table 5(a) and Table 5(b).

Season I

During first season, growing condition had no significant influence on the flower length of the cultivars, since there was no significant interaction effect. Even though there was no significant difference between the growing conditions, more flower length was achieved by plants grown in open field condition rather than rain shelter condition, regardless of cultivars. Irrespective of growing conditions, highest flower length was recorded in cultivar Orange Giant (11.30 cm). This was followed by Sonata Orange (11.22 cm) and Sierra Yellow (10.94 cm) which were on par with Orange Giant. The cultivar Biocarve Yellow recorded the least flower length (6.37 cm) which was on par with Biocarve Orange (7.12 cm).

Table 5(a). Effect of growing conditions on floral characters in African marigold cultivars during first season (July – November)

Cultivars	Flower diameter (cm)			Flower length (cm)			Pedicel length (cm)			Individual flower weight (g)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	5.67	6.87	6.27	11.27	11.18	11.22	7.73	7.61	7.67	7.63	12.09	9.86
Sonata Yellow	5.40	6.09	5.74	8.83	8.13	8.48	4.48	3.84	4.16	10.01	11.89	10.95
Biocarve Orange	4.29	4.73	4.51	7.29	6.96	7.12	4.16	3.81	3.98	4.43	4.63	4.53
Biocarve Yellow	4.59	4.84	4.72	6.49	6.24	6.37	3.58	3.22	3.40	3.58	4.77	4.18
Local Orange	5.68	4.70	5.19	9.48	9.35	9.41	5.92	5.93	5.93	8.79	6.07	7.43
Local Yellow	6.05	5.91	5.98	8.72	7.54	8.13	5.14	4.02	4.58	5.72	12.07	8.89
Sierra Yellow	4.65	4.86	4.76	10.65	11.23	10.94	7.73	8.20	7.96	5.28	6.15	5.72
Orange Giant	6.74	6.38	6.56	11.67	10.93	11.30	7.97	7.59	7.78	12.21	12.37	12.29
Mean	5.38	5.55		9.30	8.94		5.84	5.53		7.21	8.76	
CD (0.05) (Cultivars)	0.58			0.95			0.92			0.48		
CD (0.05) (Growing conditions)	NS			NS			NS			0.24		
CD (0.05) (Interaction)	0.83			NS			NS			0.68		

G1 – Open field condition G2 – Rain shelter condition

Table 5(b). Effect of growing conditions on floral characters in African marigold cultivars during second season (January – April)

Cultivars	Flower diameter (cm)			Flower length (cm)			Pedicel length (cm)			Individual flower weight (g)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	4.26	4.31	4.28	7.25	6.95	7.10	4.11	3.74	3.93	2.27	2.71	2.49
Sonata Yellow	4.49	4.76	4.63	6.73	7.34	7.04	3.51	4.10	3.80	3.35	3.79	3.57
Biocarve Orange	3.50	3.92	3.71	6.97	6.33	6.65	3.89	3.18	3.54	1.70	1.42	1.56
Biocarve Yellow	3.24	3.94	3.59	6.75	6.01	6.38	3.55	2.78	3.16	1.99	2.11	2.05
Local Orange	4.10	3.95	4.03	5.92	6.78	6.35	3.19	3.74	3.46	2.87	3.05	2.96
Local Yellow	3.71	4.06	3.89	5.29	6.53	5.91	2.34	3.48	2.91	3.04	3.06	3.05
Sierra Yellow	4.13	4.27	4.20	7.03	7.07	7.05	4.05	3.89	3.97	2.72	2.77	2.74
Orange Giant	4.20	4.37	4.29	6.84	6.90	6.87	3.72	3.78	3.75	3.40	3.61	3.50
Mean	3.96	4.20		6.60	6.74		3.54	3.59		2.67	2.82	
CD (0.05) (Cultivars)	0.21			0.37			0.35			0.18		
CD (0.05) (Growing conditions)	0.11			NS			NS			0.09		
CD (0.05) (Interaction)	0.30			0.53			0.49			0.25		

G1 – Open field condition G2 – Rain shelter condition

Table 5(c). Effect of seasons on floral characters of African marigold cultivars in open field condition

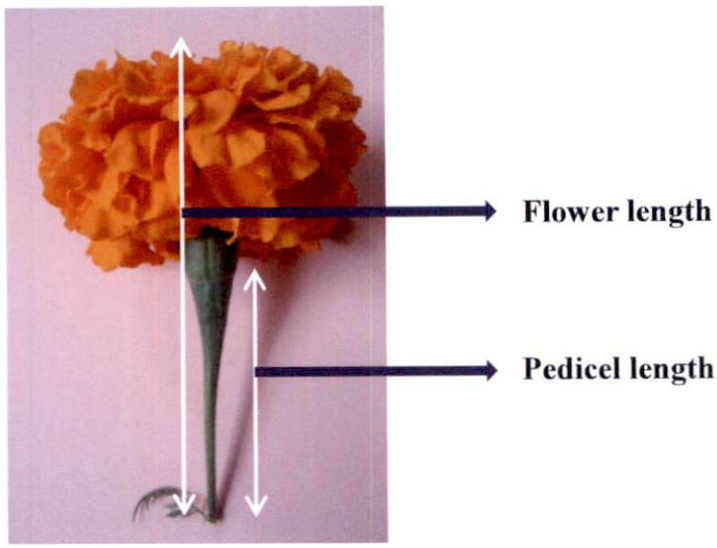
Cultivars	Flower diameter (cm)		Flower length (cm)	
	S1	S2	S1	S2
Sonata Orange	5.67	4.26	11.27	7.25
Sonata Yellow	5.40	4.49	8.83	6.73
Biocarve Orange	4.29	3.50	7.29	6.97
Biocarve Yellow	4.59	3.24	6.49	6.75
Local Orange	5.68	4.10	9.48	5.92
Local Yellow	6.05	3.71	8.72	5.29
Sierra Yellow	4.65	4.13	10.65	7.03
Orange Giant	6.74	4.20	11.67	6.84
CD (0.05)	0.66		0.80	

S1 –1st season (July – November) S2 – 2nd season (January – April)

Table 5(d). Effect of seasons on floral characters of African marigold cultivars under rain shelter condition

Cultivars	Flower diameter (cm)		Flower length (cm)	
	S1	S2	S1	S2
Sonata Orange	6.87	4.31	11.18	6.95
Sonata Yellow	6.09	4.76	8.13	7.34
Biocarve Orange	4.73	3.92	6.96	6.33
Biocarve Yellow	4.84	3.94	6.24	6.01
Local Orange	4.70	3.95	9.35	6.78
Local Yellow	5.91	4.06	7.54	6.53
Sierra Yellow	4.86	4.27	11.23	7.07
Orange Giant	6.38	4.37	10.93	6.90
CD (0.05)	0.57		1.15	

S1 – 1st season (July – November) S2 – 2nd season (January – April)



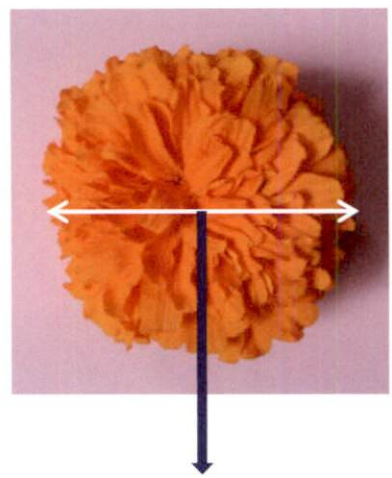


Plate 9. Measurements for flower length, pedicel length and flower diameter

Season II

The cultivar Sonata Orange recorded the highest flower length (7.25 cm) in the open field condition. The flower length of Sierra Yellow (7.03 cm), Biocarve Orange (6.97 cm), Orange Giant (6.84 cm), Biocarve Yellow (6.75 cm) and Sonata Yellow (6.73 cm) were statistically on par with Sonata Orange. Local Yellow recorded the least flower length (5.29 cm) which was on par with Local Orange (5.92 cm).

The highest flower length under rain shelter condition was recorded in Sonata Yellow (7.34 cm). This was followed by Sierra Yellow (7.07 cm), Sonata Orange (6.95 cm) and Orange Giant (6.90 cm) which were on par with Sonata Yellow. The least flower length was observed in Biocarve Yellow (6.01 cm) which was on par with Biocarve Orange (6.33 cm) and Local Yellow (6.53 cm).

The flower length of all cultivars was significantly influenced by the growing conditions. Irrespective of cultivars, the growing conditions had no significant effect on the flower length of the plants. Among the cultivars, Sonata Orange recorded the highest flower length (7.10 cm), regardless of growing conditions. This was followed by Sierra Yellow (7.05 cm), Sonata Yellow (7.04 cm) and Orange Giant (6.87 cm) which were on par with Sonata Orange. The cultivar Local Yellow (5.91 cm) recorded the least flower length.

4.2.4.1 Effect of Seasons on Flower Length

Significant influence of seasons on flower length of all the cultivars could be observed in the open field (Table 5(c)) and rain shelter conditions (Table 5(d)). In the open field condition, all the cultivars except Biocarve Yellow recorded greater flower length during the first season (Table 5(c)). The cultivar Orange Giant grown during first season recorded the highest flower length (11.67 cm) among all the cultivars.

All the cultivars grown under rain shelter condition recorded higher flower length during the first season compared to second season (Table 5(d)). Highest

flower length was recorded in cultivar Sierra Yellow (11.23 cm) grown during the first season.

4.2.5 Pedicel Length

Data pertaining to pedicel length of the cultivars grown under open field and rain shelter conditions during the two seasons are presented in Tables 5(a) and 5(b).

Season I

The growing condition had no significant influence on the pedicel length of the cultivars, since the interaction effect was not significant during the first season. Irrespective of cultivars, there was no significant difference between the pedicel lengths of the plants grown under open field and rain shelter conditions. The plants recorded better pedicel length in the open field condition rather than rain shelter condition. Irrespective of growing conditions, the highest pedicel length was observed in cultivar Sierra Yellow (7.96 cm). This was followed by Orange Giant (7.78 cm) and Sonata Orange (7.67 cm) which were on par with Sierra Yellow. The least pedicel length was recorded in cultivar Biocarve Yellow (3.40 cm) which was on par with Biocarve Orange (3.98 cm) and Sonata Yellow (4.16 cm).

Season II

Even though the cultivar Sonata Orange recorded the highest pedicel length (4.11 cm) in the open field condition, it was on par with Sierra Yellow (4.05 cm), Biocarve Orange (3.89 cm) and Orange Giant (3.72 cm). The cultivars Biocarve Yellow, Sonata Yellow and Local Orange recorded pedicel length of 3.55 cm, 3.51 cm and 3.19 cm respectively which were on par with one another. Least pedicel length was observed in Local Yellow (2.34 cm) which was significantly different from other cultivars.

The cultivar Sonata Yellow recorded the highest pedicel length (4.10 cm) under rain shelter. This was followed by Sierra Yellow (3.89 cm), Orange Giant (3.78 cm), Sonata Orange (3.74 cm) and Local Orange (3.74 cm) which were on

par with Sonata Yellow. The least pedicel length was noticed in Biocarve Yellow (2.78 cm) which was on par with Biocarve Orange (3.18 cm).

The cultivars under different growing conditions showed significant response in pedicel length. Irrespective of cultivars, the growing condition had no significant influence on the pedicel length of the plants. The cultivar Sierra Yellow recorded the highest pedicel length (3.97 cm), regardless of growing conditions. This was followed by Sonata Orange (3.93 cm), Sonata Yellow (3.80 cm) and Orange Giant (3.75 cm) which were on par with Sierra Yellow. Least pedicel length was noticed in cultivar Local Yellow (2.91 cm) which was on par with Biocarve Yellow (3.16 cm).

4.2.5.1 Effect of Seasons on Pedicel Length

The seasons have a significant influence on the pedicel length of the cultivars grown under the two growing conditions (Table 5(e) and Table 5(f)). In the open field condition, all the cultivars recorded higher pedicel length during the first season compared to second season (Table 5(e)). Highest pedicel length was observed in the cultivar Orange Giant (7.97 cm) grown during first season.

Under rain shelter condition, all the cultivars except Sonata Yellow recorded higher pedicel length during the first season (Table 5(f)). Sierra Yellow grown during first season recorded the highest pedicel length (8.20 cm), among all the cultivars.

4.2.6 Individual Flower Weight

The individual flower weight was significantly influenced by the growing conditions during both seasons for all the cultivars (Tables 5(a) and 5(b)).

Season I

Orange Giant recorded highest individual flower weight (12.21 g) in the open field condition which was significantly superior to all other cultivars. This was followed by Sonata Yellow (10.01 g). The flower weight recorded in the

cultivars Local Yellow (5.72 g) and Sierra Yellow (5.28 g) were on par with each another. Biocarve Yellow recorded the least individual flower weight (3.58 g).

The cultivar Orange Giant recorded the highest individual flower weight (12.37 g) under rain shelter condition also. The flower weight of Sonata orange (12.09 g), Local Yellow (12.07 g) and Sonata Yellow (11.89 g) were statistically on par with Orange Giant. Least individual flower weight was observed in Biocarve Orange (4.63 g) which was on par with Biocarve Yellow (4.77 g).

Significant response of cultivars under open field and rain shelter conditions with regard to individual flower weight was observed during the first season. Regardless of cultivars, the plants grown under rain shelter condition recorded the highest individual flower weight. Among the cultivars, significantly highest flower weight was recorded in Orange Giant (12.29 g) irrespective of growing conditions. The least individual flower weight was recorded in cultivar Biocarve Yellow (4.18 g) which was on par with Biocarve Orange (4.53 g).

Season II

During the second season, cultivar Orange Giant recorded the highest individual flower weight (3.40 g) in the open field condition. This was followed by Sonata Yellow (3.35 g) which was on par with Orange Giant. The flower weight observed in Local Yellow (3.04 g) and Local Orange (2.87 g) were on par with each other. Biocarve Orange recorded the least individual flower weight (1.70 g) which was on par with Biocarve Yellow (1.99 g).

Under rain shelter condition, Sonata Yellow recorded the highest individual flower weight (3.79 g) and was superior to all other cultivars except Orange Giant (3.61 g). The flower weight recorded in the cultivars Local Yellow (3.06 g) and Local Orange (3.05 g) were statistically on par with each other. Least individual flower weight was recorded in cultivar Biocarve Orange (1.42 g) which was significantly different from all other cultivars.

Table 5(e). Effect of seasons on floral characters of African marigold cultivars in open field condition

Cultivars	Pedicel length (cm)		Individual flower weight (g)	
	S1	S2	S1	S2
Sonata Orange	7.73	4.11	7.63	2.27
Sonata Yellow	4.48	3.51	10.01	3.35
Biocarve Orange	4.16	3.89	4.43	1.70
Biocarve Yellow	3.58	3.55	3.58	1.99
Local Orange	5.92	3.19	8.79	2.87
Local Yellow	5.14	2.34	5.72	3.04
Sierra Yellow	7.73	4.05	5.28	2.72
Orange Giant	7.97	3.72	12.21	3.40
CD (0.05)	0.76		0.43	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 5(f). Effect of seasons on floral characters of African marigold cultivars under rain shelter condition

Cultivars	Pedicel length (cm)		Individual flower weight (g)	
	S1	S2	S1	S2
Sonata Orange	7.61	3.74	12.09	2.71
Sonata Yellow	3.84	4.10	11.89	3.79
Biocarve Orange	3.81	3.18	4.63	1.42
Biocarve Yellow	3.22	2.78	4.77	2.11
Local Orange	5.93	3.74	6.07	3.05
Local Yellow	4.02	3.48	12.07	3.06
Sierra Yellow	8.20	3.89	6.15	2.77
Orange Giant	7.59	3.78	12.37	3.61
CD (0.05)	1.14		0.52	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

The individual flower weight of all the cultivars was significantly influenced by the growing conditions. Significantly higher individual flower weight was recorded under rain shelter condition compared to open field condition, irrespective of cultivars. Among the cultivars, regardless of growing conditions, Sonata Yellow recorded the highest flower weight (3.57 g) which was significantly superior to all other cultivars except Orange Giant (3.50 g). The cultivar Biocarve Orange recorded the least individual flower weight (1.56 g).

4.2.6.1 Effect of Seasons on Individual Flower Weight

The individual flower weight of the cultivars was significantly influenced by the seasons in open field and rain shelter conditions (Table 5(e) and Table 5(f)). In general, the cultivars recorded higher flower weight when grown during the first season compared to second season, in the open field condition. Orange Giant grown during first season recorded the highest individual flower weight (12.21 g), followed by Sonata Yellow (10.01 g) grown during the same season (Table 5(e)).

Under rain shelter condition also all the eight cultivars recorded higher individual flower weight during the first season (Table 5(f)). Highest individual flower weight under rain shelter condition also was recorded in cultivar Orange Giant (12.37 g) grown during the first season.

4.2.7 Number of Flowers per Plant

Data pertaining to the number of flowers per plant of the cultivars grown under open field and rain shelter conditions during the first and second seasons are presented in Table 6(a) and Table 6(b).

Season I

In the open field condition, Local Yellow recorded the highest number of flowers per plant (49.17). This was followed by Orange Giant (48.75) and Local Orange (46.57), which were on par with Local Yellow. The number of flowers observed in the cultivars Sonata Orange (42.65) and Sonata Yellow (39.92) were statistically on par with each other. Sierra Yellow recorded the least number of

flowers per plant (26.08) which was on par with Biocarve Orange (28.17) and Biocarve Yellow (31.92).

Under rain shelter condition, Local Orange recorded the highest number of flowers per plant (76.83) which was significantly superior to all other cultivars. This was followed by Local Yellow (63.92) and Orange Giant (59.33) which were on par with each other. The least number of flowers per plant was observed in Sierra Yellow (37.67) however, it was on par with Biocarve Yellow (39.33).

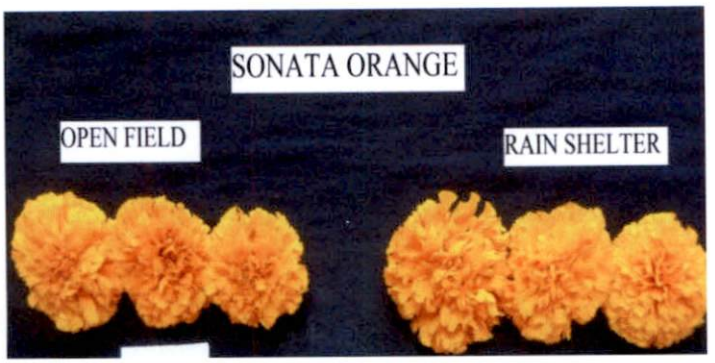
Irrespective of cultivars, the plants grown under rain shelter condition produced significantly higher number of flowers per plant when compared to those grown in the open field condition. Among the cultivars, Local Orange recorded significantly highest number of flowers per plant (61.70) regardless of growing conditions. The least number of flowers per plant was recorded in Sierra Yellow (31.88) which was on par with Biocarve Yellow (35.63).

Season II

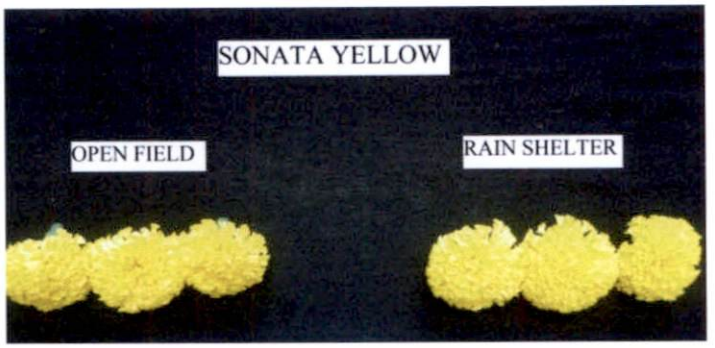
The growing condition had no significant influence on the number of flowers per plant, since the interaction effect was found not significant. Regardless of cultivars, significantly more number of flowers per plant was produced in plants grown under rain shelter condition compared to open field condition. Among the cultivars, Orange Giant recorded the highest number of flowers per plant (51.27), irrespective of growing conditions. This was followed by Sonata Orange (49.90) which was on par with Orange Giant. The cultivar Biocarve Orange recorded the least number of flowers per plant (25.40) which was on par with Sierra Yellow (26.00) and Biocarve Yellow (27.43).

4.2.7.1 Effect of Seasons on Number of Flowers per Plant

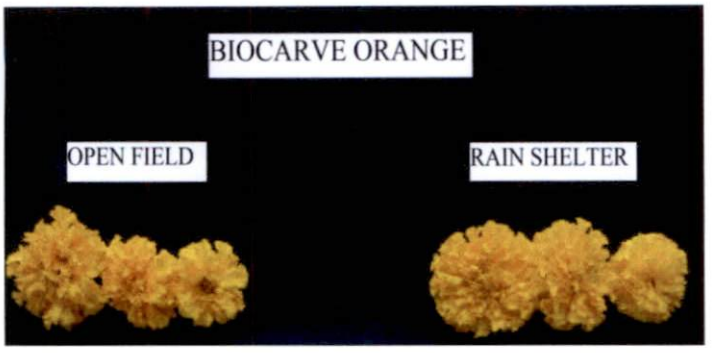
The number of flowers per plant was significantly influenced by the seasons in both open field and rain shelter conditions (Table 6(c) and Table 6(d)). In the open field condition, most of the cultivars recorded higher number of flowers per plant, when grown during the first season compared to second season (Table 6(c)).



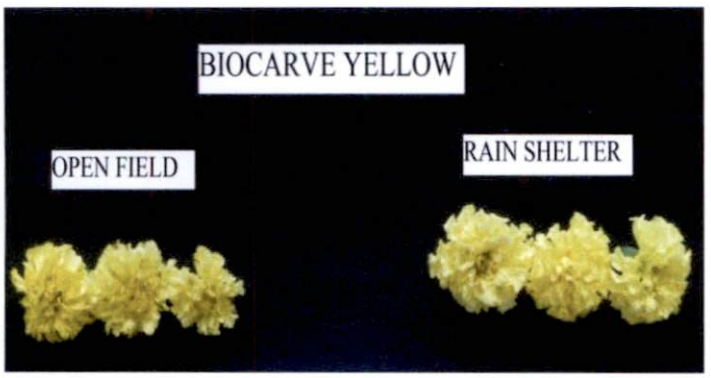
Sonata Orange



Sonata Yellow

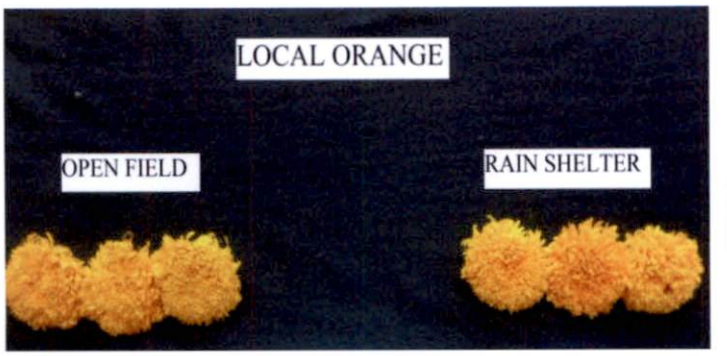


Biocarve Orange

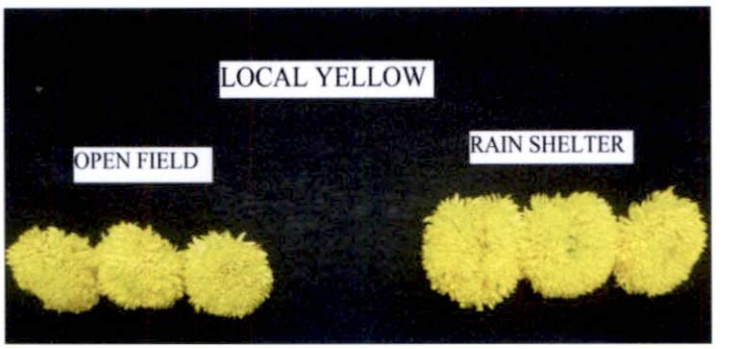


Biocarve Yellow

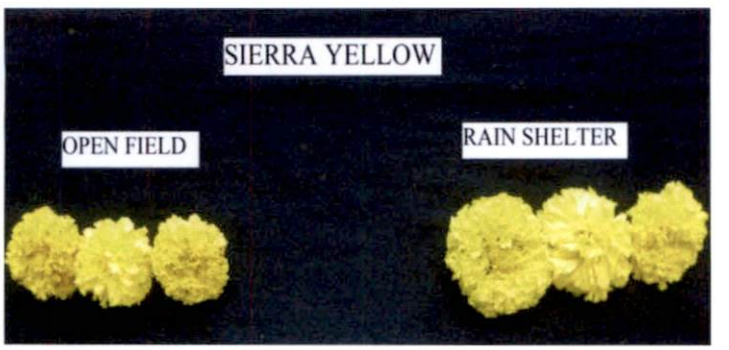
Plate 10. Comparison of flowers obtained from open field and rain shelter conditions during first season



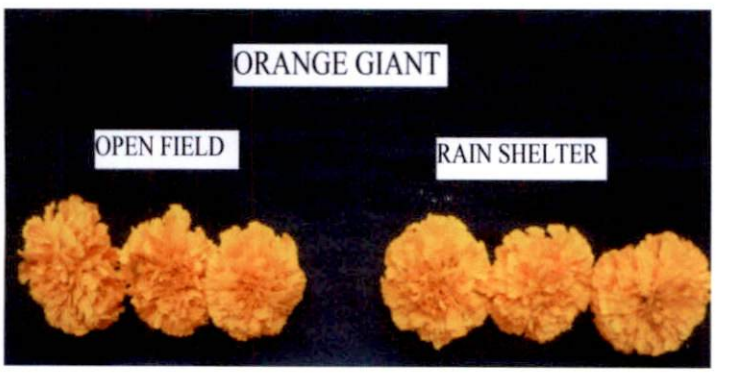
Local Orange



Local Yellow



Sierra Yellow



Orange Giant

Plate 11. Comparison of flowers obtained from open field and rain shelter conditions during first season (contd..)

The highest number of flowers was recorded in cultivar Local Yellow (49.17) grown during the first season.

Under rain shelter condition also, all the cultivars except Sonata Orange recorded higher number of flowers per plant, when grown during the first season (Table 6(d)). Highest number of flowers under rain shelter condition was recorded in Local Orange (76.83) grown during the first season.

4.2.8 Total Flower Yield

Data pertaining to the total flower yield of the plants grown under the two growing conditions during both the seasons are presented in Table 6(a) and Table 6(b).

Season I

Highest total flower yield in the open field condition was recorded in Orange Giant (646.57 g/plant) which was significantly superior to all other cultivars. This was followed by Sonata Orange (488.15 g/plant), Sonata Yellow (429.65 g/plant) and Local Orange (395.40 g/plant). The total flower yield obtained from Sonata Yellow and Local Orange were on par with each other. The least flower yield was observed in Biocarve Yellow (134.85 g/plant) which was on par with Biocarve Orange (135.26 g/plant) and Sierra Yellow (146.61 g/plant).

The highest total flower yield under rain shelter condition was recorded in cultivar Local Yellow (692.23 g/plant). This was followed by Orange Giant (689.55 g/plant) and Sonata Yellow (659.19 g/plant) which were on par with Local Yellow. The least total flower yield was observed in Biocarve Yellow (182.56 g/plant) which was on par with Biocarve Orange (226.67 g/plant).

The total flower yield of the cultivars was significantly influenced by the growing conditions. Regardless of cultivars, significantly higher flower yield was obtained in plants grown under rain shelter condition compared to open field condition. The cultivar Orange Giant recorded significantly highest flower yield (668.06 g/plant), irrespective of growing conditions. Least total flower yield was

recorded in cultivar Biocarve Yellow (158.70 g/plant) which was on par with Biocarve Orange (180.97 g/plant).

Season II

During second season, highest total flower yield in the open field condition was noticed in cultivar Orange Giant (166.00 g/plant) which was significantly superior to all other cultivars. The total flower yield obtained from the cultivars Sonata Yellow (138.54 g/plant), Local Yellow (131.25 g/plant) and Local Orange (123.00 g/plant) were on par with one another. The cultivar Biocarve Orange recorded the least total flower yield (39.95 g/plant), which was on par with Biocarve Yellow (46.21 g/plant).

Highest total flower yield under rain shelter condition was also noticed in cultivar Orange Giant (206.85 g/plant). The total flower yield obtained from Sonata Yellow (195.37 g/plant) was statistically on par with Orange Giant. The cultivars Biocarve Yellow (71.66 g/plant) and Sierra Yellow (84.72 g/plant) were on par with regard to flower yield. Least flower yield was recorded in the cultivar Biocarve Orange (46.10 g/plant) which was significantly different from all other cultivars.

In general, the flower yield of all the cultivars was significantly influenced by the growing conditions. Regardless of cultivars, the plants under rain shelter condition recorded significantly higher total flower yield compared to open field condition. The cultivar Orange Giant recorded significantly highest flower yield (186.43 g/plant), irrespective of growing conditions. Least total flower yield was recorded in cultivar Biocarve Orange (43.03 g/plant).

4.2.8.1 Effect of Seasons on Total Flower Yield

The seasons have a significant influence on the total flower yield of the cultivars grown under open field and rain shelter conditions (Table 6(e) and Table 6(f)). All the cultivars in the open field condition, recorded higher flower yield when grown during the first season compared to second season (Table 6(e)). The

Table 6(a). Effect of growing conditions on flower yield of African marigold cultivars during first season (July – November)

Cultivars	No. of flowers/ plant			Total flower yield (g/plant)			Marketable flower yield (g/plant)			Shelf life (days)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	42.65	51.25	46.95	488.15	625.37	556.76	415.52	601.10	508.31	4.34	4.79	4.57
Sonata Yellow	39.92	52.58	46.25	429.65	659.19	544.42	361.31	639.76	500.54	3.13	4.79	3.96
Biocarve Orange	28.17	44.75	36.46	135.26	226.67	180.97	101.47	213.07	157.27	2.96	3.33	3.15
Biocarve Yellow	31.92	39.33	35.63	134.85	182.56	158.70	98.06	169.99	134.02	2.67	3.21	2.94
Local Orange	46.57	76.83	61.70	395.40	435.94	415.67	331.28	421.88	376.58	3.43	4.17	3.80
Local Yellow	49.17	63.92	56.54	376.21	692.23	534.22	308.82	661.68	485.25	4.13	4.50	4.31
Sierra Yellow	26.08	37.67	31.88	146.61	251.46	199.04	119.68	245.78	182.73	3.38	4.21	3.79
Orange Giant	48.75	59.33	54.04	646.57	689.55	668.06	548.47	665.02	606.74	3.88	4.08	3.98
Mean	39.15	53.21		344.09	470.37		285.58	452.28		3.49	4.14	
CD (0.05) (Cultivars)	4.38			33.47			34.29			0.34		
CD (0.05) (Growing conditions)	2.19			16.74			17.15			0.17		
CD (0.05) (Interaction)	6.20			47.34			48.50			0.48		

G1 – Open field condition G2 – Rain shelter condition

Table 6(b). Effect of growing conditions on flower yield of African marigold cultivars during second season (January – April)

Cultivars	No. of flowers/ plant			Total flower yield (g/plant)			Marketable flower yield (g/plant)			Shelf life (days)		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	45.87	53.93	49.90	110.51	161.41	135.96	108.16	160.07	134.12	2.93	3.13	3.03
Sonata Yellow	39.93	49.40	44.67	138.54	195.37	166.96	134.35	192.36	163.36	2.83	3.27	3.05
Biocarve Orange	21.47	29.33	25.40	39.95	46.10	43.03	37.94	44.97	41.46	2.27	2.67	2.47
Biocarve Yellow	23.13	31.73	27.43	46.21	71.66	58.93	42.44	70.43	56.44	2.23	2.77	2.50
Local Orange	37.33	48.47	42.90	123.00	160.30	141.65	121.62	157.56	139.59	2.77	3.07	2.92
Local Yellow	39.53	46.13	42.83	131.25	154.24	142.75	125.94	152.30	139.12	2.83	3.13	2.98
Sierra Yellow	22.27	29.73	26.00	63.01	84.72	73.86	60.20	81.75	70.97	3.07	3.20	3.13
Orange Giant	47.80	54.73	51.27	166.00	206.85	186.43	161.11	204.78	182.94	3.07	3.27	3.17
Mean	34.67	42.93		102.31	135.08		98.97	133.03		2.75	3.06	
CD (0.05) (Cultivars)	2.30			12.00			11.61			0.27		
CD (0.05) (Growing conditions)	1.15			6.00			5.81			0.14		
CD (0.05) (Interaction)	NS			16.97			16.42			NS		

G1 – Open field condition G2 – Rain shelter condition

Table 6(c). Effect of seasons on floral characters of African marigold cultivars in open field condition

Cultivars	No. of flowers/ plant		Shelf life (days)	
	S1	S2	S1	S2
Sonata Orange	42.65	45.87	4.34	2.93
Sonata Yellow	39.92	39.93	3.13	2.83
Biocarve Orange	28.17	21.47	2.96	2.27
Biocarve Yellow	31.92	23.13	2.67	2.23
Local Orange	46.57	37.33	3.43	2.77
Local Yellow	49.17	39.53	4.13	2.83
Sierra Yellow	26.08	22.27	3.38	3.07
Orange Giant	48.75	47.80	3.88	3.07
CD (0.05)	4.66		0.45	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 6(d). Effect of seasons on flower characters of African marigold cultivars under rain shelter condition

Cultivars	No. of flowers/ plant		Shelf life (days)	
	S1	S2	S1	S2
Sonata Orange	51.25	53.93	4.79	3.13
Sonata Yellow	52.58	49.40	4.79	3.27
Biocarve Orange	44.75	29.33	3.33	2.67
Biocarve Yellow	39.33	31.73	3.21	2.77
Local Orange	76.83	48.47	4.17	3.07
Local Yellow	63.92	46.13	4.50	3.13
Sierra Yellow	37.67	29.73	4.21	3.20
Orange Giant	59.33	54.73	4.08	3.27
CD (0.05)	5.29		0.42	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

cultivar Orange Giant grown during first season recorded the highest flower yield (646.57 g/plant) among all the cultivars.

Under rain shelter condition also, higher flower yield was recorded in plants grown during the first season (Table 6(f)). Highest flower yield was observed in cultivar Local Yellow (692.23 g/plant) grown during the first season.

4.2.9 Marketable Flower Yield

Data pertaining to the marketable flower yield of the eight cultivars grown under open field and rain shelter conditions during both seasons are presented in Tables 6(a) and 6(b).

Season I

Highest marketable flower yield in the open field condition was recorded in cultivar Orange Giant (548.47 g/plant), which was significantly superior to all other cultivars. This was followed by Sonata Orange (415.52 g/plant). The marketable flower yield in the cultivars Sonata Yellow (361.31 g/plant) and Local Orange (331.28 g/plant) were on par with each other. Biocarve Yellow recorded the least marketable flower yield (98.06 g/plant) which was on par with Biocarve Orange (101.47 g/plant) and Sierra Yellow (119.68 g/plant).

Under rain shelter condition also, the cultivar Orange Giant recorded the highest marketable flower yield (665.02 g/plant). The marketable flower yield observed in the cultivars Local Yellow (661.68 g/plant) and Sonata Yellow (639.76 g/plant) were statistically on par with Orange Giant. Even though, Biocarve Yellow recorded the least marketable flower yield (169.99 g/plant) it was on par with Biocarve Orange (213.07 g/plant).

The marketable flower yield of all the cultivars was significantly influenced by the growing conditions. Significantly higher marketable flower yield was obtained from plants grown under rain shelter condition compared to open field condition, irrespective of cultivars. Among the cultivars regardless of growing conditions, the cultivar Orange Giant recorded significantly highest marketable

flower yield (606.74 g/plant). The least marketable flower yield was recorded in cultivar Biocarve Yellow (134.02 g/plant) which was on par with Biocarve Orange (157.27 g/plant).

Season II

In the open field condition, the highest marketable flower yield was recorded in Orange Giant (161.11 g/plant). This was followed by Sonata Yellow (134.35 g/plant), Local Yellow (125.94 g/ plant) and Local Orange (121.62 g/plant) which were on par with one another. The least marketable flower yield was recorded in Biocarve Orange (37.94 g/plant) which was on par with Biocarve Yellow (42.44 g/plant).

Under rain shelter condition, highest marketable flower yield was observed in cultivar Orange Giant (204.78 g/plant) which was significantly superior to all other cultivars except Sonata Yellow (192.36 g/plant). The marketable flower yield in the cultivars Sonata Orange, Local Orange and Local Yellow (160.07 g/plant, 157.56 g/plant and 152.30 g/plant respectively) were on par with one another. Biocarve Orange recorded the least marketable flower yield (44.97 g/plant) which was significantly different from all other cultivars.

The marketable flower yield of all cultivars was significantly influenced by the growing conditions. Significantly higher marketable flower yield was recorded in the plants under rain shelter condition than those in open field condition, irrespective of cultivars. Among the cultivars, Orange Giant recorded significantly highest marketable flower yield (182.94 g/plant), irrespective of growing conditions. The least marketable flower yield was recorded in cultivar Biocarve Orange (41.46 g/plant).

4.2.9.1 Effect of Seasons on Marketable Flower Yield

The marketable flower yield recorded in all the cultivars was significantly influenced by the seasons, both under open field (Table 6(e)) and rain shelter conditions (Table 6(f)). In the open field condition, higher marketable flower yield

was recorded in plants grown during the first season compared to the second season (Table 6(e)). Highest marketable flower yield was recorded in Orange Giant grown (548.47 g/plant) during the first season.

Under rain shelter condition also, all the cultivars recorded higher marketable flower yield when grown during the first season (Table 6(f)). The cultivar Orange Giant grown during first season recorded the highest marketable flower yield (665.02 g/plant) among all the cultivars.

4.2.10 Shelf Life

Data pertaining to the shelf life of the flowers of all cultivars grown in the open field and rain shelter conditions during first and second season are presented in Tables 6(a) and 6(b) respectively.

Season I

The highest shelf life in the open field condition was recorded in cultivar Sonata Orange (4.34 days) which was significantly superior to all other cultivars except Local Yellow (4.13 days) and Orange Giant (3.88 days). The shelf life observed in the cultivars Local Orange (3.43 days) and Sierra Yellow (3.38 days) were on par with each other. Among the cultivars, Biocarve Yellow recorded the least shelf life (2.67 days) which was on par with Biocarve Orange (2.96 days) and Sonata Yellow (3.13 days).

Under rain shelter condition, highest shelf life of 4.79 days was observed in two cultivars *viz.*, Sonata Orange and Sonata Yellow. This was followed by Local Yellow (4.50 days) which was on par with Sonata Orange and Sonata Yellow. The shelf life of the cultivars Sierra Yellow (4.21 days), Local Orange (4.17 days) and Orange Giant (4.08 days) were on par with one another. Biocarve Yellow recorded the least shelf life (3.21 days) which was on par with Biocarve Orange (3.33 days).

The growing conditions have significant influence on the cultivars with regard to shelf life of flowers. Significantly higher shelf life was recorded in flowers obtained from rain shelter condition compared to the open field condition,

Table 6(e). Effect of seasons on flower yield of African marigold cultivars in open field condition

Cultivars	Total flower yield (g/plant)		Marketable flower yield (g/plant)	
	S1	S2	S1	S2
Sonata Orange	488.15	110.51	415.52	108.16
Sonata Yellow	429.65	138.54	361.31	134.35
Biocarve Orange	135.26	39.95	101.47	37.94
Biocarve Yellow	134.85	46.21	98.06	42.44
Local Orange	395.40	123.00	331.28	121.62
Local Yellow	376.21	131.25	308.82	125.94
Sierra Yellow	146.61	63.01	119.68	60.20
Orange Giant	646.57	166.00	548.47	161.11
CD (0.05)	29.35		26.23	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 6(f). Effect of seasons on flower yield of African marigold cultivars under rain shelter condition

Cultivars	Total flower yield (g/plant)		Marketable flower yield (g/plant)	
	S1	S2	S1	S2
Sonata Orange	625.37	161.41	601.10	160.07
Sonata Yellow	659.19	195.37	639.76	192.36
Biocarve Orange	226.67	46.10	213.07	44.97
Biocarve Yellow	182.56	71.66	169.99	70.43
Local Orange	435.94	160.30	421.88	157.56
Local Yellow	692.23	154.24	661.68	152.30
Sierra Yellow	251.46	84.72	245.78	81.75
Orange Giant	689.55	206.85	665.02	204.78
CD (0.05)	41.68		43.07	

S1 –1st season (July – November) S2 – 2nd season (January – April)

regardless of cultivars. The cultivar Sonata Orange recorded the highest shelf life (4.57 days), irrespective of growing conditions. This was followed by Local Yellow (4.31 days) which was on par with Sonata Orange. The least shelf life was recorded in cultivar Biocarve Yellow (2.94 days) which was on par with Biocarve Orange (3.15 days).

Season II

During second season, the growing condition had no significant influence on shelf life of the cultivars, because the interaction effect was found not significant. Irrespective of cultivars, the shelf life of the flowers varied significantly with respect to the growing conditions. Significantly higher shelf life was observed in flowers obtained from rain shelter condition compared to open field condition. Irrespective of growing conditions, highest shelf life was recorded in cultivar Orange Giant (3.17 days). The cultivars Sierra Yellow (3.13 days), Sonata Yellow (3.05 days), Sonata Orange (3.03 days), Local Yellow (2.98 days) and Local Orange (2.92 days) were on par with Orange Giant. The cultivar Biocarve Orange (2.47 days) recorded the least shelf life which was on par with Biocarve Yellow (2.50 days).

4.2.10.1 Effect of Seasons on Shelf Life

The seasons have significant influence on shelf life of all the cultivars grown under open field and rain shelter conditions (Table 6(c) and Table 6(d)). In the open field condition, all the cultivars, when grown during first season, recorded higher shelf life (Table 6(c)). Highest shelf life in the open field condition was observed in cultivar Sonata Orange (4.34 days) grown during the first season.

Under rain shelter condition also, higher shelf life in all the cultivars was recorded during the first season (Table 6(d)). Among the cultivars, Sonata Orange and Sonata Yellow grown during first season recorded the highest shelf life (4.79 days).

4.2.11 Flower Colour

Data presented in Table 6(g) shows the variation in flower colour of the cultivars grown in the open field and rain shelter conditions during both the seasons. The flower colour of the cultivars varied from light yellow to sulphur yellow and from light orange to bright orange under open field and rain shelter conditions during both the growing seasons.

4.2.12 Duration of Flowering

The observations recorded on flowering duration of all the cultivars during both the seasons under open field and rain shelter conditions are presented in Table 6(h) and Table 6(i) respectively.

Season I

During first season, all the cultivars grown under rain shelter condition showed greater flowering duration when compared to the open field condition (Table 6(h) and Table 6(i)). During first season, the cultivar Orange Giant grown under rain shelter condition recorded the highest flowering duration (56.83 days), among all the cultivars.

Season II

During second season also, greater flowering duration in all the cultivars was recorded under rain shelter condition compared to the open field condition (Table 6(h) and Table 6(i)). Among the cultivars, Sierra Yellow grown under rain shelter condition recorded the highest flowering duration (45.87 days).

4.2.12.1 Effect of Seasons on Duration of Flowering

Compared to second season, more flowering duration was observed during first season in all the cultivars. Under both growing conditions, Local Yellow grown during first season recorded the highest flowering duration.

Table 6(g). Effect of growing conditions on flower colour of African marigold cultivars during the two seasons

Cultivars	Flower colour			
	Season I (July – November)		Season II (December – April)	
	Open field	Rain shelter	Open field	Rain shelter
Sonata Orange	Brilliant orangish yellow (23B)	Brilliant orangish yellow (23B)	Brilliant orangish yellow (23B)	Brilliant orangish yellow (23B)
Sonata Yellow	Light greenish yellow (1C)	Light greenish yellow (1C)	Light greenish yellow (1C)	Light greenish yellow (1C)
Biocarve Orange	Pale orangish yellow (16D)	Pale orangish yellow (16D)	Pale orangish yellow (16D)	Pale orangish yellow (16D)
Biocarve Yellow	Pale greenish yellow (1D)	Pale greenish yellow (1D)	Pale greenish yellow (1D)	Pale greenish yellow (1D)
Local Orange	Light orangish yellow (16C)	Light orangish yellow (16C)	Light orangish yellow (16C)	Light orangish yellow (16C)
Local Yellow	Light yellowish green (2C)	Light yellowish green (2C)	Light yellowish green (2C)	Light yellowish green (2C)
Sierra Yellow	Light greenish yellow (3D)	Light greenish yellow (3D)	Light greenish yellow (3D)	Light greenish yellow (3D)
Orange Giant	Strong orangish yellow (17A)	Strong orangish yellow (17A)	Strong orangish yellow (17A)	Strong orangish yellow (17A)

Table 6(h). Flowering duration of African marigold cultivars grown in the open field condition during the two seasons

Cultivars	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sonata Orange												
Sonata Yellow												
Biocarve Orange												
Biocarve Yellow												
Local Orange												
Local Yellow												
Sierra Yellow												
Orange Giant												

Duration of flowering during first season (July –Nov.) Duration of flowering during second season (Jan.–April)

Table 6(i). Flowering duration of African marigold cultivars grown under rain shelter condition during the two seasons

Cultivars	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sonata Orange												
Sonata Yellow												
Biocarve Orange												
Biocarve Yellow												
Local Orange												
Local Yellow												
Sierra Yellow												
Orange Giant												

Duration of flowering during first season (July –Nov.) Duration of flowering during second season (Jan.–April)

4.3 SEED CHARACTERS

The observations pertaining to various seed characters (seed yield and seed germination) during both the seasons in open field and rain shelter were statistically analysed and the data are presented in Table 7(a) to Table 7(d).

4.3.1 Seed Yield per Flower

The seed yield per flower of the cultivars was not significantly influenced by the growing conditions during both the seasons (Tables 7(a) and 7(b)).

Season I

The growing condition had no significant influence on the cultivars with regard to seed yield. Even though there was no significant difference between the growing conditions, regardless of cultivars, higher seed yield was obtained under rain shelter condition compared to open field condition. The cultivar Local Yellow recorded the highest seed yield (1.12 g/flower), irrespective of growing conditions. This was followed by Orange Giant (1.11 g/flower) and Sonata Orange (1.08 g/flower) which were on par with Local Yellow. The least seed yield was recorded in cultivar Biocarve Yellow (0.44 g/flower) which was on par with Biocarve Orange (0.45 g/flower).

Season II

Since the interaction effect was not significant, the seed yield of the cultivars was not significantly influenced by the growing conditions. Higher seed yield was obtained from plants grown under rain shelter condition rather than open field condition, but there was no significant difference between the growing conditions, irrespective of cultivars. Among the cultivars, Local Yellow recorded the highest seed yield (0.62 g/flower), regardless of growing conditions. This was followed by Local Orange (0.58 g/flower), which was on par with Local Yellow. The least seed yield was recorded in cultivar Biocarve Yellow (0.24 g/plant) which was on par with Biocarve Orange (0.25 g/plant).

4.3.1.1 Effect of Seasons on Seed Yield

The seed yield obtained from all the cultivars were significantly influenced by the seasons both under open field and rain shelter conditions (Table 7(c) and Table 7(d)). In the open field condition, all the cultivars grown during first season recorded higher seed yield (Table 7(c)). The cultivar Local Yellow grown during first season recorded the highest seed yield (1.10 g/flower) in the open field condition.

Under rain shelter condition also higher seed yield was recorded in the cultivars grown during first season compared to second season (Table 7(d)). Highest seed yield under rain shelter condition was recorded in Sonata Orange (1.14 g) grown during the first season.

4.3.2 Seed Germination

Data pertaining to seed germination of the cultivars grown during the first season are included in Table 7(a) and that of second season are included in Table 7(b).

Season I

During first season, there was no significant influence of growing conditions on seed germination of the cultivars. Even though, there was no significant difference between the seed germination recorded under open field and rain shelter conditions, better seed germination was recorded in the open field condition compared to the rain shelter condition, regardless of cultivars. Among the cultivars, Local Yellow recorded highest seed germination (90.00%), irrespective of growing conditions. This was followed by Orange Giant (89.67%), Sonata Orange (89.00%) and Local Orange (88.33%) which were on par with Local Yellow. No seed germination was recorded in cultivar Sierra Yellow.

Table 7(a). Effect of growing conditions on seed characters of African marigold cultivars grown during first season (July – November)

Cultivars	Seed yield/ flower (g/flower)			Seed germination (%)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	1.01	1.14	1.08	90.67	87.33	89.00
Sonata Yellow	0.83	0.99	0.91	47.33	49.33	48.33
Biocarve Orange	0.42	0.47	0.45	34.00	35.33	34.67
Biocarve Yellow	0.44	0.45	0.44	32.67	32.00	32.33
Local Orange	0.88	0.84	0.86	88.67	88.00	88.33
Local Yellow	1.10	1.13	1.12	89.33	90.67	90.00
Sierra Yellow	0.69	0.74	0.72	0.00	0.00	0.00
Orange Giant	1.09	1.12	1.11	91.33	88.00	89.67
Mean	0.81	0.86		59.25	58.83	
CD (0.05) (Cultivars)	0.11			4.33		
CD (0.05) (Growing conditions)	NS			NS		
CD (0.05) (Interaction)	NS			NS		

G1 – Open field condition G2 – Rain shelter condition

Table 7(b). Effect of growing conditions on seed characters of African marigold cultivars grown during second season (January – April)

Cultivars	Seed yield (g/flower)			Seed germination (%)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	0.57	0.54	0.56	87.33	86.00	86.67
Sonata Yellow	0.43	0.49	0.46	48.67	48.00	48.33
Biocarve Orange	0.25	0.25	0.25	32.67	30.67	31.67
Biocarve Yellow	0.23	0.25	0.24	36.67	34.67	35.67
Local Orange	0.55	0.61	0.58	88.00	85.33	86.67
Local Yellow	0.61	0.63	0.62	86.67	86.67	86.67
Sierra Yellow	0.50	0.51	0.50	0.00	0.00	0.00
Orange Giant	0.53	0.55	0.54	88.67	89.33	89.00
Mean	0.46	0.48		58.58	57.58	
CD (0.05) (Cultivars)	0.04			5.05		
CD (0.05) (Growing conditions)	NS			NS		
CD (0.05) (Interaction)	NS			NS		

G1 – Open field condition G2 – Rain shelter condition

Table 7(c). Effect of seasons on seed characters of African marigold cultivars grown in open field condition

Cultivars	Seed yield (g/flower)		Seed germination (%)	
	S1	S2	S1	S2
Sonata Orange	1.01	0.57	90.67	87.33
Sonata Yellow	0.83	0.43	47.33	48.67
Biocarve Orange	0.42	0.25	34.00	32.67
Biocarve Yellow	0.44	0.23	32.67	36.67
Local Orange	0.88	0.55	88.67	88.00
Local Yellow	1.10	0.61	89.33	86.67
Sierra Yellow	0.69	0.50	0.00	0.00
Orange Giant	1.09	0.53	91.33	88.67
CD (0.05)	0.12		NS	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 7(d). Effect of seasons on seed characters of African marigold cultivars grown under rain shelter condition

Cultivars	Seed yield (g/flower)		Seed germination (%)	
	S1	S2	S1	S2
Sonata Orange	1.14	0.54	87.33	86.00
Sonata Yellow	0.99	0.49	49.33	48.00
Biocarve Orange	0.47	0.25	35.33	30.67
Biocarve Yellow	0.45	0.25	32.00	34.67
Local Orange	0.84	0.61	88.00	85.33
Local Yellow	1.13	0.63	90.67	86.67
Sierra Yellow	0.74	0.51	0.00	0.00
Orange Giant	1.12	0.55	88.00	89.33
CD (0.05)	0.12		NS	

S1 –1st season (July – November) S2 – 2nd season (January – April)

Season II

The seed germination of the cultivars was not influenced by the growing conditions, since the interaction effect was found not significant. There was no significant difference between the seed germination of plants, irrespective of cultivars. But, higher seed germination was observed in plants grown in the open field condition rather than rain shelter condition. Regardless of growing conditions, the cultivar Orange Giant recorded highest seed germination (89.00%). This was followed by Sonata Orange, Local Orange and Local Yellow which were on par with Orange Giant. Sierra Yellow recorded zero seed germination.

4.3.2.1 Effect *of Seasons on Seed Germination*

There was no significant influence of seasons on the seed germination of the cultivars grown under open field and rain shelter conditions (Table 7(c) and Table 7(d)). In the open field condition, the cultivar Orange Giant grown during first season recorded the highest seed germination (91.33%) among all the cultivars (Table 7(c)). Under rain shelter condition, Local Yellow (90.67%) grown during first season recorded the highest seed (Table 7(d)).

4.4 BIOCHEMICAL ATTRIBUTES

Observations recorded on various chemical attributes of the cultivars grown under open field and rain shelter were statistically analysed and data are presented in Table 8(a) to Table 9(d).

4.4.1 Chlorophyll Content in Leaves

Chlorophyll a, chlorophyll b, and total chlorophyll content recorded in leaves of the cultivars grown under the two growing conditions during both the seasons are given in Table 8(a) and Table 8(b).

4.4.1.1 Chlorophyll a

Season I

Orange Giant recorded the highest chlorophyll a content (1.21 mg/g fresh wt) in the open field condition. This was followed by Local Yellow (1.20 mg/g fresh wt) which was on par with Orange Giant. Chlorophyll a content recorded in the cultivars Local Orange (1.10 mg/g fresh wt) and Sonata Orange (1.08 mg/g fresh wt) were statistically on par with each other. Lowest content of chlorophyll a was noticed in cultivar Biocarve Yellow (0.23 mg/g fresh wt) which was on par with Biocarve Orange (0.25 mg/g fresh wt).

Under rain shelter condition, highest chlorophyll a content was recorded in Local Yellow (0.95 mg/g fresh wt) which was significantly superior to all other cultivars except Sonata Yellow (0.86 mg/g fresh wt) and Orange Giant (0.85 mg/g fresh wt). The cultivars Sonata Orange and Local Orange recorded the same chlorophyll a content (0.84 mg/g fresh wt). Biocarve Yellow recorded the least chlorophyll a content (0.19 mg/g fresh wt), which was on par with Biocarve Orange (0.26 mg/g fresh wt).

In general, a significant influence of the growing conditions on chlorophyll a content of the cultivars was observed during the first season. Irrespective of cultivars, significantly higher chlorophyll a content was observed in plants grown under open field condition compared to rain shelter condition. Regardless of growing conditions, the cultivar Local Yellow recorded highest chlorophyll a content (1.08 mg/g fresh wt). This was followed by Orange Giant (1.03 mg/g fresh wt) which was on par with Local Yellow. The cultivar Biocarve Yellow recorded the least chlorophyll a content (0.21 mg/g fresh wt) which was on par with Biocarve Orange (0.26 mg/g fresh wt).

Season II

In the open field condition, highest chlorophyll a content was recorded in cultivar Local Orange (0.91 mg/g fresh wt) which was significantly superior to all

other cultivars except Local Yellow (0.90 mg/g fresh wt), Orange Giant (0.88 mg/g fresh wt) and Sierra Yellow (0. 83 mg/g fresh wt). The lowest content of chlorophyll a was observed in Biocarve Orange (0.22 mg/g fresh wt) which was on par with Biocarve Yellow (0.26 mg/g fresh wt).

The cultivar Orange Giant recorded the highest chlorophyll a content (0.82 mg/g fresh wt) under rain shelter condition. The chlorophyll a content noticed in Local Orange (0.77 mg/g fresh wt), Sonata Orange (0.74 mg/g fresh wt) and Local Yellow (0.73 mg/g fresh wt) were statistically on par with Orange Giant. The cultivar Biocarve Yellow recorded the least content of chlorophyll a (0.20 mg/g fresh wt) which was on par with Biocarve Orange (0.29 mg/g fresh wt).

The data revealed that the chlorophyll a content in all the cultivars was significantly influenced by the growing conditions. Significantly higher chlorophyll a content was recorded in the open field compared to rain shelter condition, regardless of cultivars. Among the cultivars, Orange Giant recorded highest chlorophyll a content (0.85 mg/g fresh wt), irrespective of growing conditions. This was followed by Local Orange (0.84 mg/g fresh wt) and Local Yellow (0.81 mg/g fresh wt) which were on par with Orange Giant. Least chlorophyll a content was recorded in cultivar Biocarve Yellow (0.23 mg/g fresh wt) which was on par with Biocarve Orange (0.26 mg/g fresh wt).

4.4.1.1.1 Effect of Seasons on Chlorophyll a Content

The chlorophyll a content in leaves was significantly influenced by seasons, both under open field and rain shelter conditions (Table 8(c) and Table 8(d)). In the open field condition, all cultivars recorded higher chlorophyll a content during the first season. The cultivar Orange Giant grown during first season recorded the highest chlorophyll a content (1.21 mg/g fresh wt), among all the cultivars (Table 8(c)).

Under rain shelter condition also, higher chlorophyll a content was recorded in plants grown during first season compared to second season. Highest

chlorophyll a content was noticed in cultivar Local Yellow (0.95 mg/g fresh wt) grown during the first season (Table 8(d)).

4.4.1.2 Chlorophyll b

Season I

The interaction effect between the growing conditions and cultivars was found not significant with regard to the chlorophyll b content. Even though there was no significant difference between chlorophyll b content recorded under the two growing conditions, regardless of cultivars, higher chlorophyll b content was observed in plants grown in the open field condition compared to rain shelter condition. Significantly higher chlorophyll b content was recorded in cultivar Local Yellow (0.68 mg/g fresh wt), irrespective of growing conditions. The least chlorophyll b content was recorded in cultivar Biocarve Orange (0.21 mg/g fresh wt).

Season II

During second season, Sonata Orange and Orange Giant recorded the highest chlorophyll b content (0.58 mg/g fresh wt) in the open field condition. The cultivars Sonata Orange and Orange Giant were significantly superior to all other cultivars except Local Yellow (0.52 mg/g fresh wt). The lowest chlorophyll b content was observed in cultivar Biocarve Yellow (0.22 mg/g fresh wt) which was statistically on par with Biocarve Orange (0.24 mg/g fresh wt).

Under rain shelter condition, Local Yellow recorded the highest chlorophyll b content (0.52 mg/g fresh wt). The chlorophyll b content recorded in the cultivar Sierra Yellow (0.49 mg/g fresh wt) was statistically on par with Local Yellow. The least chlorophyll b content was 0.21 mg/g fresh wt, recorded in the cultivar Biocarve Yellow which was on par with Biocarve Orange (0.23 mg/g fresh wt).

Growing condition had a significant influence on the chlorophyll b content of all the cultivars. Irrespective of cultivars, significantly higher chlorophyll b content was observed in plants grown in the open field condition rather than rain

Table 8(a). Effect of growing conditions on chlorophyll content of African marigold cultivars during first season (July – November)

Cultivars	Chlorophyll content in leaf (mg/g fresh wt)								
	Chlorophyll a			Chlorophyll b			Total chlorophyll		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	1.08	0.84	0.96	0.61	0.56	0.58	1.69	1.40	1.54
Sonata Yellow	0.99	0.86	0.93	0.55	0.53	0.54	1.53	1.39	1.46
Biocarve Orange	0.25	0.26	0.26	0.21	0.22	0.21	0.46	0.48	0.47
Biocarve Yellow	0.23	0.19	0.21	0.28	0.30	0.29	0.51	0.49	0.50
Local Orange	1.10	0.84	0.97	0.57	0.62	0.59	1.67	1.45	1.56
Local Yellow	1.20	0.95	1.08	0.72	0.63	0.68	1.93	1.58	1.75
Sierra Yellow	0.89	0.69	0.79	0.62	0.50	0.56	1.52	1.20	1.36
Orange Giant	1.21	0.85	1.03	0.65	0.61	0.63	1.86	1.46	1.66
Mean	0.87	0.69		0.53	0.50		1.40	1.18	
CD (0.05) (Cultivars)	0.07			0.06			0.10		
CD (0.05) (Growing conditions)	0.04			NS			0.05		
CD (0.05) (Interaction)	0.10			NS			0.14		

G1 – Open field condition G2 – Rain shelter condition

Table 8(b). Effect of growing conditions on chlorophyll content of African marigold cultivars during second season (January – April)

Cultivars	Chlorophyll content in leaf (mg/g fresh wt)								
	Chlorophyll a			Chlorophyll b			Total chlorophyll		
	G1	G2	Mean	G1	G2	Mean	G1	G2	Mean
Sonata Orange	0.80	0.74	0.77	0.58	0.41	0.50	1.38	1.16	1.27
Sonata Yellow	0.79	0.70	0.75	0.45	0.40	0.43	1.24	1.11	1.17
Biocarve Orange	0.22	0.29	0.26	0.24	0.23	0.24	0.46	0.52	0.49
Biocarve Yellow	0.26	0.20	0.23	0.22	0.21	0.22	0.47	0.41	0.44
Local Orange	0.91	0.77	0.84	0.50	0.44	0.48	1.41	1.22	1.31
Local Yellow	0.90	0.73	0.81	0.52	0.52	0.52	1.42	1.25	1.33
Sierra Yellow	0.83	0.70	0.77	0.44	0.49	0.47	1.27	1.20	1.24
Orange Giant	0.88	0.82	0.85	0.58	0.43	0.51	1.46	1.25	1.36
Mean	0.70	0.62		0.44	0.39		1.14	1.01	
CD (0.05) (Cultivars)	0.07			0.04			0.06		
CD (0.05) (Growing conditions)	0.03			0.02			0.03		
CD (0.05) (Interaction)	0.09			0.06			0.09		

G1 – Open field condition G2 – Rain shelter condition

Table 8(c). Effect of seasons on chlorophyll content of African marigold cultivars in open field condition

Cultivars	Chlorophyll content in leaf (mg/g fresh wt)					
	Chlorophyll a		Chlorophyll b		Total chlorophyll	
	S1	S2	S1	S2	S1	S2
Sonata Orange	1.08	0.80	0.61	0.58	1.69	1.38
Sonata Yellow	0.99	0.79	0.55	0.45	1.53	1.24
Biocarve Orange	0.25	0.22	0.21	0.24	0.46	0.46
Biocarve Yellow	0.23	0.26	0.28	0.22	0.51	0.47
Local Orange	1.10	0.91	0.57	0.50	1.67	1.41
Local Yellow	1.20	0.90	0.72	0.52	1.93	1.42
Sierra Yellow	0.89	0.83	0.62	0.44	1.52	1.27
Orange Giant	1.21	0.88	0.65	0.58	1.86	1.46
CD (0.05)	0.12		0.08		0.14	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 8(d). Effect of seasons on chlorophyll content of African marigold cultivars under rain shelter condition

Cultivars	Chlorophyll content in leaf (mg/g fresh wt)					
	Chlorophyll a		Chlorophyll b		Total chlorophyll	
	S1	S2	S1	S2	S1	S2
Sonata Orange	0.84	0.74	0.56	0.41	1.40	1.16
Sonata Yellow	0.86	0.70	0.53	0.40	1.39	1.11
Biocarve Orange	0.26	0.29	0.22	0.23	0.48	0.52
Biocarve Yellow	0.19	0.20	0.30	0.21	0.49	0.41
Local Orange	0.84	0.77	0.62	0.44	1.45	1.22
Local Yellow	0.95	0.73	0.63	0.52	1.58	1.25
Sierra Yellow	0.69	0.70	0.50	0.49	1.20	1.20
Orange Giant	0.85	0.82	0.61	0.43	1.46	1.25
CD (0.05)	0.09		0.07		0.09	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

shelter condition. Among the cultivars, Local Yellow recorded the highest chlorophyll b content (0.52 mg/g fresh wt) regardless of growing conditions. This was followed by Orange Giant (0.51 mg/g fresh wt), Sonata Orange (0.50 mg/g fresh wt) and Local Orange (0.48 mg/g fresh wt) which were on par with Local Yellow. The cultivar Biocarve Yellow recorded the least chlorophyll b content (0.22 mg/g fresh wt) which was on par with Biocarve Orange (0.24 mg/g fresh wt).

4.4.1.2.1 Effect of Seasons on Chlorophyll b Content

The chlorophyll b content in all the cultivars was significantly influenced by the seasons under both the growing conditions (Table 8(c) and Table 8(d)). In the open field condition, most of the cultivars recorded higher chlorophyll b content during the first season. Among the cultivars, Local Yellow (0.72 mg/g fresh wt) grown during first season recorded the highest chlorophyll b content (Table 8(c)).

Under rain shelter condition also, most of the cultivars recorded higher chlorophyll b content during the first season compared to second season. The cultivar Local Yellow (0.63 mg/g fresh wt) grown during first season recorded the highest chlorophyll b content (Table 8(d)).

4.4.1.3 Total Chlorophyll

Season I

During first season, highest total chlorophyll content in the open field condition was recorded in Local Yellow (1.93 mg/g fresh wt) which was significantly superior to all other cultivars except Orange Giant (1.86 mg/g fresh wt). The total chlorophyll content recorded in the cultivars Sonata Orange (1.69 mg/g fresh wt) and Local Orange (1.67 mg/g fresh wt) were on par with each other. Even though, the least total chlorophyll content under rain shelter condition was recorded in Biocarve Orange (0.46 mg/g fresh wt), it was on par with Biocarve Yellow (0.51 mg/g fresh wt).

The highest total chlorophyll content under rain shelter condition also was recorded by the cultivar Local Yellow (1.58 mg/g fresh wt) which was

significantly superior to all other cultivars. This was followed by Orange Giant (1.46 mg/g fresh wt) and Local Orange (1.45 mg/g fresh wt) which were statistically on par with Local Yellow. Biocarve Orange recorded the least content of total chlorophyll (0.48 mg/g fresh wt) which was on par with Biocarve Yellow (0.49 mg/g fresh wt).

A significant influence of growing conditions on total chlorophyll content of the cultivars was observed during the first season. Regardless of cultivars, the plants grown in the open field condition recorded significantly higher total chlorophyll content compared the rain shelter condition. Among the cultivars, Local Yellow recorded the highest total chlorophyll content (1.75 mg/g fresh wt), irrespective of growing conditions. This was followed by Orange Giant (1.66 mg/g fresh wt) which was on par with Local Yellow. Least total chlorophyll content was recorded in Biocarve Orange (0.47 mg/g fresh wt) which was on par with Biocarve Yellow (0.50 mg/g fresh wt).

Season II

In the open field condition, Orange Giant recorded the highest total chlorophyll content (1.46 mg/g fresh wt). This was followed by Local Yellow (1.42 mg/g fresh wt), Local Orange (1.41 mg/g fresh wt) and Sonata Orange (1.38 mg/g fresh wt) which were statistically on par with Orange Giant. The least content of total chlorophyll was observed in Biocarve Orange (0.46 mg/g fresh wt) which was on par with Biocarve Yellow (0.47 mg/g fresh wt).

Under rain shelter condition, the highest total chlorophyll content (1.25 mg/g fresh wt) was recorded in two cultivars *viz.*, Local Yellow and Orange Giant. They were followed by Local Orange (1.22 mg/g fresh wt), Sierra Yellow (1.20 mg/g fresh wt) and Sonata Orange (1.16 mg/g fresh wt) which were on par with Local Yellow and Orange Giant. The least total chlorophyll content was recorded in Biocarve Yellow (0.41 mg/g fresh wt) which was on par with Biocarve Orange (0.52 mg/g fresh wt).

The total chlorophyll content of all cultivars was significantly influenced by the growing conditions. Irrespective of cultivars, significantly higher total chlorophyll content was recorded in plants grown in the open field condition compared to the rain shelter condition. Regardless of growing conditions, the cultivar Orange Giant recorded the highest total chlorophyll content (1.36 mg/g fresh wt). This was followed by Local Yellow (1.33 mg/g fresh wt) and Local Orange (1.31 mg/g fresh wt) which were on par with Orange Giant. The least total chlorophyll content was recorded in Biocarve Yellow (0.44 mg/g fresh wt) which was statistically on par with Biocarve Orange (0.49 mg/g fresh wt).

4.4.1.3.1 Effect of Seasons on Total Chlorophyll Content

Significant influence of seasons on the total chlorophyll content in leaves could be observed under open field and rain shelter conditions (Table 8(c) and Table 8(d)). In general, higher total chlorophyll content was recorded during the first season in all the cultivars (Table 8(c)). The cultivar Orange Giant grown during first season recorded the highest total chlorophyll content (1.86 mg/g fresh wt), among all the cultivars.

Under rain shelter condition also, the cultivars recorded higher total chlorophyll content during the first season compared to second season (Table 8(d)). Highest total chlorophyll content was observed in the cultivar Local Yellow (1.58 mg/g fresh wt) grown during first season.

4.4.2 Xanthophyll Content in Flowers

Data pertaining to xanthophyll content in flowers of the cultivars grown under the two growing conditions during both the seasons are presented in Tables 9(a) and 9(b).

Season I

During first season, the growing condition had no significant influence on xanthophyll content of the cultivars, since the interaction effect was found not significant. There was no significant difference between the xanthophyll content

recorded under the two growing conditions, irrespective of cultivars. But, the plants recorded higher xanthophyll content in the open field condition rather than rain shelter condition. Among the cultivars, Orange Giant recorded the highest xanthophyll content (0.58 mg/100g fresh wt), regardless of growing conditions. This was followed by Local Orange (0.57 mg/100g fresh wt) and Sonata Orange (0.54 mg/100g fresh wt) which were on par with Orange Giant. The cultivar Biocarve Yellow recorded the least xanthophyll content (0.26 mg/100g fresh wt).

Season II

During second season also, the interaction effect of growing conditions on xanthophyll content of the cultivars was not significant. Irrespective of cultivars, the growing conditions have significant influence on xanthophyll content of the plants. Significantly highest xanthophyll content was recorded under open field condition compared to rain shelter condition. The cultivar Local Orange recorded the highest xanthophyll content (0.59 mg/100g fresh wt) among all the cultivars regardless of growing conditions. This was followed by Sonata Orange (0.58 mg/100g fresh wt) and Orange Giant (0.57 mg/100g fresh wt) which were on par with Local Orange. The least xanthophyll content (0.37 mg/100g fresh wt) was recorded in cultivar Biocarve Yellow.

4.4.2.1 Effect of Seasons on Xanthophyll Content

The xanthophyll content in flowers was not significantly influenced by the seasons under open filed condition whereas, under rain shelter condition there was significant influence of seasons on xanthophyll content in flowers (Table 9(c) and Table 9(d)). In the open field condition (Table 9(c)), Sonata Orange and Local Orange grown during second season recorded the highest xanthophyll content (0.64 mg/100g fresh wt) among the cultivars.

Under rain shelter condition also, higher xanthophyll content was observed during the second season in most of the cultivars (Table 9(d)). The cultivar Orange Giant grown during first season recorded the highest xanthophyll content (0.59 mg/100g fresh wt).

Table 9(a). Effect of growing conditions on xanthophyll and flavonoid contents of African marigold flowers grown during first season (July – November)

Cultivars	Xanthophyll content in flower (mg/100g fresh wt)			Flavonoid content in flower (A_{300}/g fresh wt)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	0.54	0.53	0.54	50.80	44.44	47.62
Sonata Yellow	0.46	0.47	0.47	44.11	41.82	42.97
Biocarve Orange	0.38	0.41	0.39	38.43	36.96	37.70
Biocarve Yellow	0.27	0.24	0.26	37.78	35.73	36.76
Local Orange	0.61	0.53	0.57	46.70	40.62	43.66
Local Yellow	0.48	0.50	0.49	48.92	42.22	45.57
Sierra Yellow	0.45	0.44	0.44	49.20	40.72	44.96
Orange Giant	0.57	0.59	0.58	40.41	43.12	41.76
Mean	0.47	0.46		44.54	40.71	
CD (0.05) (Cultivars)	0.05			3.00		
CD (0.05) (Growing conditions)	NS			1.50		
CD (0.05) (Interaction)	NS			4.24		

G1 – Open field condition G2 – Rain shelter condition

Table 9(b). Effect of growing conditions on xanthophyll and flavonoid contents of African marigold flowers grown during second season (January – April)

Cultivars	Xanthophyll content in flower (mg/100g fresh wt)			Flavonoid content in flower (A_{300}/g fresh wt)		
	G1	G2	Mean	G1	G2	Mean
Sonata Orange	0.64	0.53	0.58	53.56	49.05	51.31
Sonata Yellow	0.51	0.47	0.49	45.45	40.96	43.20
Biocarve Orange	0.45	0.49	0.47	39.73	37.47	38.60
Biocarve Yellow	0.38	0.36	0.37	38.13	35.94	37.03
Local Orange	0.64	0.55	0.59	51.18	46.90	49.04
Local Yellow	0.54	0.52	0.53	48.00	50.86	49.43
Sierra Yellow	0.52	0.48	0.50	51.30	50.88	51.09
Orange Giant	0.58	0.55	0.57	50.29	49.59	49.94
Mean	0.53	0.49		47.21	45.21	
CD (0.05) (Cultivars)	0.05			2.59		
CD (0.05) (Growing conditions)	0.03			1.30		
CD (0.05) (Interaction)	NS			NS		

G1 – Open field condition G2 – Rain shelter condition

Table 9(c). Effect of seasons on xanthophyll and flavonoid contents of African marigold flowers grown in open field condition

Cultivars	Xanthophyll content in flower (mg/100g fresh wt)		Flavonoid content in flower (A_{300}/g fresh wt)	
	S1	S2	S1	S2
Sonata Orange	0.54	0.64	50.80	53.56
Sonata Yellow	0.46	0.51	44.11	45.45
Biocarve Orange	0.38	0.45	38.43	39.73
Biocarve Yellow	0.27	0.38	37.78	38.13
Local Orange	0.61	0.64	46.70	51.18
Local Yellow	0.48	0.54	48.92	48.00
Sierra Yellow	0.45	0.52	49.20	51.30
Orange Giant	0.57	0.58	40.41	50.29
CD (0.05)	NS		3.43	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

Table 9(d). Effect of seasons on xanthophyll and flavonoid contents of African marigold flowers grown under rain shelter condition

Cultivars	Xanthophyll content in flower (mg/100g fresh wt)		Flavonoid content in flower (A_{300}/g fresh wt)	
	S1	S2	S1	S2
Sonata Orange	0.53	0.53	44.44	49.05
Sonata Yellow	0.47	0.47	41.82	40.96
Biocarve Orange	0.41	0.49	36.96	37.47
Biocarve Yellow	0.24	0.36	35.73	35.94
Local Orange	0.53	0.55	40.62	46.90
Local Yellow	0.50	0.52	42.22	50.86
Sierra Yellow	0.44	0.48	40.72	50.88
Orange Giant	0.59	0.55	43.12	49.59
CD (0.05)	0.06		4.17	

S1 – 1st season (July – November) S2 – 2nd season (January – April)

4.4.3 Flavonoid Content in Flowers

Data pertaining to flavonoid content in flowers of all the cultivars grown under open field and rain shelter conditions during the first and second seasons are included in Table 9(a) and Table 9(b) respectively.

Season I

During the first season, highest flavonoid content in the open field condition was recorded in cultivar Sonata Orange (50.80 A_{300}/g fresh wt). This was followed by Sierra Yellow (49.20 A_{300}/g fresh wt), Local Yellow (48.92 A_{300}/g fresh wt) and Local Orange (46.70 A_{300}/g fresh wt) which were statistically on par with Sonata Orange. The least flavonoid content (37.78 A_{300}/g fresh wt) was observed in Biocarve Yellow which was on par with Biocarve Orange (38.43 A_{300}/g fresh wt).

Under rain shelter condition also, Sonata Orange recorded the highest flavonoid content (44.44 A_{300}/g fresh wt). The flavonoid content recorded in the cultivars Orange Giant (43.12 A_{300}/g fresh wt), Local Yellow (42.22 A_{300}/g fresh wt), Sonata Yellow (41.82 A_{300}/g fresh wt), Sierra Yellow (40.72 A_{300}/g fresh wt) and Local Orange (40.62 A_{300}/g fresh wt) were statistically on par with Sonata Orange. Biocarve Yellow recorded the least flavonoid content (35.73 A_{300}/g fresh wt) which was on par with Biocarve Orange (36.96 A_{300}/g fresh wt).

The flavonoid content in flowers was significantly influenced by the growing conditions. Irrespective of cultivars, the plants grown under open field condition recorded significantly higher flavonoid content compared to rain shelter condition. The cultivar Sonata Orange recorded highest flavonoid content (47.62 A_{300}/g fresh wt), irrespective of growing conditions. This was followed by Local Yellow (45.57 A_{300}/g fresh wt) and Sierra Yellow (44.96 A_{300}/g fresh wt) which were on par with Sonata Orange. The least flavonoid content was recorded in cultivar Biocarve Yellow (36.76 A_{300}/g fresh wt) which was on par with Biocarve Orange (37.70 A_{300}/g fresh wt).

Season II

The growing conditions had no significant influence on the cultivars with regard to flavonoid content in flowers. But, irrespective of cultivars, the growing conditions had significant influence on the flavonoid content in flowers. The plants recorded significantly higher flavonoid content under open field condition compared to the rain shelter condition. Among the cultivars, Sonata Orange recorded the highest flavonoid content (51.31 A_{300}/g fresh wt), regardless of growing conditions. The least flavonoid content was recorded in cultivar Biocarve Yellow (37.03 A_{300}/g fresh wt) which was on par with Biocarve Orange (38.60 A_{300}/g fresh wt).

4.4.3.1 Effect of Seasons on Flavonoid Content

Seasons have a significant influence on the flavonoid content of flowers in the open field and rain shelter conditions (Table 9(c) and Table 9(d)). In the open field condition, most of the cultivars recorded higher flavonoid content during the second season compared to first season (Table 9(c)). Highest flavonoid content was observed in cultivar Sonata Orange (53.56 A_{300}/g fresh wt) grown during the first season.

Under rain shelter condition also, higher flavonoid content was observed in most of the cultivars grown during second season. The cultivar Sierra yellow grown during second season recorded the highest flavonoid content (50.88 A_{300}/g fresh wt) among all the cultivars (Table 9(d)).

4.5 BC RATIO

The benefit cost ratio calculated during both the seasons under open field and rain shelter conditions are presented in Table 10(a) and Table 10(b).

In general, the highest benefit cost ratio was recorded in the cultivar Orange Giant (2.71) planted in the open field condition during the first season compared to all other cultivars grown under both growing conditions, during both the seasons.

Table 10(a). Benefit cost analysis under open field and rain shelter condition during first season (5 cent^{-1})

Cultivars	Open field (5 cent)				Rain shelter (5 cent)			
	Marketable yield (kg)	Returns (Rs.)	Total cost (Rs.)	BCR	Marketable yield (kg)	Returns (Rs.)	Total cost (Rs.)	BCR
Sonata Orange	410.53	24631.80	12001.40	2.05	593.89	35633.40	15056.95	2.37
Sonata Yellow	356.97	21418.20	12001.40	1.78	632.08	37924.80	15056.95	2.52
Biocarve Orange	100.25	3609.00	12001.40	0.30	210.51	7578.36	15056.95	0.50
Biocarve Yellow	96.88	3487.68	12001.40	0.29	167.95	6046.20	15056.95	0.40
Local Orange	327.30	15710.40	12001.40	1.31	416.82	20007.36	15056.95	1.33
Local Yellow	305.11	14645.28	12001.40	1.22	653.74	31379.52	15056.95	2.08
Sierra Yellow	118.24	7094.40	12001.40	0.59	242.83	14569.80	15056.95	0.97
Orange Giant	541.89	32513.40	12001.40	2.71	657.04	39422.40	15056.95	2.62

Table 10(b). Benefit cost analysis under open field and rain shelter condition during second season (5 cent^{-1})

Cultivars	Open field (5 cent)				Rain shelter (5 cent)			
	Marketable yield (kg)	Returns (Rs.)	Total cost (Rs.)	BCR	Marketable yield (kg)	Returns (Rs.)	Total cost (Rs.)	BCR
Sonata Orange	106.86	5343.00	9586.40	0.56	158.15	7907.50	12641.95	0.63
Sonata Yellow	132.74	6637.00	9586.40	0.69	190.05	9502.50	12641.95	0.75
Biocarve Orange	37.48	1124.40	9586.40	0.12	44.43	1332.90	12641.95	0.11
Biocarve Yellow	41.93	1257.90	9586.40	0.13	69.58	2087.40	12641.95	0.17
Local Orange	120.16	4806.40	9586.40	0.50	155.67	6226.80	12641.95	0.49
Local Yellow	124.43	4977.20	9586.40	0.52	150.47	6018.80	12641.95	0.48
Sierra Yellow	59.48	2974.00	9586.40	0.31	80.77	4038.50	12641.95	0.32
Orange Giant	159.18	7959.00	9586.40	0.83	202.32	10116.00	12641.95	0.80

Table 11(a). Correlation between different vegetative and floral characters during first season (July – November)

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	Plant height	–	0.754*	–	0.673*	–	0.695*	0.713*	0.632*	0.601*	0.538*	0.655*
X_2	Plant spread		–	0.297*	0.649*	0.415*	0.905*	0.389*	0.801*	0.459*	0.286*	0.443*
X_3	Primary branches			–	0.572*	–	–	–	–	0.329*	0.337*	0.469*
X_4	Secondary branches				–	–	0.518*	0.526*	0.448*	0.599*	0.691*	0.813*
X_5	Leaf area					–	0.411*	–	0.342*	–	–	–
X_6	Stem girth						–	0.304*	0.770*	0.466*	0.303*	0.431*
X_7	Internodal length							–	–	0.543*	0.540*	0.601*
X_8	Days to first flowering								–	0.455*	0.347*	0.417*
X_9	Flower diameter									–	0.777*	0.778*
X_{10}	Flower weight										–	0.925*
X_{11}	Total flower yield											–

* Significant at 5%

Table 11(b). Correlation between different vegetative and floral characters during second season (January – April)

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	Plant height	–	0.797*	0.652*	0.902*	0.364*	0.795*	–	0.702*	0.595*	0.651*	0.721*
X_2	Plant spread		–	0.842*	0.842*	0.445*	0.778*	-0.385*	0.744*	0.370*	0.526*	0.615*
X_3	Primary branches			–	0.671*	–	0.646*	-0.319*	0.726*	0.325*	0.494*	0.549*
X_4	Secondary branches				–	0.417*	0.826*	–	0.680*	0.604*	0.694*	0.706*
X_5	Leaf area					–	–	-0.351*	0.349*	–	–	–
X_6	Stem girth						–	–	0.722*	–	0.649*	0.673*
X_7	Internodal length							–	–	0.329*	–	–
X_8	Days to first flowering								–	–	0.598*	0.509*
X_9	Flower diameter									–	0.613*	0.612*
X_{10}	Flower weight										–	0.875*
X_{11}	Total flower yield											–

* Significant at 5%

During first season, all cultivars except Orange Giant recorded higher benefit cost ratio when under rain shelter condition compared to the open field condition. In the open field condition highest benefit cost ratio was recorded by the cultivar Orange Giant (2.71) followed by Sonata Orange (2.05). Under rain shelter condition also, the cultivar Orange Giant recorded highest benefit cost ratio (2.62) followed by Sonata Yellow (2.52).

During second season, half of the cultivars (Biocarve Orange, Local Orange, Local Yellow and Orange Giant) recorded higher benefit cost ratio in the open field condition. While, the remaining cultivars recorded higher benefit cost ratio under rain shelter condition. In the open field condition, Orange Giant recorded the highest benefit cost ratio (0.83) followed by Sonata Yellow (0.69). Under rain shelter condition also, highest benefit cost ratio was recorded in cultivar Orange Giant (0.83) followed by Sonata Yellow (0.75).

It can be concluded from the above data that, the cultivars in general had a differential performance with respect to the growing conditions, as the interaction effect was significant for all the major parameters of the crop.

4.6 CORRELATION STUDIES

The results of correlation studies on correlation among the different vegetative and floral characters of African marigold during the two seasons are given in Table 11(a) and Table 11(b).

4.6.1 Correlation between Different Vegetative and Floral Characters during the First Season

The plant height of the cultivars was significantly and positively correlated with plant spread, number of secondary branches, stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield (Table 11(a)). The plant spread had a highly significant positive correlation with all other characters. Positive correlation was observed among number of primary branches, number of secondary branches, flower diameter, flower weight and total

flower yield. The number of secondary branches was significantly correlated with stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield. The leaf area, stem girth and days to first flowering were positively correlated with one another. Stem girth was correlated with internodal length and all other floral characters. Internodal length was significantly and positively correlated with flower diameter, flower weight and total flower yield. All the floral characters *viz.*, days to first flowering, flower diameter, flower weight and total flower yield were significantly and positively correlated with one another.

4.6.2 Correlation between Different Vegetative and Floral Characters during the Second Season

During second season, plant height was significantly and positively correlated with all other characters except internodal length (Table 11(b)). A significant but negative correlation was observed between plant spread and internodal length. But the plant spread had a positive correlation with all other characters. The number of primary branches had no correlation with leaf area, but it was negatively correlated with internodal length and positively correlated with rest of the characters. There was no correlation between internodal length and number of secondary branches but, the later was positively correlated with all other characters. The leaf area had a negative correlation with internodal length but a significant positive correlation with days to first flowering. The stem girth, days to first flowering, flower weight and total flower yield were positively correlated with one another. Internodal length was significantly correlated with flower diameter. Days to first flowering and flower diameter were positively correlated with flower weight and total flower yield. Flower weight had a significant and positive correlation with the total flower yield.

Discussion

5. DISCUSSION

African marigold (*Tagetes erecta* L.) is one of the most important traditional flower crops commercially cultivated in different parts of India. In Kerala, the loose flowers of marigold have a constant demand year round. However, due to the intense rainfall and high relative humidity, the commercial production of marigold is quite low under Kerala conditions during monsoon season. Traditional cultivation practices of marigold in open field conditions do not provide any opportunities for environmental control. An improvement in flower quality and productivity can be achieved by rain shelter cultivation, which helps to satisfy the domestic market demands of the crop.

Hence, the present study entitled "Performance of African marigold (*Tagetes erecta* L.) under different growing conditions" was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the year 2015-16. The results obtained on the effect of growing conditions and seasons on growth and yield of African marigold are briefly discussed hereunder.

5.1 VEGETATIVE CHARACTERS

5.1.1 Plant Height

5.1.1.1 Effect of Growing Conditions on Plant Height

The plant height of the cultivars was significantly influenced by the growing conditions during second season. But during first season, growing condition had no significant influence on the plant height of the cultivars (Table 1(a) and Table 1(b)). Irrespective of cultivars, the plants showed better plant height under rain shelter condition compared to the open field condition, during first season. Enhanced height inside rain shelter might be due to the higher concentration of carbon dioxide. Carbon dioxide enrichment of the gerbera plants grown under polyhouse condition was reported by Ahlawat *et al.* (2012). According to Mukherjee (1992), the plants grown under polyhouse conditions exhibited better growth due to more concentration of carbon dioxide and optimum light availability

which favours greater photosynthesis and more photosynthate production as compared to open field condition. This might be the reason for increased plant height under rain shelter condition during both seasons. The differential response of chrysanthemum with respect to plant height under different growing conditions was reported by Gaikwad and Dumbre-Patil, 2001; Swaroop *et al.*, 2006; Talukdar *et al.*, 2006; Gantait and Pal, 2011. Similar findings were also reported in gerbera by Pattanashetti, 2009 and in gladiolus by Dadlani *et al.*, 1990; Sarkar and Maitra, 2005; Islam and Haque, 2011; Kirtimala *et al.*, 2011; Simmy, 2015.

During first season, the cultivar Orange Giant grown under rain shelter condition recorded the highest plant height. While during second season, Sonata Orange grown in the open field condition recorded the highest plant height. The individual cultivar characters might have resulted in variation in plant height among the cultivars.

5.1.1.2 Effect of Seasons on Plant Height

Higher plant height in the open field and rain shelter conditions was recorded during the first season (July – November 2015) and least plant height was observed during the second season (January – April 2016) in all the cultivars (Table 1(c) & Table 1(d) and Fig 5 & Fig 6). First growing season coincided with monsoon hence, high amount of rainfall might have resulted in plenty of water in soil as well as high humidity level in the atmosphere. Significantly positive correlation between soil moisture content and plant height in gerbera was reported by Sartaj (2014). In January planting the soil moisture starts depleting without much water and nutrient movement in the soil. The plants have to exert more energy for the acquisition of water and nutrients from soil. The reduction is vegetative growth especially plant height during second season is probably due to the reduction in rainfall and less soil moisture availability. While during first season, the plants are supplied with enough soil moisture near to field capacity, good rainfall, high relative humidity and maximum nutrient flow in soil which promoted their growth. Similar results on plant height was also reported by Samantaray *et al.*, 1999; Ghosh and Pal, 2008; Pramila *et al.*, 2011; Ismail *et al.*, 2013; Meena *et al.*, 2015;

Mohanty *et al.,* 2015; Prakash, 2015 in African marigold; Naik *et al.*, 2003 in French marigold; Sartaj, 2014 in gerbera; Barman *et al.*, 1997; Meher *et al.*, 1999; Kulkarni and Reddy, 2008 in chrysanthemum.

In the open field and rain shelter conditions, the cultivar Orange Giant grown during first season recorded the highest plant height.

5.1.2 Plant Spread

5.1.2.1 Effect of Growing Conditions on Plant Spread (NS and EW)

Even though better plant spread (NS and EW) was noticed in open field condition during both the seasons, there was no significant difference. Slight variation was noticed in some cultivars like Sonata Yellow, Biocarve Yellow and Sierra Yellow which had more plant spread under rain shelter condition during the first season (Table 1(a) and Table 1(b)). Variation was also observed in cultivars Sonata Orange, Sonata Yellow, Biocarve Orange and Biocarve Yellow during the second season. Irrespective of cultivars, better plant spread was observed in the open field condition than under rain shelter condition during both the seasons. But there was no significant difference between the growing conditions with respect to plant spread. This might be due to the higher leaf area observed in plants grown in the open field condition which contributed to an increase in the plant spread. Higher values for plant spread of the cultivars in the open field condition were also reported by Talukdar *et al.* (2006) in chrysanthemum.

During both the seasons, highest plant spread was recorded in the cultivar Local Yellow grown under open field condition.

5.1.2.2 Effect of Seasons on Plant Spread (NS and EW)

The seasons have significant effect on plant spread (NS and EW) of all the cultivars under open field and rain shelter conditions (Table 1(c) and Table 1(d)). Under both growing conditions, higher plant spread was recorded during the first season compared to second season. July planting recorded the highest plant spread, probably be due to favourable climatic conditions and maximum nutrient

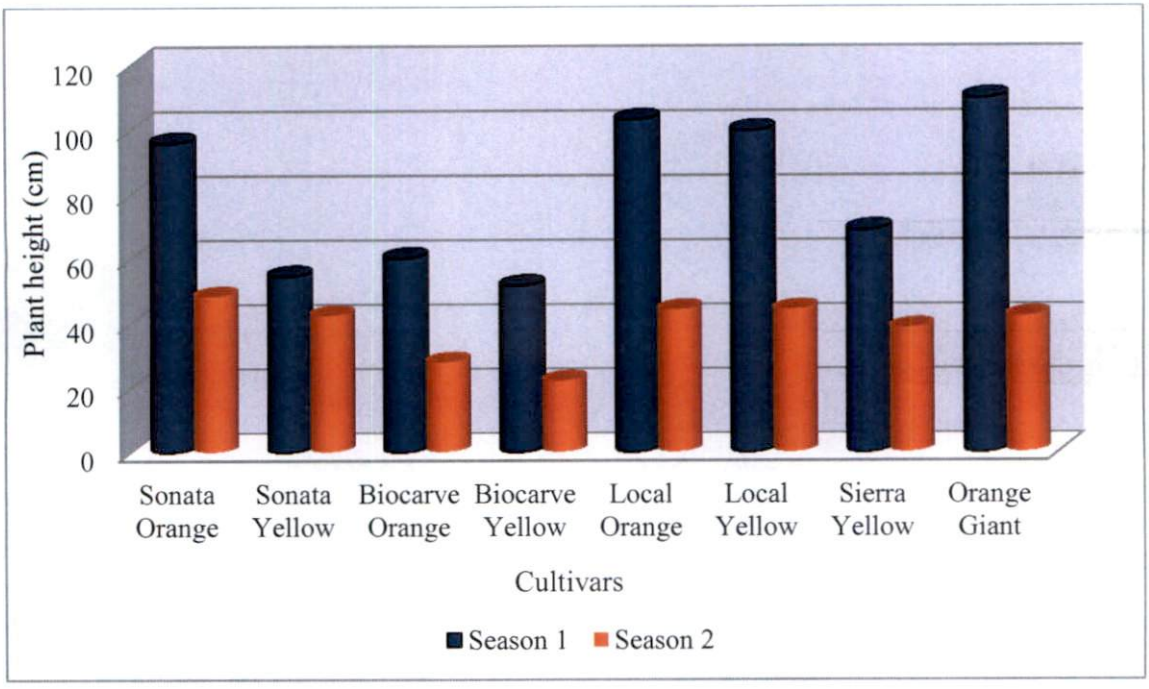


Fig 5. Effect of growing seasons on plant height of the cultivars grown in the open field condition

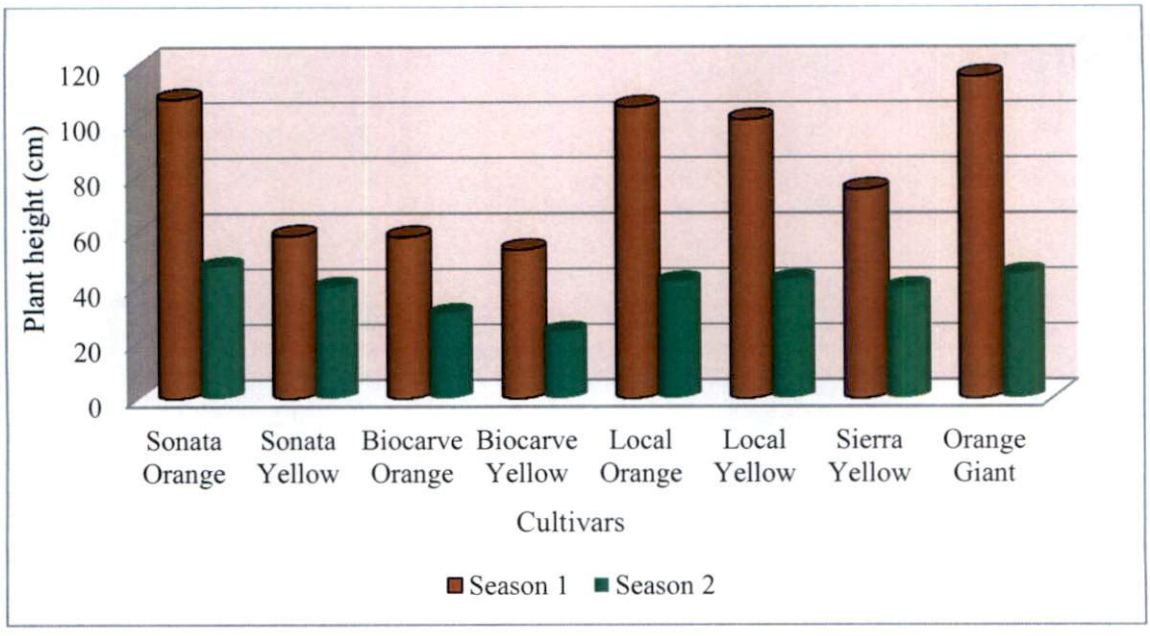


Fig 6. Effect of growing seasons on plant height of the cultivars grown under rain shelter condition

availability which in turn increased the vegetative growth of plants. The performance of the gerbera plants with respect to plant spread varied due to several factors like genotype, environmental factors and growing conditions (Keditsu, 2013). Such variations in plant spread due to seasons were reported by Nair *et al.*, 1985; Chanda and Roychaudhary, 1991; Ritu and Gupta, 2004; Chauhan *et al.*, 2014; Lakshmi *et al.*, 2014; Mohanty *et al.*, 2015 in African marigold; Dilta *et al.*, 2007 in China aster; Kulkarni and Reddy, 2008 in chrysanthemum.

Local Yellow grown during first season recorded the highest plant spread in the open field condition. Under rain shelter condition, highest plant spread was observed in Local Orange grown during first season.

5.1.3 Stem Girth

5.1.3.1 Effect of Growing Conditions on Stem Girth

The stem girth of the cultivars was significantly influenced by the growing conditions. During first and second seasons higher stem girth was observed under the open field condition compared to rain shelter condition (Table 1(a) and Table 1(b)). The higher stem girth in plants under open field condition might be due to the increased leaf area which contributed to more photosynthate accumulation in the main stem of the plants. Variation in stem diameter of chrysanthemum plants with respect to the growing conditions was reported by Budiarto and Marwoto (2009).

During both growing seasons, the cultivar Local Yellow grown in the open field condition recorded the highest stem girth.

5.1.3.2 Effect of Seasons on Stem Girth

Higher stem girth both in the open field and rain shelter conditions was recorded during the first season compared to second season (Table 1(e) and Table 1(f)). The better stem girth in July planted crop might be due to the higher vegetative growth observed during the season. Similar findings were reported by

the workers Meena *et al.* (2015) in African marigold and Kulkarni and Reddy (2008) in chrysanthemum.

In the open field condition, Local Yellow grown during first season recorded the highest stem girth while, the cultivar Local Orange grown during first season recorded highest stem girth under rain shelter condition.

5.1.4 Internodal Length

5.1.4.1 Effect of Growing Conditions on Internodal Length

During first season, the internodal length of the cultivars was significantly influenced by the growing conditions. But during second season, growing conditions have no significant influence on internodal length of the cultivars (Table 1(a) and Table 1(b)). Irrespective of cultivars the plants recorded higher internodal length under rain shelter condition during the second season. The increase in internodal length of plants grown under rain shelter condition was possibly due to the increased plant height recorded in those plants.

During the first season, highest internodal length was observed in cultivar Orange Giant grown in the open field condition. Highest internodal length during second season was also recorded in the cultivar Orange Giant grown under rain shelter condition.

5.1.4.2 Effect of Seasons on Internodal Length

The internodal length of the cultivars was significantly influenced by the seasons under both growing conditions. The cultivars recorded higher internodal length when grown during first season compared to the second season, both in the open field and rain shelter conditions (Table 1(e) & Table 1(f) and Fig 7 & Fig 8). This was probably due to the significant and positive correlation between plant height and internodal length observed during the first season.

Under open field and rain shelter conditions, highest internodal length was recorded in cultivar Orange Giant grown during the first season.

5.1.5 Number of Primary Branches

5.1.5.1 Effect of Growing Conditions on Number of Primary Branches

Growing condition had no significant influence on the cultivars with regard to number of primary branches, during first season. While during second season, the number of primary branches of the cultivars was significantly influenced by the growing conditions (Table 2(a) and Table 2(b)). Irrespective of cultivars, the plants recorded significantly higher number of primary branches when grown under rain shelter condition compared to the open field condition, during first season. The carbon dioxide enrichment bring about enhanced photosynthetic rate of plants (Panigrahi *et al.*, 2016) grown under rain shelter condition. The increase in the number of primary branches per plant under rain shelter condition might be due to the enhanced rate of growth inside rain shelter. Superiority in the growth characters of plants grown under polyhouse condition was reported by Swaroop *et al.*, 2006; Gantait and Pal, 2011 in chrysanthemum.

Highest number of primary branches during first season was recorded in the cultivar Local Orange grown under rain shelter condition. During second season, Local Yellow grown in the open field condition recorded maximum number of primary branches.

5.1.5.2 Effect of Seasons on Number of Primary Branches

Growing seasons have no significant influence on number of primary branches of the cultivars, both under open field and rain shelter conditions (Table 2(c) and Table 2(d)).

In the open field condition Local Yellow grown during second season recorded highest number of primary branches while, under rain shelter condition Local Orange grown during first season recorded the highest number of primary branches per plant.

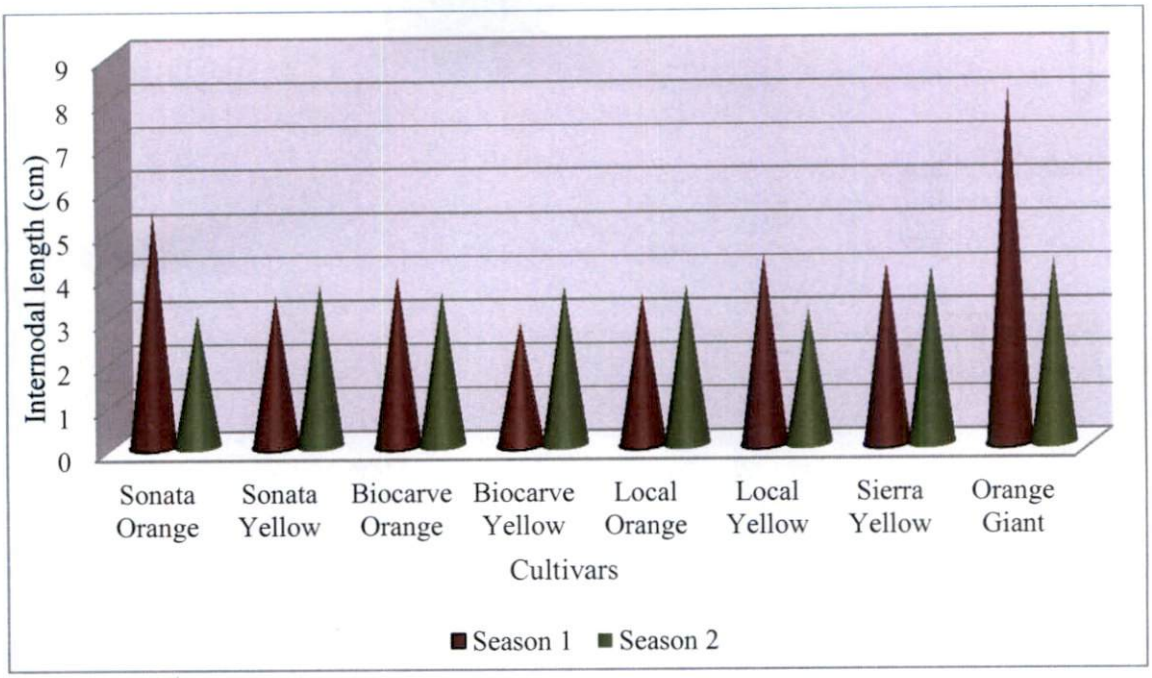


Fig 7. Effect of growing seasons on internodal length of the cultivars grown in the open field condition

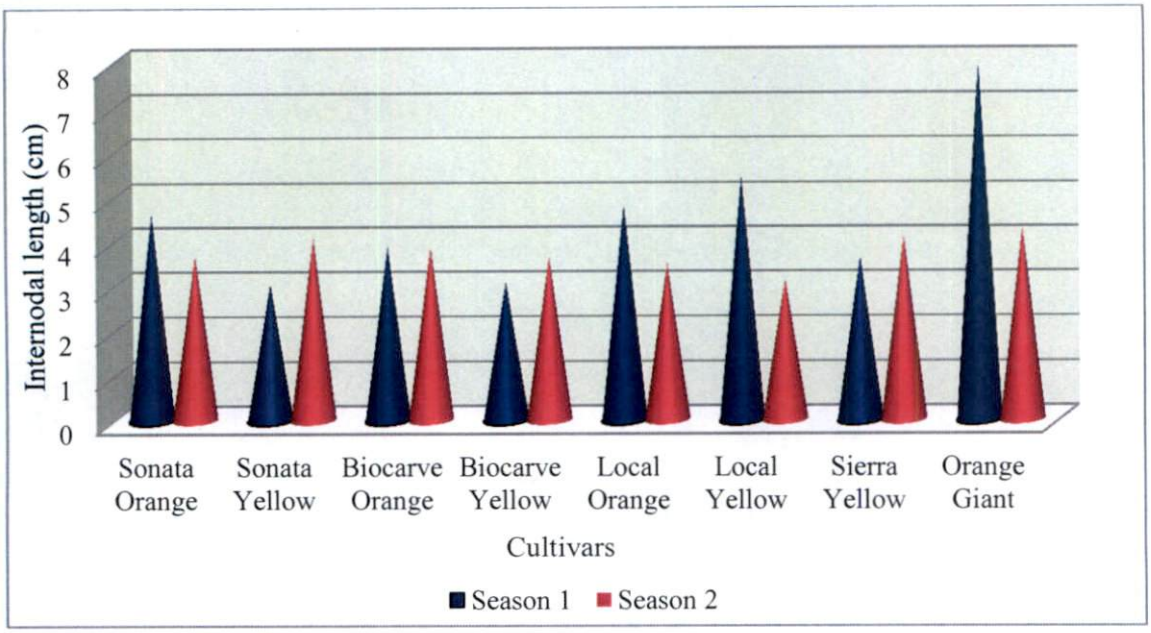


Fig 8. Effect of growing seasons on internodal length of the cultivars grown under rain shelter condition

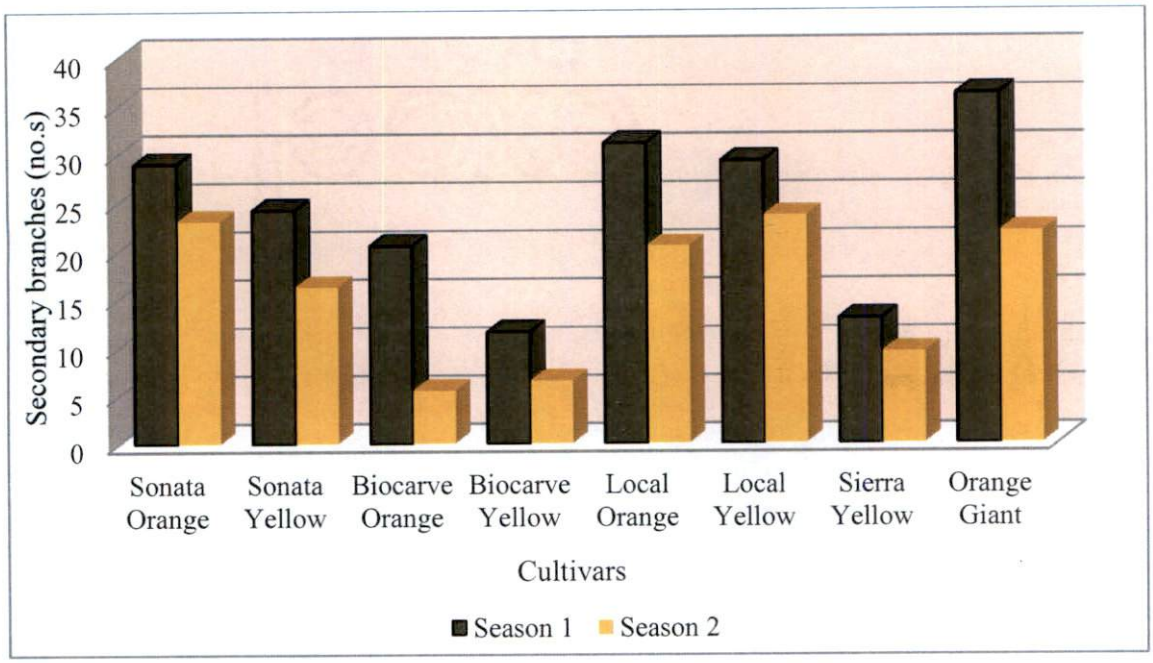


Fig 9. Effect of growing seasons on number of secondary branches of the cultivars grown in the open field condition

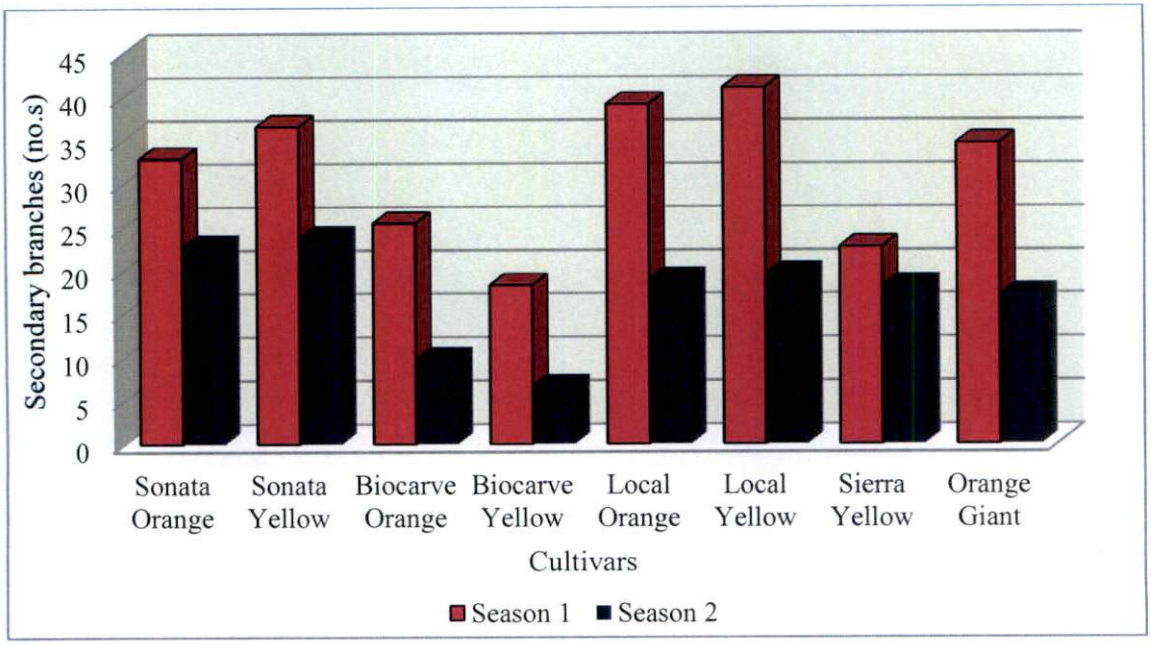


Fig 10. Effect of growing seasons on number of secondary branches of the cultivars grown under rain shelter condition

5.1.6 Number of Secondary Branches

5.1.6.1 Effect of Growing Conditions on Number of Secondary Branches

The number of secondary branches of the cultivars was not significantly influenced by the growing conditions during first season. But, growing condition had significant influence on number of secondary branches during the second season (Table 2(a) and Table 2(b)). During first season, the plants recorded significantly higher number of secondary branches under rain shelter condition, regardless of cultivars. Higher number of secondary branches under rain shelter condition might be attributed to the enhanced vegetative growth inside rain shelter in terms of plant height, internodal length, number of primary branches *etc*. Higher number of secondary branches produced inside rain shelter indicated that the environmental condition inside rain shelter was more favourable for plant growth than that in the open field condition (Budiarto and Marwoto, 2009). Similar variations in number of secondary branches per plant in chrysanthemum have been previously reported by Gantait and Pal (2011).

During first season, highest number of secondary branches was recorded in Local Yellow grown under rain shelter condition. Highest number of secondary branches during second season was recorded in Sonata Yellow grown under rain shelter condition.

5.1.6.2 Effect of Seasons on Number of Secondary Branches

Higher number of secondary branches was observed during the first season both under open field and rain shelter conditions (Table 2(c) & Table 2(d) and Fig 9 & Fig 10). The increased vegetative growth due to favourable climatic and soil conditions which have resulted in more nutrient absorption might be the reason for more number of secondary branches in the July planted crop. Variation in number of secondary branches with respect to seasons was also reported by Ghosh and Pal, 2008; Kulkarni and Reddy, 2008; Nawaz *et al.*, 2009; Mohanty *et al.*, 2015; Prakash, 2015; in African marigold; Aamir *et al.*, 2009 in chrysanthemum.

Highest number of secondary branches in the open field condition was recorded in Orange Giant grown during the first season. Under rain shelter condition, Local Yellow grown during first season recorded the highest number of secondary branches per plant.

5.1.7 Leaf Length

5.1.7.1 Effect of Growing Conditions on Leaf Length

Leaf length of the cultivars was significantly influenced by the growing conditions during the first and second seasons (Table 3(a) and Table 3(b)). The cultivars recorded higher leaf length when grown in the open field condition compared to rain shelter condition, during both seasons. According to Nawaz *et al.* (2009), the leaf number had a direct relationship with number of branches and the leaf area was less when the number of leaves was more. Increased leaf area in plants with less number of leaves was also reported by Riaz *et al.* (2013). Hence, the reduction in number of branches per plant in the open field condition might have resulted in less number of leaves with more leaf area.

During first season, Local Orange grown under rain shelter condition recorded the highest leaf length. Highest leaf length was recorded in cultivar Local Yellow grown in open field condition, during the second season.

5.1.7.2 Effect of Seasons on Leaf Length

Under both growing conditions, more leaf length was observed during the first season compared to second season (Table 3(c) and Table 3(d)). The plants are exposed to stress under low soil moisture conditions during second season, which coincided with low rainfall and high temperature period. Hence, the plants tend to decrease the leaf size in order to reduce the transpiration loss of water. This might be the reason for reduction in leaf length in January planted crop. To avoid excess transpiration loss (Parsons, 1982), a reduction in the leaf area as well as modification of leaves to spindle shape in cowpea during water stressed condition was reported by Warrag and Hall (1984).

In the open field and rain shelter conditions, the cultivar Local Yellow grown during second season recorded the highest leaf length.

5.1.8 Leaf Breadth

5.1.8.1 Effect of Growing Conditions on Leaf Breadth

The leaf breadth of the cultivars was not significantly influenced by growing conditions during first season. But the growing conditions have significant influence on leaf breadth of the cultivars during second season (Table 3(a) and Table 3(b)). Irrespective of cultivars, significantly higher leaf breadth was recorded in plants grown in the open field condition during first season. The reduction in plant height and number of branches observed in the open field condition might have resulted in more accumulation of photosynthates in the leaf which probably resulted in higher leaf breadth under open field condition.

Highest leaf breadth during first season was recorded in cultivar Local Orange grown under the rain shelter condition. During second season, highest leaf breadth was recorded in Sonata Yellow grown under rain shelter condition.

5.1.8.2 Effect of Seasons on Leaf Breadth

In the open field and rain shelter conditions, higher leaf breadth was recorded during the first season (Table 3(c) and Table 3(d)). The reduction in rainfall and soil moisture content leading to less nutrient absorption was probably responsible for the decrease in leaf breadth of January planted crop.

In the open field condition, highest leaf breadth was recorded in Local Yellow grown during first season. Highest leaf breadth under open field condition was recorded in Local Orange grown during the first season.

5.1.9 Leaf Area

5.1.9.1 Effect of Growing Conditions on Leaf Area

Growing conditions have no significant influence on leaf area of the cultivars during first season. While during second season, the leaf area of the cultivars was significantly influenced by the growing conditions (Table 3(a) and Table 3(b)). During second season, higher leaf area was recorded in the open field condition. This can be attributed to the more leaf length and leaf breadth noticed in plants grown in the open field condition during the second season. The plants responded by increasing their leaf area for the accumulation of photosynthates. Variation in leaf area with respect to the growing conditions was reported by Gantait and Pal (2011) in chrysanthemum and Simmy (2015) in gladiolus.

During first season, Local Orange grown under rain shelter condition recorded the highest leaf area. During second season, highest leaf area was observed in Local Yellow grown in the open field condition.

5.1.9.2 Effect of Seasons on Leaf Area

The leaf area of the cultivars differed significantly with respect to the growing seasons under rain shelter condition. But in the open field condition, there was no significant influence of growing seasons on leaf area of the cultivars (Table 3(e) and Table 3(f)). Under rain shelter condition, the cultivars recorded more leaf area during first season compared to the second season. Obviously the reduction in leaf area of the cultivars might be due to the reduction in leaf length and leaf breadth noticed during the second season. The results were in line with the findings of Prakash, 2015 in African marigold; Gowda, 1990 in China aster; Barman *et al.*, 1997; Kulkarni and Reddy, 2008; Aamir *et al.*, 2009; Nawaz *et al.*, 2009 in chrysanthemum; Dod *et al.*, 1989, Misra, 1997; Ahamad *et al.*, 2011, Kumari *et al.*, 2011; Mohammad *et al.*, 2012 in gladiolus.

Highest leaf area in the open field condition was recorded in Local Yellow grown during the first season, whereas under rain shelter condition highest leaf area was recorded in cultivar Local Orange grown during the first season.

5.1.10 Petiole Length

5.1.10.1 Effect of Growing Conditions on Petiole Length

During both seasons, the petiole length of the cultivars was significantly influenced by the growing conditions (Table 3(a) and Table 3(b)). The cultivars recorded higher petiole length in the open field condition, during both the seasons. Higher petiole length in open field grown plants might be due to the higher leaf area, consequent to increased leaf length and leaf breadth.

The cultivar Biocarve Yellow grown in the open field condition recorded highest petiole length during first season. While, during second season the cultivar Local Orange grown in open field condition recorded the highest petiole length.

5.1.10.2 Effect of Seasons on Petiole Length

Significant influence of seasons on petiole length was observed under the open field and rain shelter conditions. Higher petiole length was recorded during the first season under both growing conditions (Table 3(e) and Table 3(f)). The increased petiole length during first season might be due to the better vegetative growth of the plants during the first (rainy) season. The variations in petiole length among cultivars might be due to differences in genetic makeup of the plants.

In the open field condition, Biocarve Yellow grown during first season recorded the highest petiole length. The cultivar Sonata Orange grown during first season recorded highest petiole length under rain shelter condition.

5.1.11 Crop Duration

5.1.11.1 Effect of Growing Conditions on Crop Duration

During the first and second seasons, higher crop duration was recorded in plants grown under rain shelter condition which was significantly superior to open field condition. Under protected conditions, the plants are sheltered from environmental conditions like high rainfall and high light intensity, hence they can grow optimally (Budiarto and Marwoto, 2009). The increased crop duration under rain shelter condition might be due to the higher vegetative growth observed in plants grown under rain shelter. Because of the greater vegetative growth under rain shelter condition, the plants have a good carbohydrate reserve to produce flowers for an extended period therefore the overall crop duration increased.

During first season, highest crop duration was recorded in the cultivar Orange Giant grown under rain shelter condition. Highest crop duration during second season was recorded in Local Yellow grown under rain shelter condition.

5.1.11.2 Effect of Seasons on Crop Duration

Growing seasons have significant influence on crop duration of the cultivars. The cultivars recorded more crop duration during the first season both under open field and rain shelter conditions. Due to enough soil moisture, good rainfall, high relative humidity and maximum nutrient flow during rainy season, the plants remain metabolically active for an extended period (Sartaj, 2014). According to Gaastra (1980), high temperatures accelerate the growth process in plants. This might be the reason for the faster completion of life cycle by the January planted crop. Seasonal variation in crop duration was also reported by Simmy (2015) in gladiolus.

In the open field condition, highest crop duration was recorded in cultivar Sonata Orange grown during first season. Highest crop duration under rain shelter condition was recorded in Orange Giant grown during the first season.

5.2 FLORAL CHARACTERS

5.2.1 Days to First Flowering

5.2.1.1 Effect of Growing Conditions on Days to First Flowering

During both seasons, the cultivars took relatively less number of days for first flowering under rain shelter condition compared to the open field condition (Table 4(a) & Table 4(b) Fig 11 & Fig 12). Since the plants under rain shelter condition produced more number of branches, the number of leaves will be more, thereby the plants will accumulate more carbohydrates. The early flowering might be due to the accumulation of more carbohydrate in plants. The plants with enough carbohydrate reserve will come to reproductive phase earlier (Malhotra and Kumar, 2000). This might be the reason for early flowering of cultivars grown under rain shelter condition. A reduction in time taken for flowering under rain shelter condition compared to open field condition was reported by Swaroop *et al.*, 2006 in chrysanthemum; Sivasamy and Dadlani, 2002; Islam and Haque, 2011; Simmy, 2015 in gladiolus. Thus the result of the present study is in conformity with the reports in other flower crops.

During first season, Biocarve Orange grown under rain shelter condition recorded the least number of days for first flowering. While, during second season, the cultivar Biocarve Yellow grown under rain shelter condition recorded the least number of days for first flowering.

5.2.1.2 Effect of Seasons on Days to First Flowering

Both under open field and rain shelter conditions, the plants took relatively less number of days for first flowering during the second season compared to first season (Table 4(c) & Table 4(d) and Fig 13 & Fig 14). According to Parthasarathy and Nagaraju (2003), the initiation of flower bud, its growth, development and flowering were faster during the warmer period in gerbera. The crop planted during July took more number of days for first flowering compared to January planting, possibly due to the high rainfall conditions which favoured their vegetative growth

which resulted in slow entry to the reproductive phase. Hence, the initiation of reproductive phase was delayed in first (rainy) season crop. The greater tendency of plants to continue their vegetative growth during rainy season was reported by Pramila *et al.*, 2011; Ismail *et al.*, 2013; Prakash, 2015 in African marigold; Barman *et al.*, 1997 in chrysanthemum. Variation in days to first flowering with respect to seasons was also reported by Samantaray *et al.*, 1999; Rao and Reddy, 2002 in African marigold. The present result is also in conformity with their findings.

Under both growing conditions, the cultivar Biocarve Yellow grown during second season recorded the least number of days for first flowering.

5.2.2 Days to 50 per cent Flowering

5.2.2.1 Effect of Growing Conditions on Days to 50 per cent Flowering

The number of days to 50 per cent flowering of the cultivars was significantly influenced by the growing conditions, during both seasons (Table 4(a) & Table 4(b) and Fig 15 & Fig 16). During first season, the plants under rain shelter condition took less number of days for 50 per cent flowering. During second season also the plants under rain shelter condition took less number of days for 50 per cent flowering compared to the plants in open field condition. This was probably due to the presence of more carbohydrate reserve in plants under rain shelter condition compared to open field condition. However, variation could be observed among cultivars with regard to days for 50 per cent flowering. Variation among cultivars in days taken for flowering with regard to growing conditions was also reported by Talukdar *et al.* (2006) and Gantait and Pal (2011) in chrysanthemum.

Least number of days for 50 per cent flowering was recorded in cultivar Biocarve Orange grown in the open field condition during first season. The cultivar Biocarve Yellow grown under rain shelter condition took the least number of days for 50 per cent flowering.

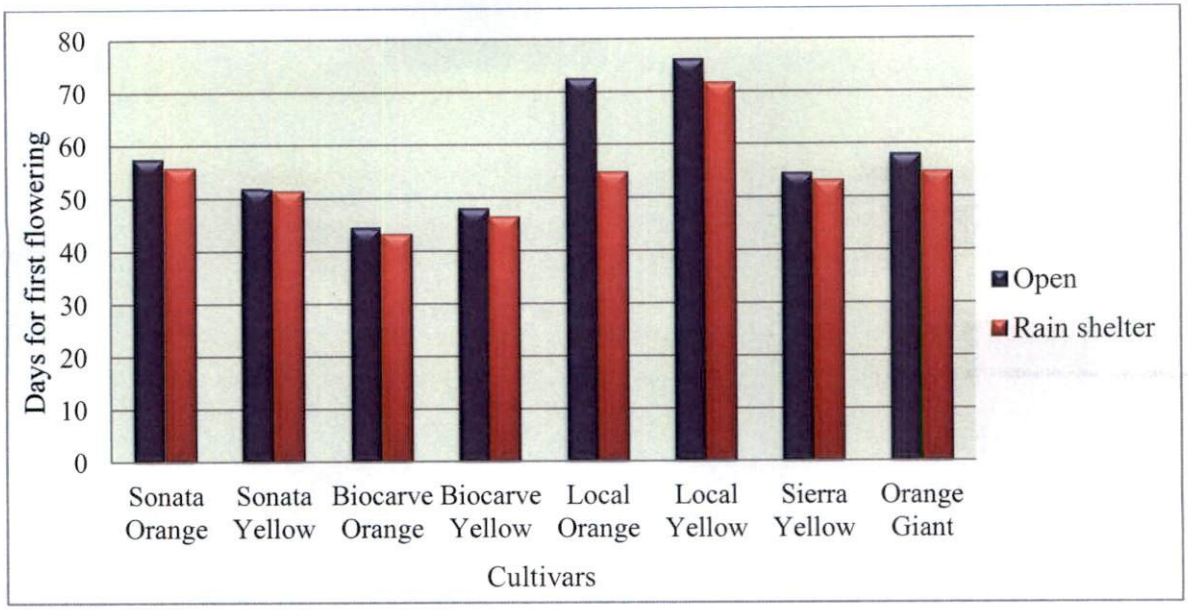


Fig 11. Effect of growing conditions on days for first flowering of the cultivars grown during first season (July - November)

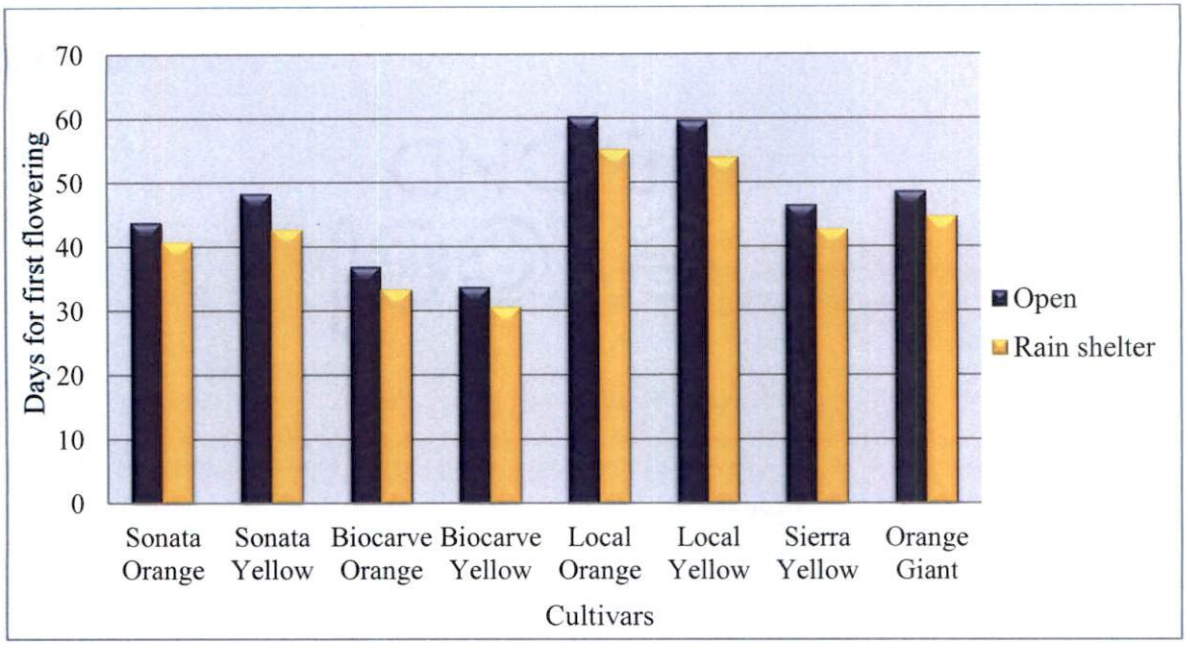


Fig 12. Effect of growing conditions on days for first flowering of the cultivars grown during second season (January - April)

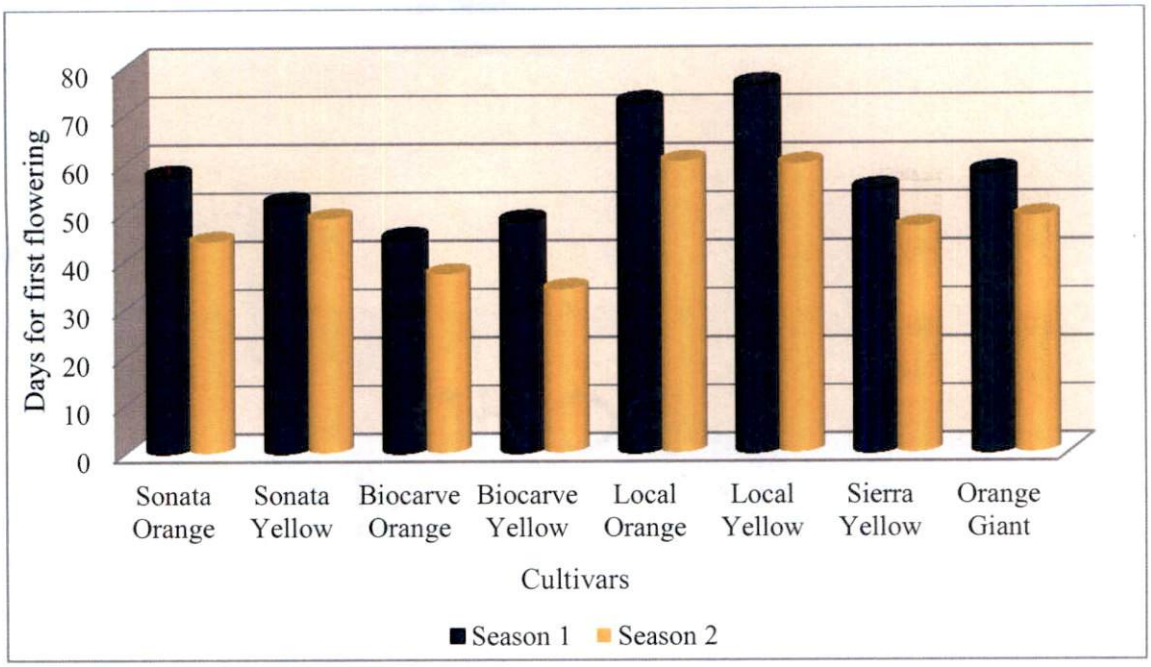


Fig 13. Effect of growing seasons on days for first flowering of the cultivars grown in the open field condition

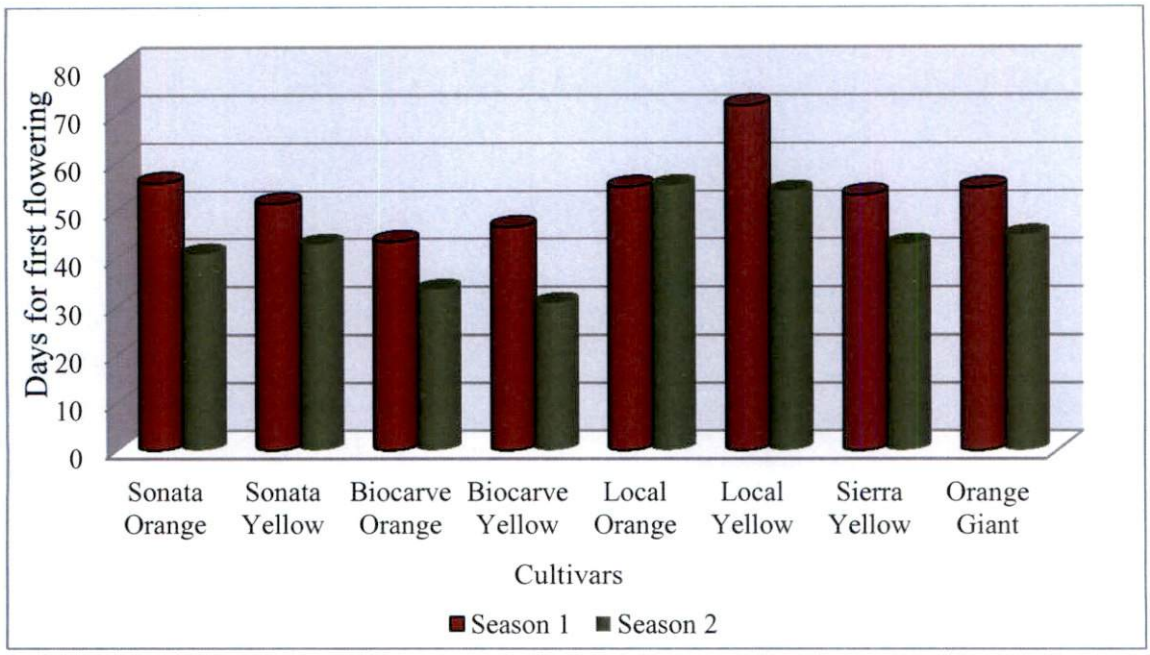


Fig 14. Effect of growing seasons on days for first flowering of the cultivars grown under rain shelter condition

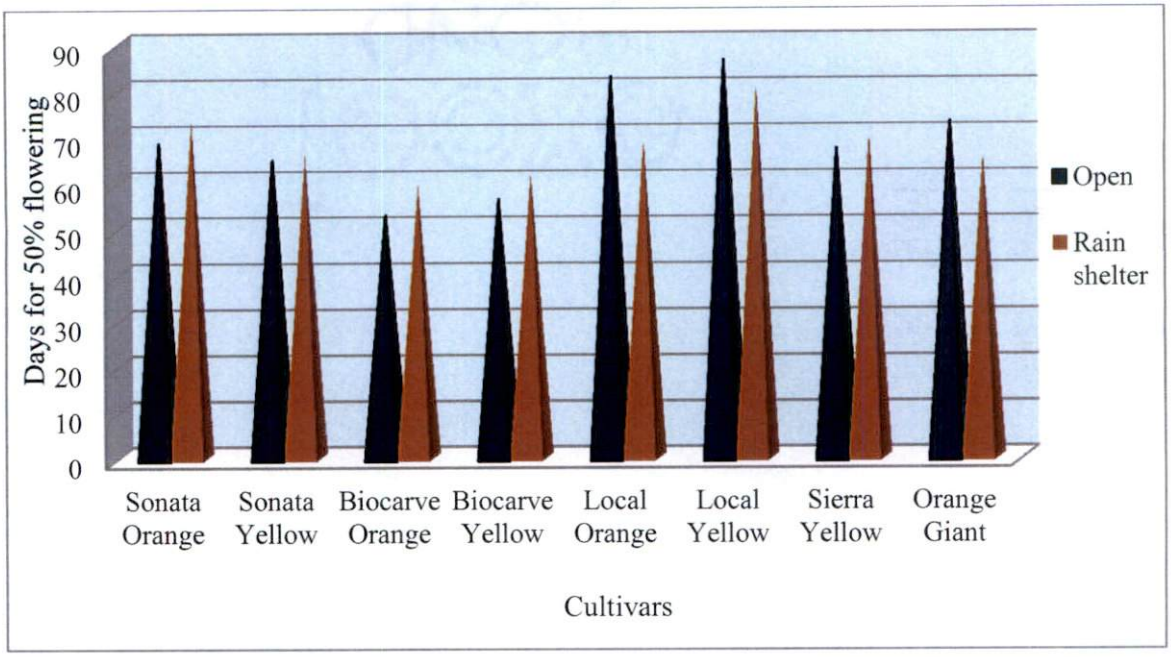


Fig 15. Effect of growing conditions on days for 50 per cent flowering of the cultivars grown during first season (July - November)

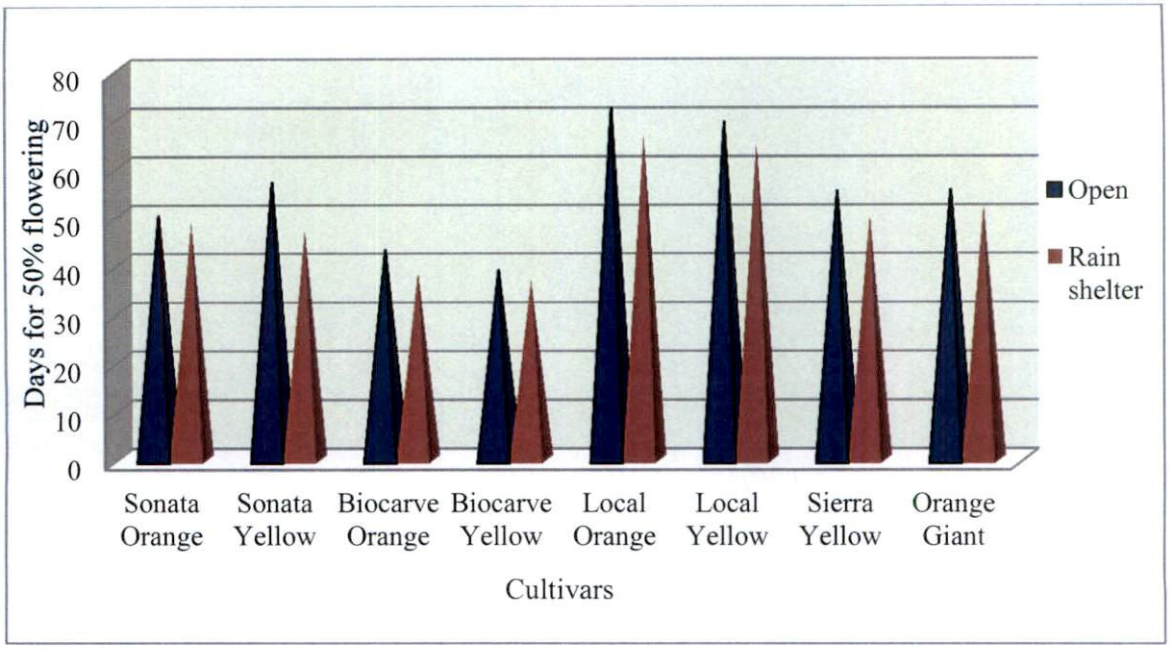


Fig 16. Effect of growing conditions on days for 50 per cent flowering of the cultivars grown during second season (January - April)

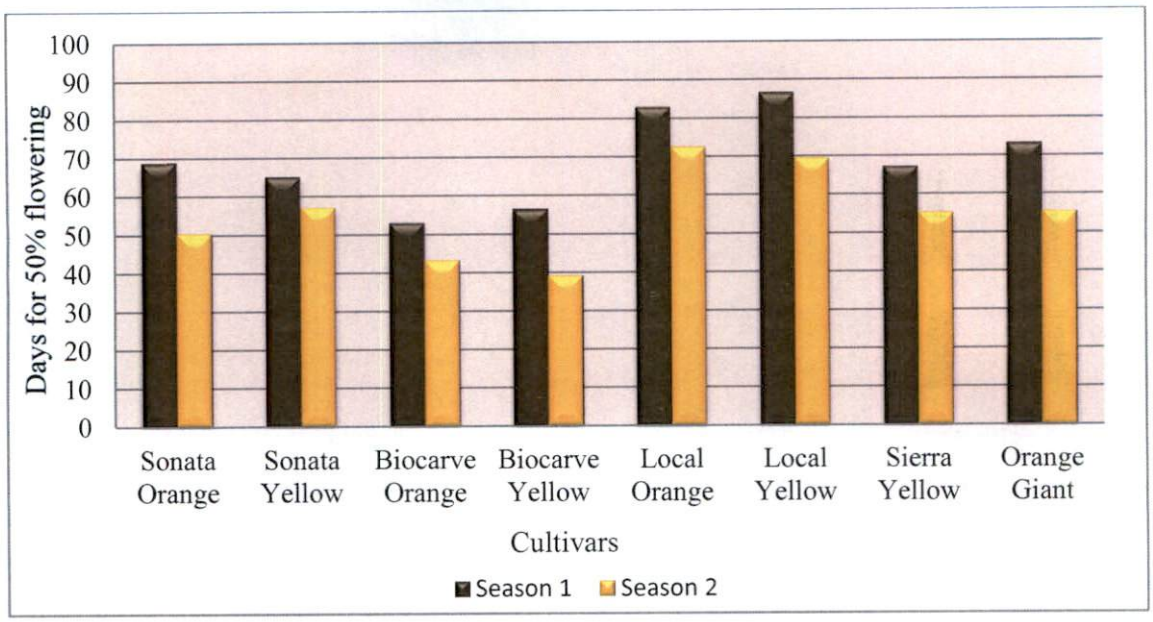


Fig 17. Effect of growing seasons on days for 50 per cent flowering of the cultivars grown in the open field condition

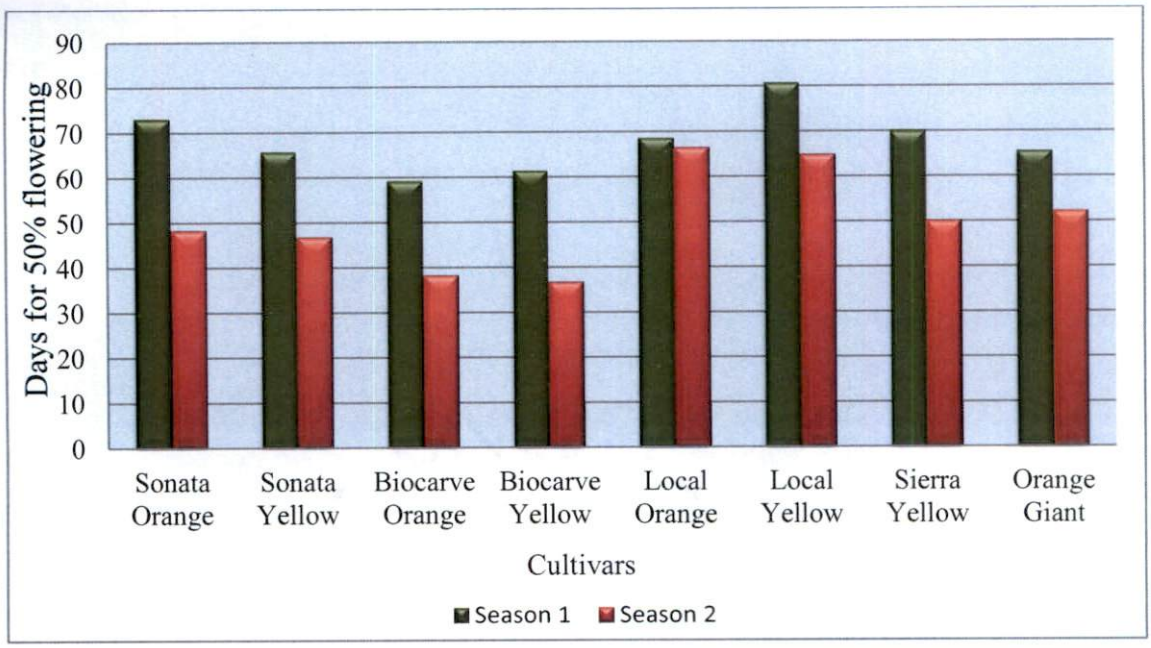


Fig 18. Effect of growing seasons on days for 50 per cent flowering of the cultivars grown under rain shelter condition

5.2.2.2 Effect of Seasons on Days to 50 per cent Flowering

The seasons have significant influence on days for 50 per cent flowering in all the cultivars, under both growing conditions. All the cultivars recorded less number of days for 50 per cent flowering during second season, both under open field and rain shelter conditions (Table 4(c) & Table 4(d) and Fig 17 & Fig 18). This might be due to the prolonged vegetative growth in plants during the (first) rainy season. Several scientists have reported differences in days for 50 per cent flowering with respect to the planting season in different flower crops (Prakash, 2015 in African marigold; Meher *et al.*, 1999 in chrysanthemum; Gowda, 1990 in China aster).

Under both growing conditions, least number of days for 50 per cent flowering was recorded in cultivar Biocarve Yellow grown during the second season.

5.2.3 Flower Diameter

5.2.3.1 Effect of Growing Conditions on Flower Diameter

Growing conditions have significant influence on flower diameter of the cultivars during both seasons (Table 5(a) & Table 5(b) and Fig 19 & Fig 20). Higher flower diameter during both seasons was recorded in plants grown under rain shelter condition compared to open field condition. The availability of optimum light intensity would produce and maintain better carbohydrate reserve in plants inside rain shelter that will be diverted for quality flower production (Mohanty *et al.*, 2011). The better carbohydrate reserve in plants under rain shelter condition might have contributed to production of flowers with large size. Similar results were reported by Swaroop *et al.*, 2006; Talukdar *et al.*, 2006; Gaikwad and Dumbre-Patil, 2001; Gantait and Pal, 2011 in chrysanthemum. Singh and Srivastava (2008) also reported the production of better sized flowers in gerbera grown under low cost polyhouse condition.

During the first season, highest flower diameter was recorded in plants grown in the open field condition. Highest flower diameter during the second season was recorded in Sonata Orange grown under open field condition.

5.2.3.2 Effect of Seasons on Flower Diameter

Growing seasons have significant influence on flower diameter of the cultivars both under open field and rain shelter conditions (Table 5(c) & Table 5(d) and Fig 21 & Fig 22). Under both growing conditions, more flower diameter was observed during the first season compared to second season. As the flower size increases the appearance as well as the market value of the flowers will be improved. The favourable weather parameters prevailed during the first season might have resulted in good sized flowers. The moderate temperature prevailed during the crop growing period might have helped the plants to grow vigorously, resulted in production of bigger sized flowers in marigold (Mohanty *et al.*, 2015). Similar results were reported by Chanda and Roychaudhary, 1991; Ghosh and Pal, 2008; Mohanty *et al.*, 2012; Chauhan *et al.*, 2014; Lakshmi *et al.*, 2014; Prakash, 2015 in African marigold; Raju *et al.*, 2006 in French marigold; Singh and Srivastava, 2008 in gerbera; Mathad *et al.*, 2008 in China aster; Dod *et al.*, 1989; Sivasamy and Dadlani, 2002; Sarkar and Maitra, 2005; Bagde *et al.*, 2009; Simmy, 2015 in gladiolus.

In the open field condition, Orange Giant grown during first season recorded the highest flower diameter. The cultivar Sonata Orange grown under rain shelter condition recorded highest flower diameter during the first season.

5.2.4 Flower Length

5.2.4.1 Effect of Growing Conditions on Flower Length

During first season, the growing conditions have no significant influence on flower length of the cultivars. But, the flower length of the cultivars was significantly influenced by the growing conditions during second season (Table 5(a) and Table 5(b)). The cultivars recorded more flower length under rain shelter

condition compared to open field condition, during second season. The variation in pedicel length might be attributed to the variation in flower length. Gantait and Pal (2011), Meher *et al.* (1999) and Gaikwad and Dumbre-Patil (2001) reported higher flower length in chrysanthemum plants under polyhouse condition compared to open field condition.

The cultivar Orange Giant grown in the open field condition recorded the highest flower length, during first season. While, during second season Sonata Yellow grown under rain shelter condition recorded the highest flower length.

5.2.4.2 Effect of Seasons on Flower Length

The growing seasons significantly influenced the flower length of the cultivars grown under open field and rain shelter conditions (Table 5(c) & Table 5(d) and Fig 23 & Fig 24). Higher flower length under both growing conditions was noticed during the first season. The increased flower length in the first season crop might be due to the profused vegetative growth, resulted in synthesis of more photosynthates which in turn increased the flower length. Variation in spike length in gladiolus with respect to planting time was reported by Sheikh and Jhon (2005) and Bagde *et al.* (2009).

Highest flower length was recorded in Orange Giant grown during first season in the open field condition. Under rain shelter condition, Sierra Yellow grown during first season recorded the highest flower length.

5.2.5 Pedicel Length

5.2.5.1 Effect of Growing Conditions on Pedicel Length

During first season, pedicel length of the cultivars was not significantly influenced by the growing conditions. While, growing conditions have significant influence on pedicel length of the cultivars during second season (Table 5(a) and Table 5(b)). During second season, most of the cultivars recorded more pedicel length under rain shelter condition compared to open field condition. During second season, due to the variation in weather conditions especially temperature, in

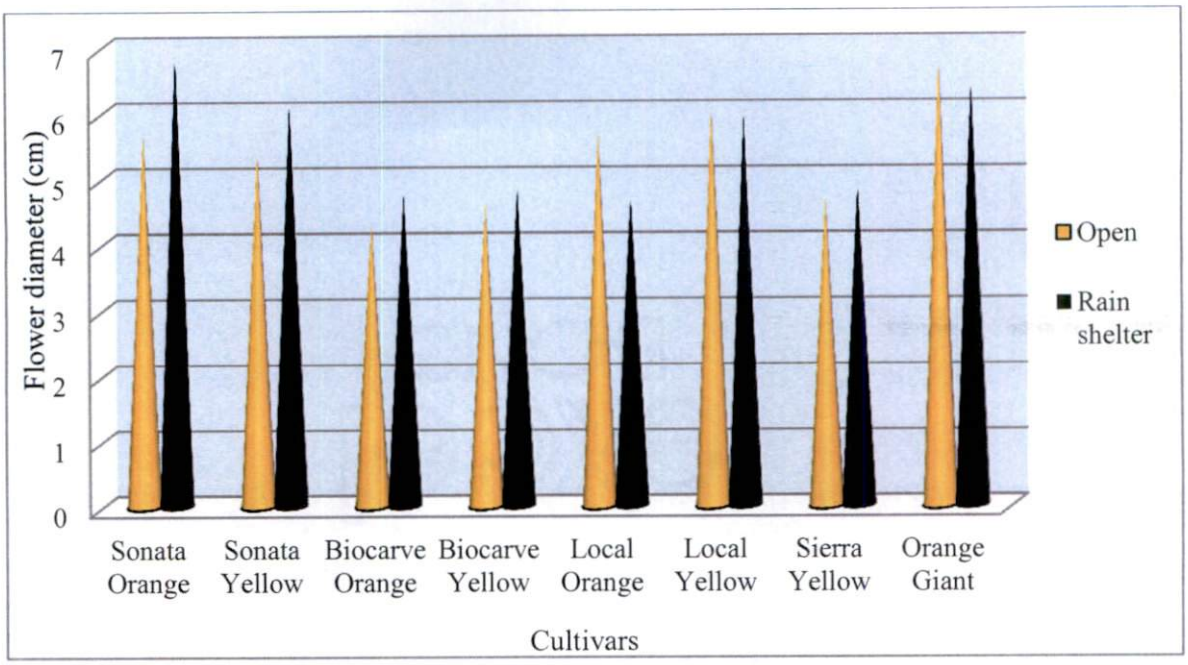


Fig 19. Effect of growing conditions on flower diameter of the cultivars grown during first season (July - November)

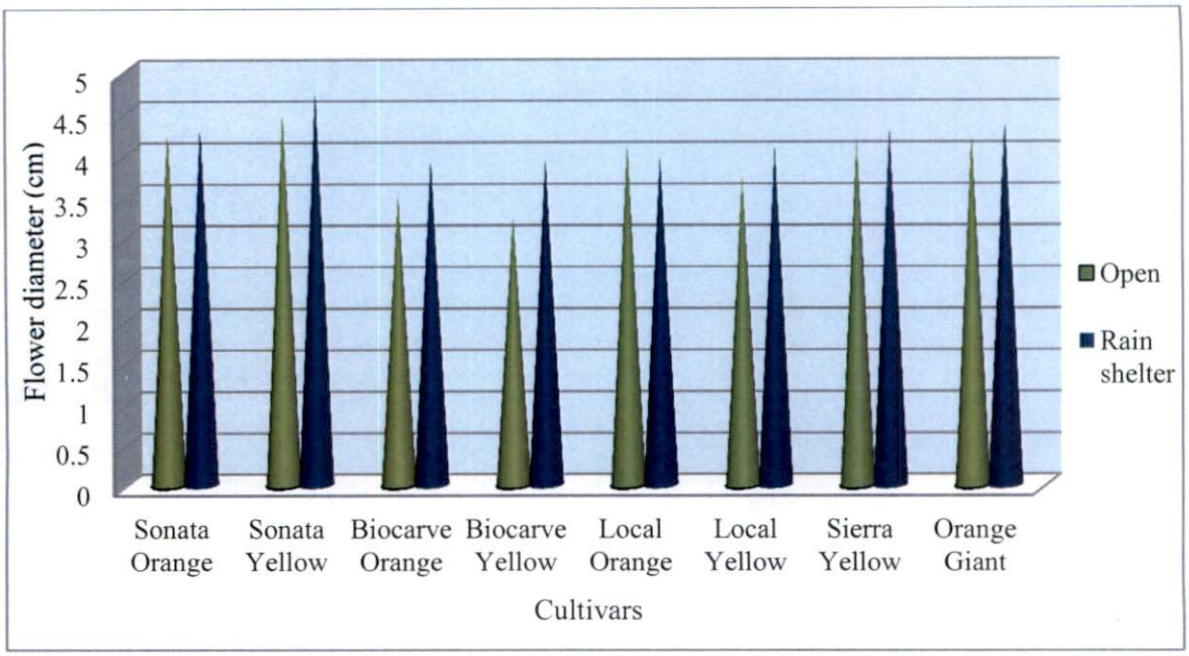


Fig 20. Effect of growing conditions on flower diameter of the cultivars grown during second season (January - April)

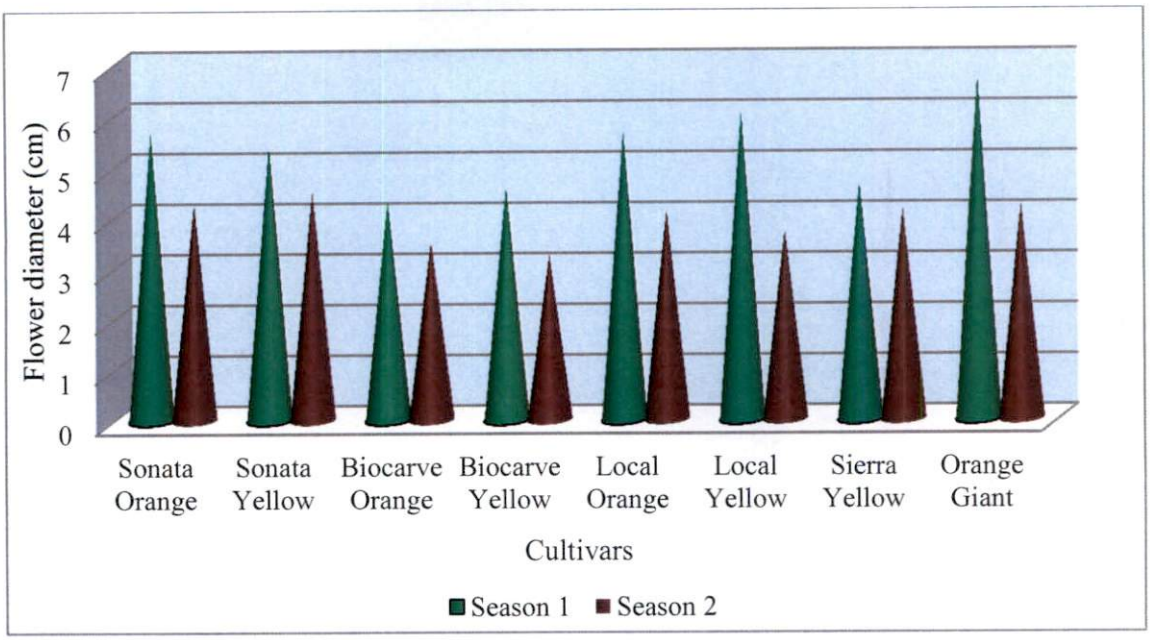


Fig 21. Effect of growing seasons on flower diameter of the cultivars grown in the open field condition

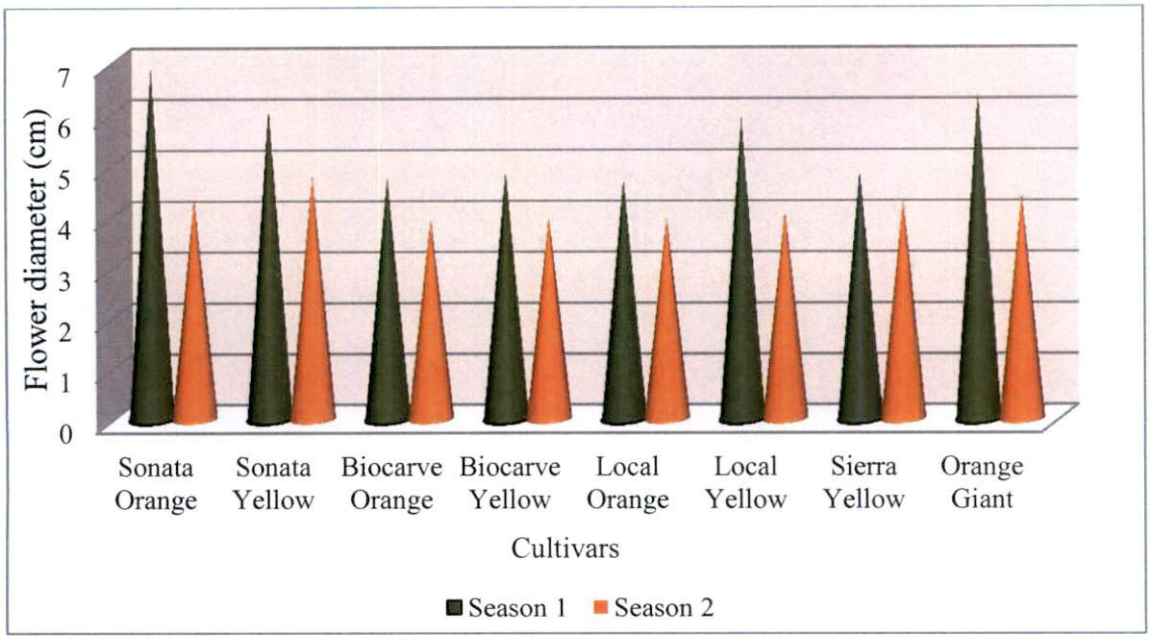


Fig 22. Effect of growing seasons on flower diameter of the cultivars grown under rain shelter condition

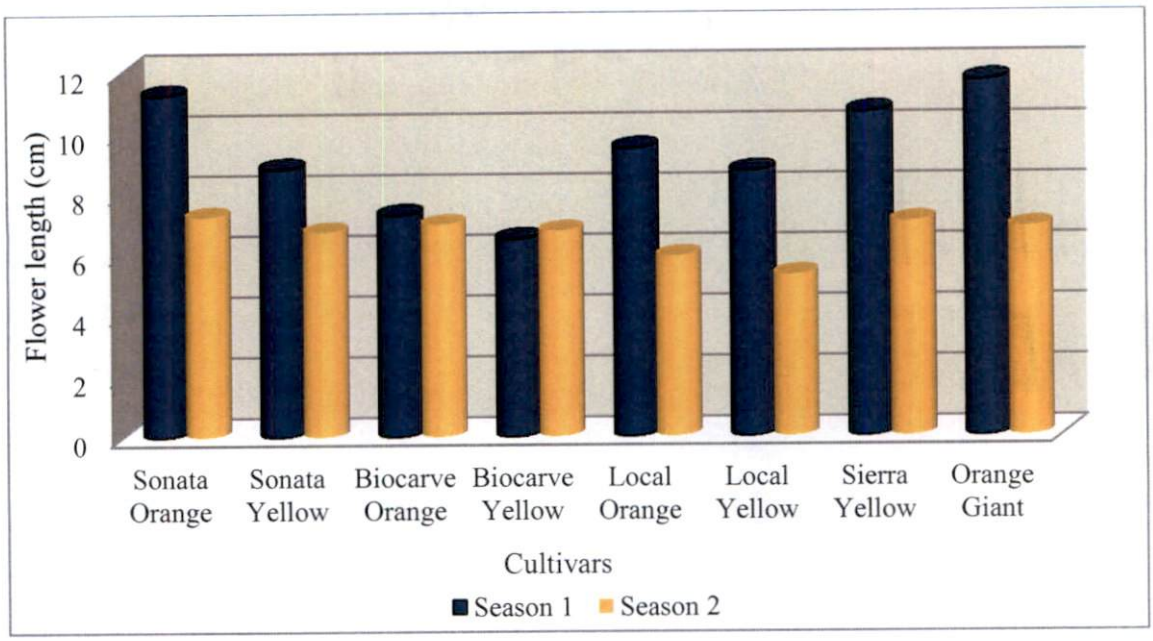


Fig 23. Effect of growing seasons on flower length of the cultivars grown in the open field condition

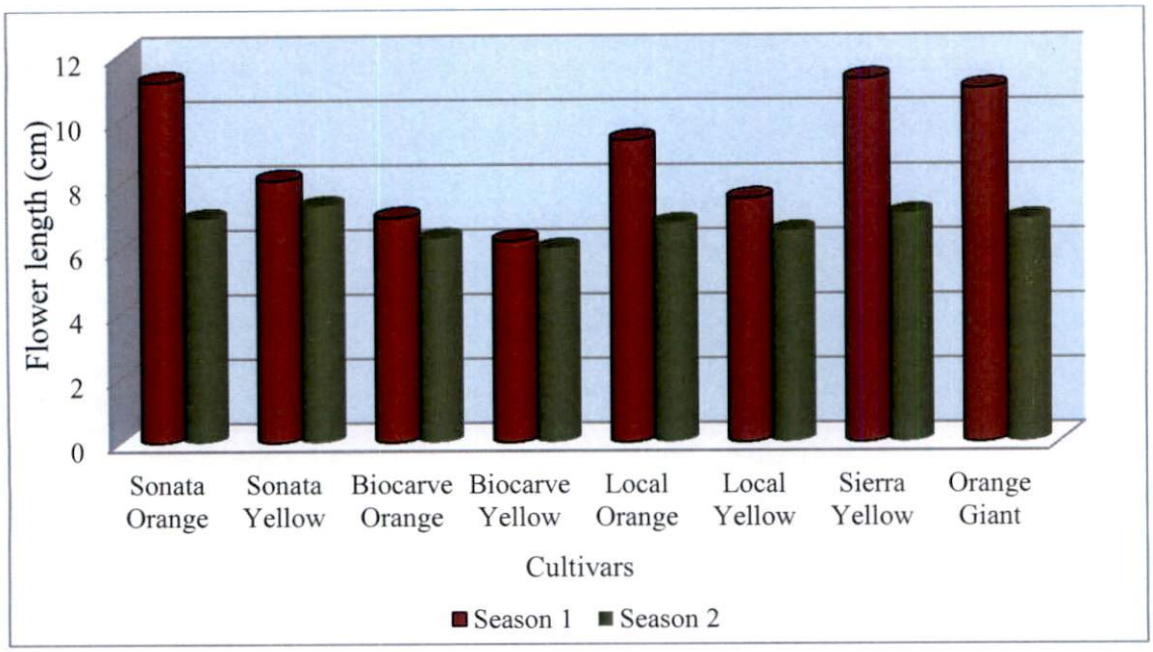


Fig 24. Effect of growing seasons on flower length of the cultivars grown under rain shelter condition

the open field condition, the growth of the pedicel might have been affected and the plants recorded comparatively better pedicel length under rain shelter condition.

During first season, the cultivar Sierra Yellow grown under rain shelter condition recorded the highest pedicel length. Highest pedicel length during second season was recorded in Sonata Orange grown in the open field condition.

5.2.5.2 Effect of Seasons on Pedicel Length

The pedicel length of the cultivars was significantly influenced by the growing seasons, under both growing conditions (Table 5(e) and Table 5(f)). Higher pedicel length in the open field and rain shelter conditions was recorded during the first season. The profused vegetative growth was probably responsible for the increase in pedicel length during first season. Variation in pedicel length with respect to the growing seasons was reported by Prakash, 2015 in African marigold; Deshmane *et al.*, 2012 in French marigold; Barman *et al.*, 1997 in chrysanthemum; Sartaj, 2014 in gerbera.

The cultivar Orange Giant grown during the first season recorded highest pedicel length in the open field condition. Highest pedicel length under rain shelter condition was recorded in Sierra Yellow grown during the first season.

5.2.6 Individual Flower Weight

5.2.6.1 Effect of Growing Conditions on Individual Flower Weight

During both seasons, significantly higher individual flower weight was recorded in the plants grown under rain shelter condition compared to the open field condition (Table 5(a) & Table 5(b) and Fig 25 & Fig 26). According to Naik *et al.* (2006), the maximum accumulation of photosynthates and bigger size of the flowers might have resulted in increased flower weight in gerbera.

The cultivar Orange Giant grown under rain shelter condition recorded the highest flower weight, during first season. During second season, highest flower weight was recorded in Sonata Yellow grown under rain shelter condition.

5.2.6.2 Effect of Seasons on Individual Flower Weight

The individual flower weight varied in all the cultivars according to seasons. Under both growing conditions, more flower weight was recorded during the first season in all the cultivars (Table 5(e) & Table 5(f) and Fig 27 & Fig 28). The higher water content and carbohydrate content in the flowers caused variations in flower weight of carnation (Gharge *et al.*, 2011). The profused vegetative growth and more photosynthate accumulation might be resulted in increased flower weight in first season crop. The results were in line with the findings of Samantaray *et al.*, 1999; Ghosh and Pal, 2008; Mohanty *et al.*, 2015; Prakash, 2015 in African marigold; Raju *et al.*, 2006; Deshmane *et al.*, 2012 in French marigold; Deotale *et al.*, 1995; Barman *et al.*, 1997; Anjum *et al.*, 2007 in chrysanthemum; Jane and Kawarkhe, 2002; Mathad *et al.*, 2008 in China aster; Singh *et al.*, 2001; Singh and Sangama, 2003 in carnation.

The cultivar Orange Giant grown during first season recorded highest individual flower weight under both growing conditions.

5.2.7 Number of Flowers per Plant

5.2.7.1 Effect of Growing Conditions on Number of Flowers per Plant

During the first season, growing conditions have significant influence on cultivars with regard to the number of flowers per plant. But during second season, the number of flowers per plant was not significantly influenced by the growing conditions (Table 6(a) and Table 6(b)). Irrespective of cultivars, more number of flowers per plant was obtained from rain shelter condition compared to the open field condition, during both seasons. According to Pramila *et al.* (2011), the number of flowers was significantly influenced by the number of branches per plant. Higher number of flowers under rain shelter condition might be due to the

more number of branches observed under rain shelter condition compared to open field condition. Similar results were observed in chrysanthemum by Gaikwad and Dumbre-Patil, 2001; Swaroop *et al.*, 2006; Gantait and Pal, 2011.

During first season, Local Orange grown under rain shelter condition recorded the highest number of flowers. Highest number of flowers during second season was recorded in Orange Giant grown under rain shelter condition.

5.2.7.2 Effect of Seasons on Number of Flowers per Plant

Most of the cultivars recorded significantly higher number of flowers per plant during the first season, both in the open field and rain shelter conditions (Table 6(c) & Table 6(d) and Fig 29 & Fig 30). Production of more number of flowers by the first season crop might be attributed to the more leaf area and enhanced vegetative growth in terms of plant height, plant spread and number of branches *etc.* would have caused maximum photosynthate accumulation, resulted in the production of more number of flowers with bigger size. Variation in number of flowers per plant with seasons was reported by Samantaray *et al.,* 1999; Sreekanth *et al.*, 2007; Ghosh and Pal, 2008; Pramila *et al.,* 2011; Chauhan *et al.*, 2014; Lakshmi *et al.,* 2014; Meena *et al.*, 2015 and Prakash, 2015 in African marigold. Seasonal variation in the number of flowers was also reported by Anjum *et al.,* 2007 in chrysanthemum; Mathad *et al.*, 2008 in China aster as well as Bagde *et al.*, 2009; Nijasure and Ranpise, 2005 in gladiolus.

In the open field condition, Local Yellow grown during first season recorded the highest number of flowers. The cultivar Local Orange grown during first season recorded the highest number of flowers under rain shelter condition.

5.2.8 Total Flower Yield

5.2.8.1 Effect of Growing Conditions on Total Flower Yield

During both growing seasons, significantly higher flower yield was obtained from plants under rain shelter condition compared to open field condition (Table 6(a) & Table 6(b) and Fig 31 & Fig 32). The more number of branches increased

the number of leaves for photosynthate accumulation which might have attributed to the highest flower yield in plants under rain shelter condition. Similar variation in total flower yield with respect to the growing conditions was reported by Gantait and Pal, 2011 in chrysanthemum.

The cultivar Local Yellow grown under rain shelter condition recorded highest flower yield during the first season. While, during second season Orange Giant grown under rain shelter condition recorded the highest flower yield.

5.2.8.2 Effect of Seasons on Total Flower Yield

Significantly higher flower yield was obtained from the plants grown during first season, both under open field and rain shelter conditions (Table 6(e) & Table 6(f) and Fig 33 & Fig 34). The higher flower yield during first season might be attributed to the increased number of flowers per plant as well as individual flower weight. The variations in flower yield with respect to seasons was also reported by Mohanty *et al.*, 1993; Samantaray *et al.,* 1999; Pramila *et al.,* 2011; Chauhan *et al.*, 2014; Lakshmi *et al.*, 2014; Prakash, 2015 in African marigold; Nawaz e*t al.*, 2009 in chrysanthemum; Sartaj, 2014 in gerbera; Dilta *et al.,* 2006 in carnation; Mohammad *et al.,* 2012 in gladiolus.

In the open field condition, Orange Giant grown during first season recorded the highest flower yield. Under rain shelter condition, highest flower yield was recorded in Local Yellow grown during first season.

5.2.9 Marketable Flower Yield

5.2.9.1 Effect of Growing Conditions on Marketable Flower Yield

Significantly higher marketable flower yield during both the seasons was recorded from plants grown under rain shelter condition (Table 6(a) and Table 6(b)). The reduction in marketable flower yield obtained from open field condition might be due to the exposure of the crop to the external fluctuating climatic conditions, while a controlled atmosphere is created inside the rain shelter.

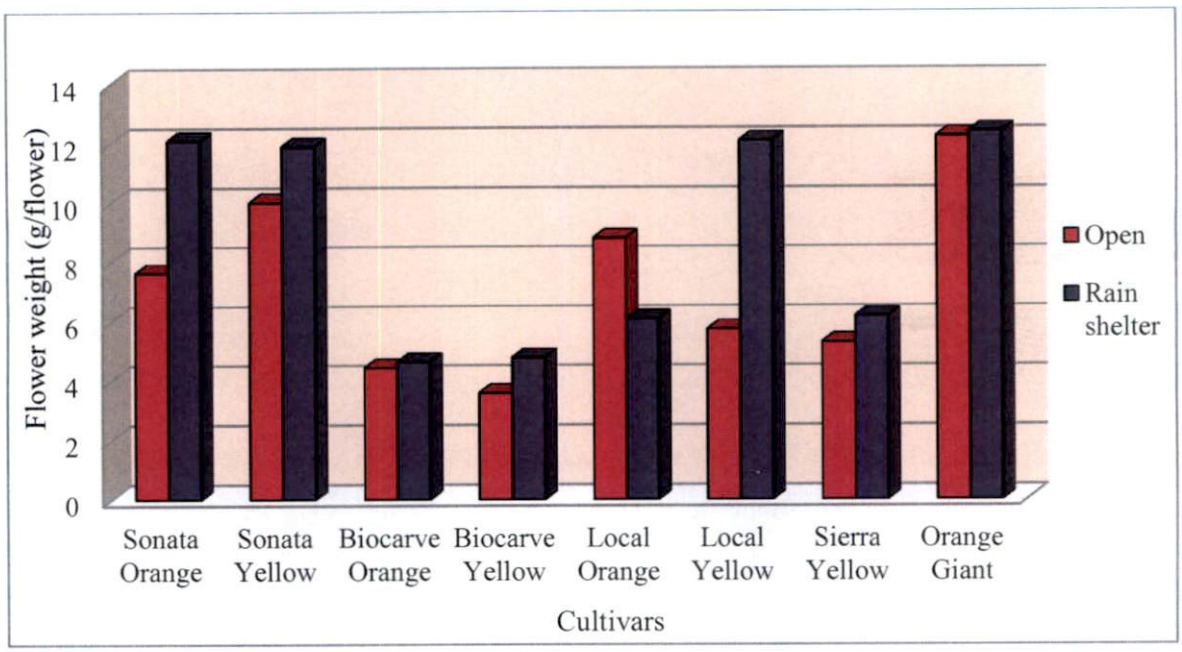


Fig 25. Effect of growing conditions on individual flower weight of the cultivars grown during first season (July - November)

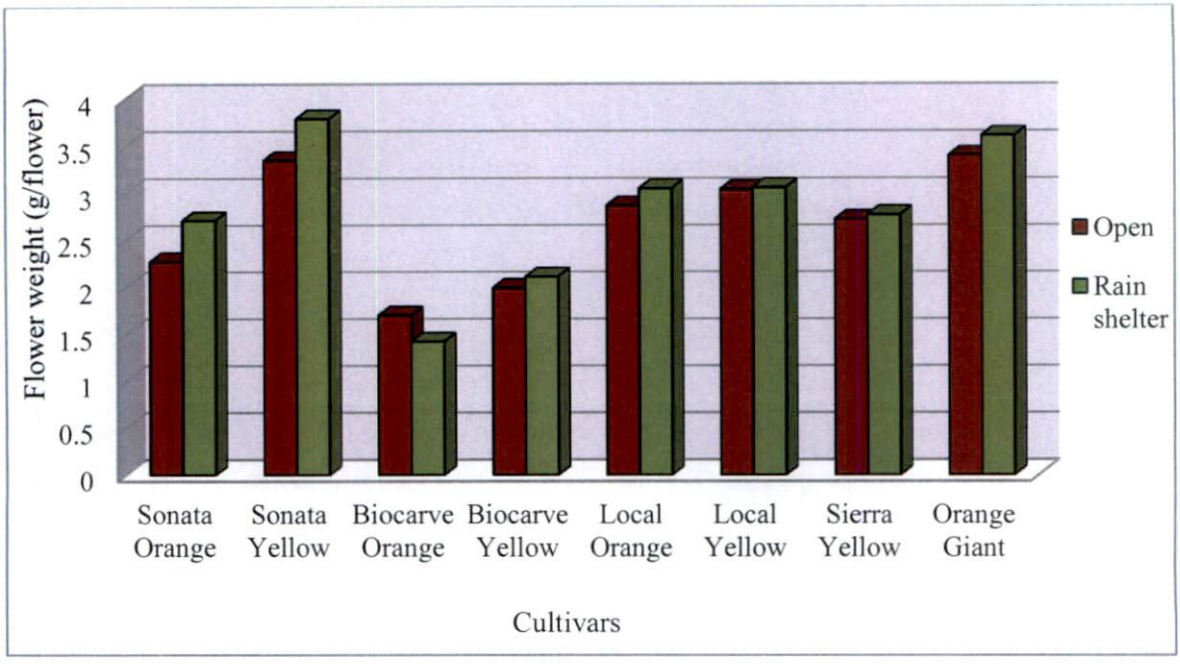


Fig 26. Effect of growing conditions on individual flower weight of the cultivars grown during second season (January - April)

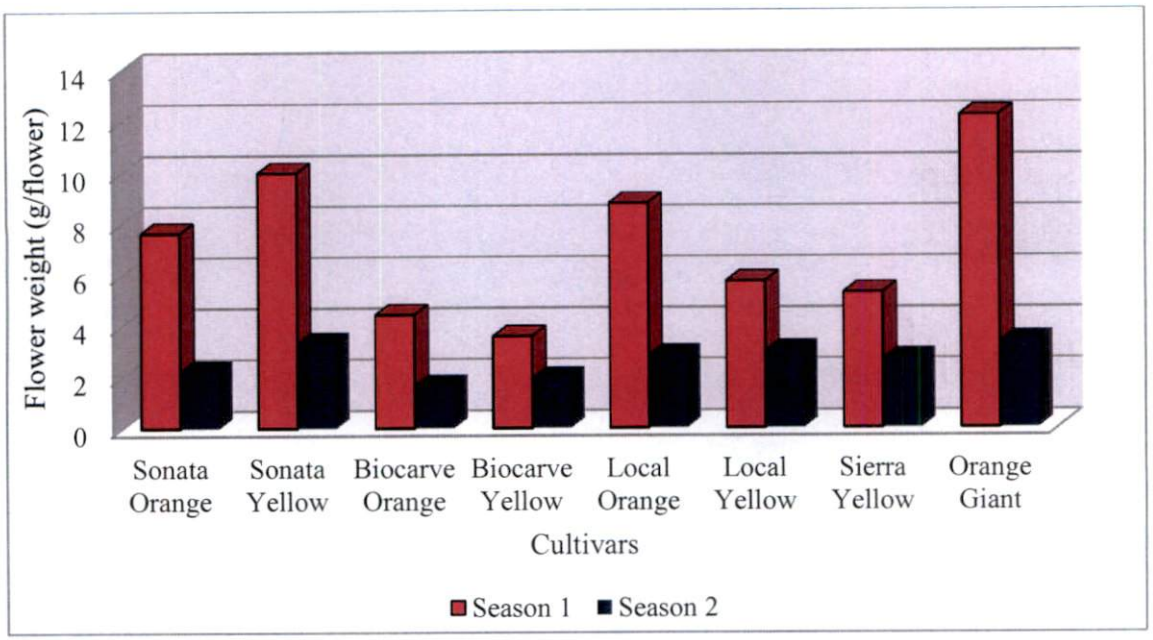


Fig 27. Effect of growing seasons on individual flower weight of the cultivars grown in the open field condition

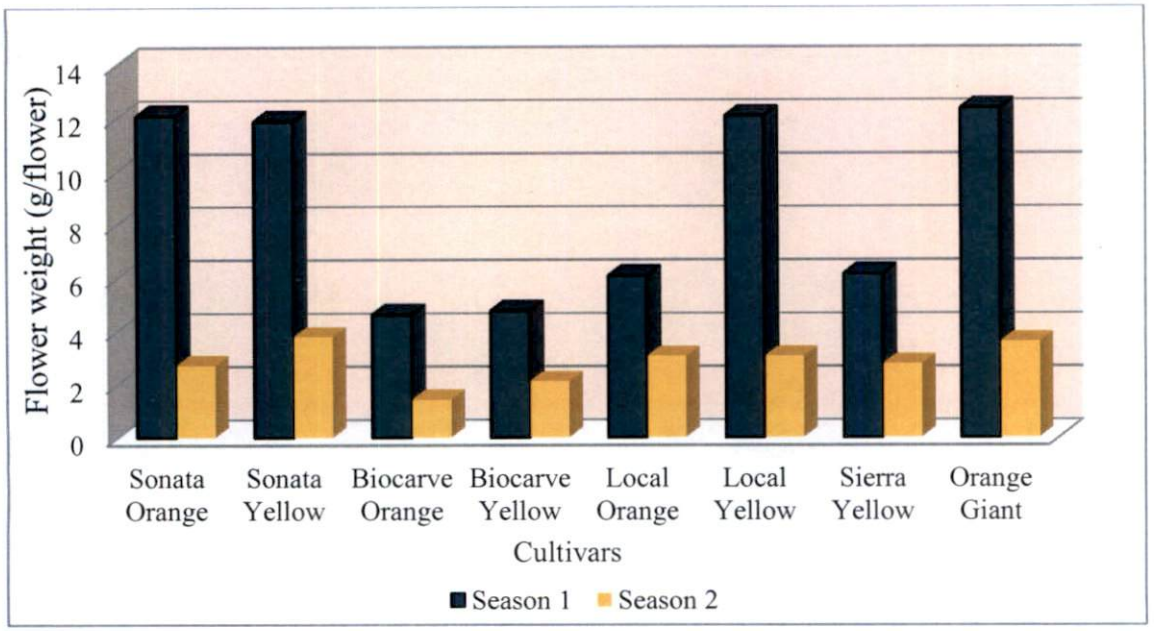


Fig 28. Effect of growing seasons on individual flower weight of the cultivars grown under rain shelter condition

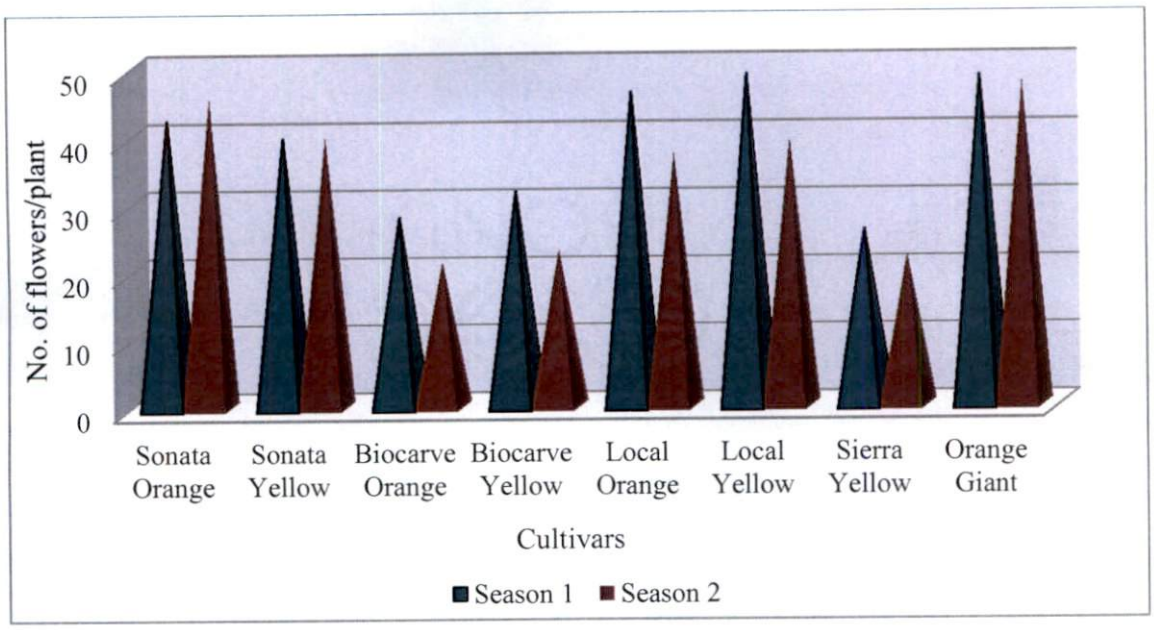


Fig 29. Effect of growing seasons on number of flowers per plant of the cultivars grown in the open field condition

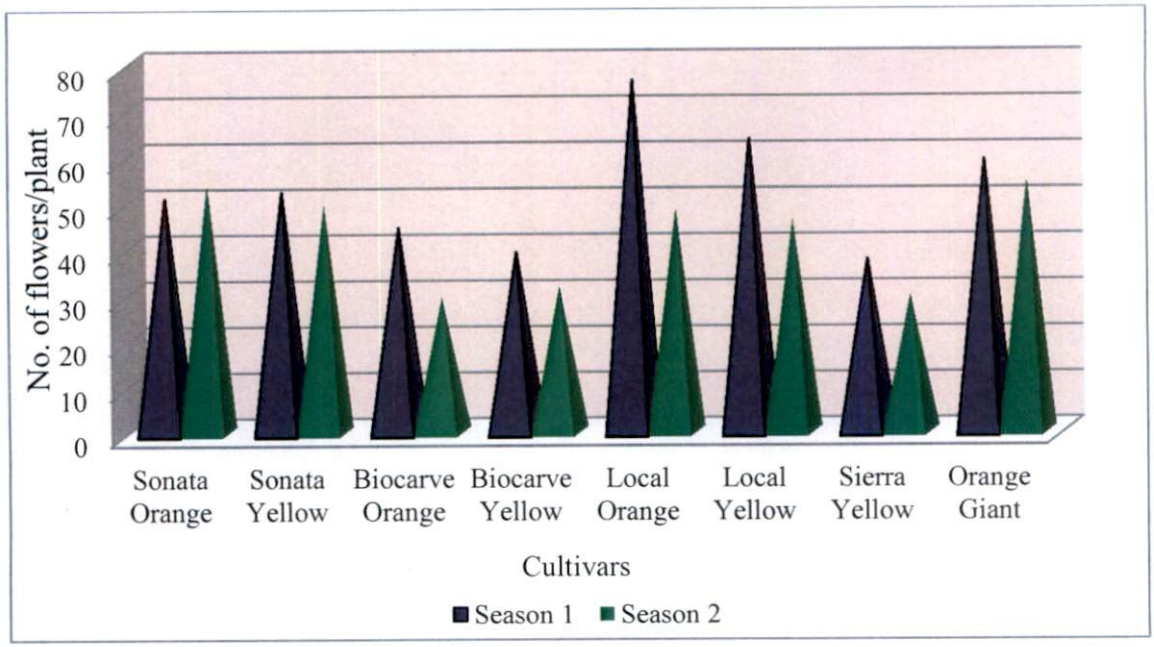


Fig 30. Effect of growing seasons on number of flowers per plant of the cultivars grown under rain shelter condition

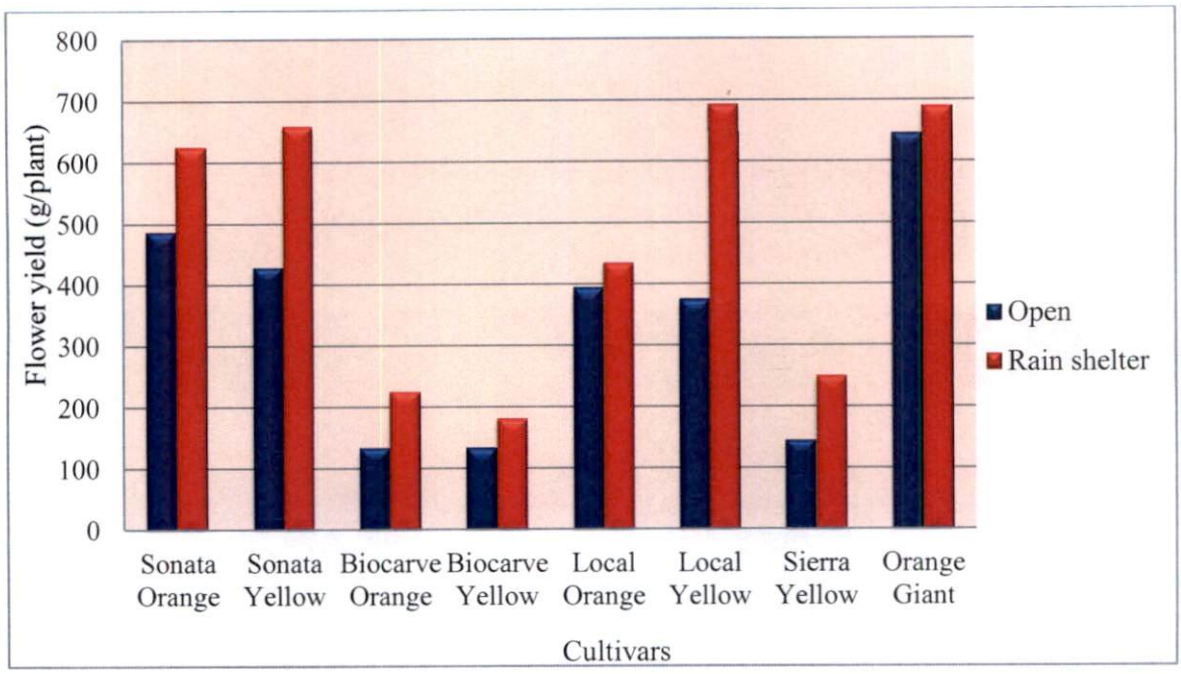


Fig 31. Effcet of growing conditions on total flower yield of the cultivars grown during first season (July - November)

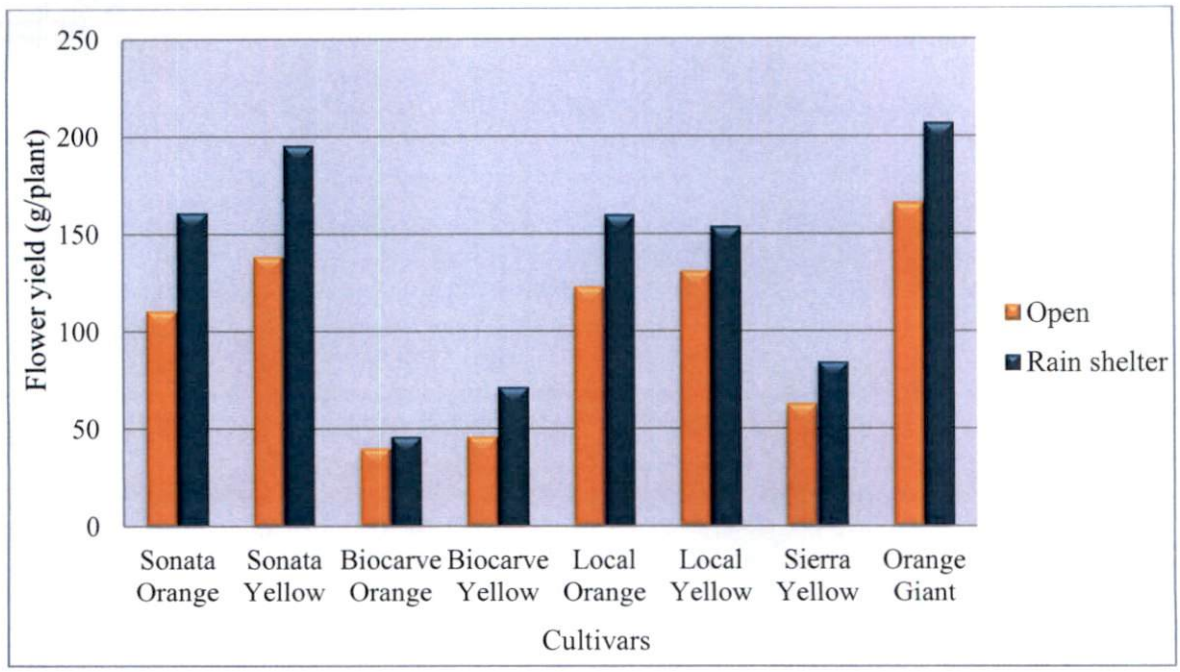


Fig 32. Effect of growing conditions on total flower yield of the cultivars grown during second season (January - April)

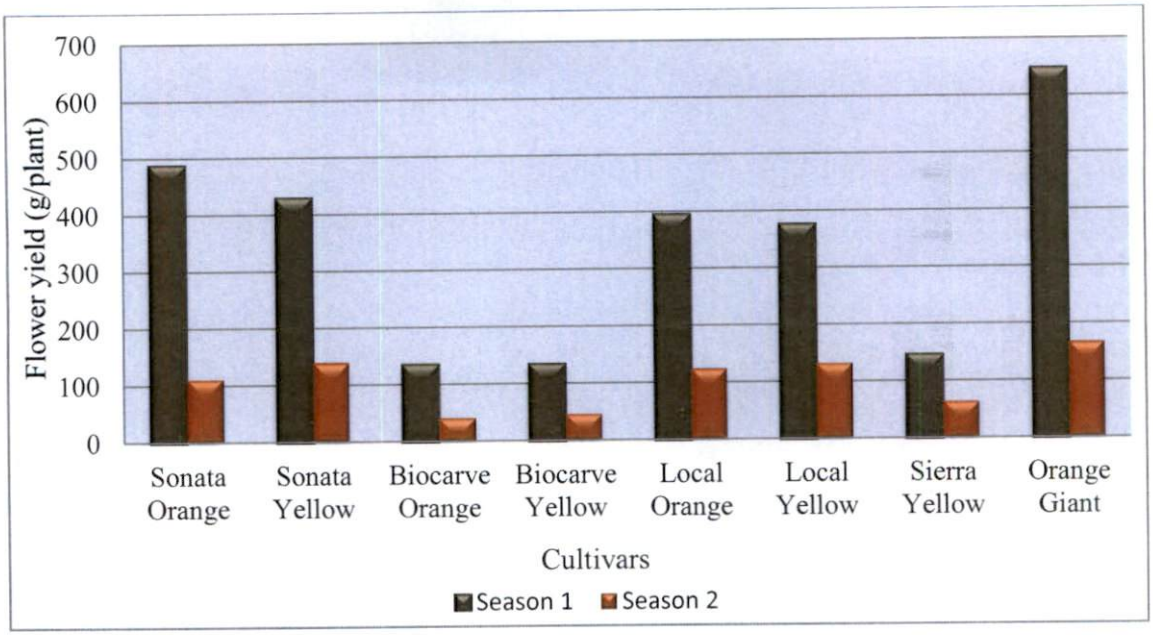


Fig 33. Effect of growing seasons on total flower yield of the cultivars grown in the open field condition

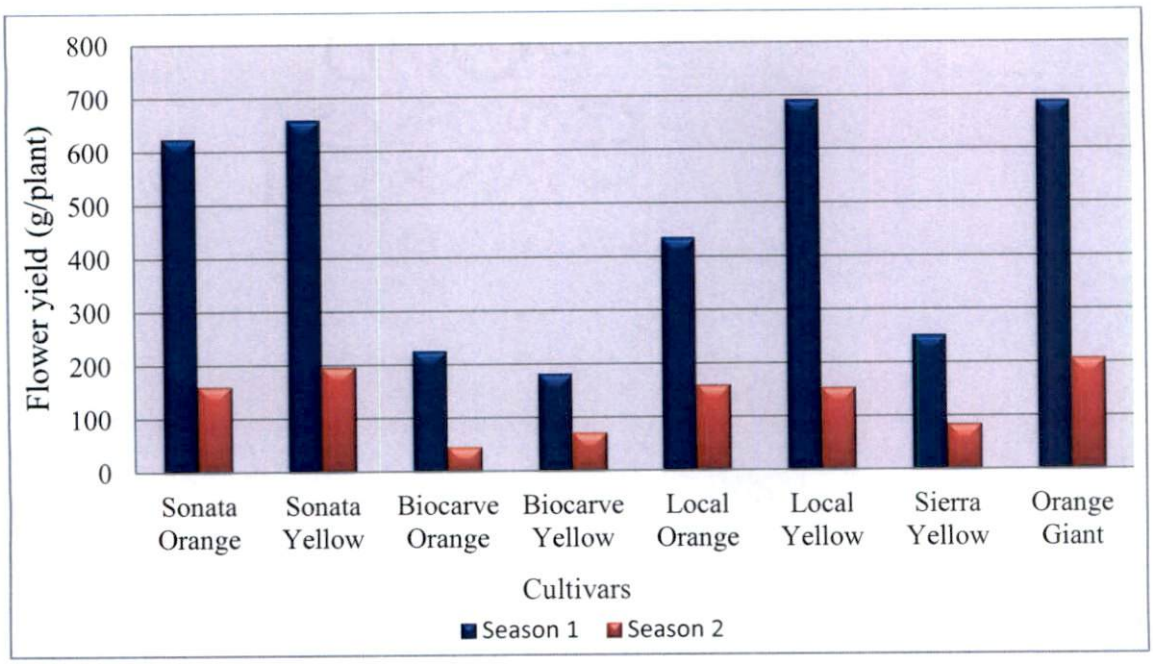


Fig 34. Effect of growing seasons on total flower yield of the cultivars grown under rain shelter condition

Aderson *et al.* (2011) reported that gerbera plants grown under open field condition were highly sensitive to the external climatic conditions.

Highest marketable flower yield during both the seasons was recorded in cultivar Orange Giant grown under rain shelter condition.

5.2.9.2 Effect of Seasons on Marketable Flower Yield

More marketable flower yield in the open field and rain shelter conditions was obtained during the first season (Table 6(e) and Table 6(f)). The increase in marketable flower yield during July planting might be due to the increase in total flower yield, consequent to the increased number of flowers and higher flower weight.

Under both growing conditions, highest marketable flower yield was recorded in cultivar Orange Giant grown during the first season.

5.2.10 Shelf Life

5.2.10.1 Effect of Growing Conditions on Shelf Life

Growing condition had significant influence on cultivars with regard to shelf life of the flowers, during first season. While, there was no significant influence of growing conditions on shelf life of the flowers, during the second season (Table 6(a) and Table 6(b)). Regardless of cultivars, higher shelf life during both the seasons was recorded in flowers obtained from rain shelter condition compared to open field condition. According to Talukdar *et al.* (2006), the longer shelf life of the flowers is possibly due to greater fresh weight, freedom from rain fall and dew fall, protection from direct sunlight and more carbon dioxide concentration inside polyhouse. Since, the plants inside rain shelter condition were protected from the outside environment the flowers might have retained their freshness for a longer period. According to Gantait and Pal (2011), the chrysanthemum flowers obtained from polyhouse condition exhibited better shelf life. Variation in shelf life of the flowers with respect to growing conditions was reported by Saud and Talukdar,

1999; Talukdar *et al.*, 2006 in chrysanthemum; Singh and Srivastava, 2008 in gerbera.

During first season, highest shelf life was recorded in the cultivars Sonata Orange and Sonata Yellow grown under rain shelter condition. The highest shelf life during second season was recorded in Orange Giant grown under rain shelter condition.

5.2.10.2 Effect of Seasons on Shelf Life

The shelf life of the cultivars was significantly influenced by the growing seasons, under both growing conditions. Under open field and rain shelter conditions, higher shelf life of the flowers was recorded during the first season (Table 6(c) and Table 6(d)). The flower turgidity, freshness and petal orientation are mostly influenced the water content in the flowers (Gharge *et al.*, 2011). July planted crop recorded the maximum shelf life probably due to the high soil moisture level during the season. The plants can absorb enough water to maintain the turgidity of cells and freshness of flowers. The results were in close conformity with the findings of Prakash, 2015 in African marigold; Anjum *et al.*, 2007 in chrysanthemum; Kumari *et al.*, 2011 in gladiolus regarding the long shelf life of the flowers during monsoon season.

Highest shelf life in the open field condition was recorded in Sonata Orange grown during first season. Under rain shelter condition, Sonata Orange and Sonata Yellow recorded the highest shelf life.

5.2.11 Duration of Flowering

5.2.11.1 Effect of Growing Conditions on Duration of Flowering

During first and second seasons, higher duration of flowering was recorded in cultivars grown under rain shelter condition compared to open field condition. The better carbohydrate reserve in the plants under rain shelter condition might have attributed to prolonged flowering duration. Similar results were obtained in other flower crops also. More flowering duration in the chrysanthemum cultivars

grown inside polyhouse condition was reported by Swaroop *et al.* (2006) and Talukdar *et al.* (2006).

During first season, the cultivar Orange Giant grown under rain shelter condition recorded the highest flowering duration. The highest flowering duration during second season was recorded in cultivar Sierra Yellow grown under rain shelter condition.

5.2.11.2 Effect of Seasons on Duration of Flowering

Significant variation among cultivars with respect to duration of flowering was observed under open field and rain shelter conditions. More duration flowering was observed during the first season under both growing conditions. The long flowering duration might be due to the more vegetative growth in terms of number of branches and leaves. This might have helped the plants to synthesis more amount of photosynthates which in turn increased the flowering duration (Kulkarni and Reddy, 2008). Variation in the flowering duration with respect to seasons was reported by Chanda and Roychaudhary, 1991; Chauhan *et al.*, 2014; Lakshmi *et al.*, 2014; Prakash, 2015 in African marigold; Barman *et al.*, 1997; Anjum *et al.*, 2007; Kulkarni and Reddy, 2008 in chrysanthemum; Nagaraju, 2001 in China aster and Misra, 1997; Sheikh and Jhon, 2005; Kumari *et al.*, 2011 in gladiolus.

In the open field condition, Local Yellow grown during first season recorded the highest duration of flowering. The highest flowering duration under rain shelter condition was recorded in cultivar Orange Giant grown during the first season.

5.3 SEED CHARACTERS

5.3.1 Seed Yield per Flower

5.3.1.1 Effect of Growing Conditions on Seed Yield per Flower

The growing conditions have no significant influence on seed yield of the cultivars during both the seasons (Table 7(a) and Table 7(b)).

During first season, highest seed yield was recorded in Sonata Orange grown under rain shelter condition. The cultivar Local Yellow grown under rain shelter condition recorded the highest seed yield during second season. The individual cultivar characters resulted in variation in seed yield among the cultivars.

5.3.1.2 Effect of Seasons on Seed Yield per Flower

The seed yield was significantly influenced by the growing seasons in most of the cultivars under both growing conditions. Under open field and rain shelter conditions, higher seed yield was obtained during the first season (Table 7(c) and Table 7(d)). According to Pramila *et al.* (2011), the higher accumulation of photosynthates and translocation of these photosynthates from source to sink during the rainy season crop might have resulted in higher seed yield. Similar findings were reported by many workers Shivakumar, 2000; Pramila *et al.*, 2011; Meena *et al.*, 2015 in African marigold; Raman *et al.*, 1969 in chrysanthemum as well as Gowda, 1990; Mathad *et al.*, 2008 in China aster.

In the open field condition, highest seed yield was recorded in cultivar Local Yellow grown during the first season. The cultivar Sonata Orange grown during first season recorded the highest seed yield under rain shelter condition.

5.3.2 Seed Germination

5.3.2.1 Effect of Growing Conditions on Seed Germination

During both seasons, growing conditions have no significant influence on seed germination of the cultivars (Table 7(a) and Table 7(b)).

The variation in seed germination might be due to the inherent characters of the individual cultivars. During first season, highest seed germination was recorded in cultivar Orange Giant grown in the open field condition. Highest seed germination during second season was also recorded in cultivar Orange Giant grown under rain shelter condition.

5.3.2.2 Effect of Seasons on Seed Germination

The seed germination was found not significantly influenced by the growing seasons, both under open field and rain shelter conditions (Table 7(c) and Table 7(d)).

In the open field condition, Orange Giant grown during the first season recorded the highest seed germination. Highest seed germination under rain shelter condition was recorded in cultivar Local Yellow grown during the first season.

5.4 BIOCHEMICAL ATTRIBUTES

5.4.1 Chlorophyll Content in Leaves

5.4.1.1 Effect of Growing Conditions on Chlorophyll Content in Leaves

The chlorophyll content of the cultivars was significantly influenced by the growing conditions during both the seasons (Table 8(a) and Table 8(b)). Irrespective of cultivars, significantly higher chlorophyll content was recorded in plants grown in the open field condition compared to rain shelter condition. According to Pandey *et al.* (2015), the increased content of chlorophyll may be attributed to the differential synthesis and degradation of chlorophyll in the open field condition whereas more photo-oxidation of chlorophyll and high chlorophyllase enzyme activity may be attributed to less chlorophyll content inside polyhouse condition.

During first season, highest total chlorophyll content was recorded in cultivar Local Yellow grown in the open field condition. During second season Orange Giant grown in the open field condition recorded the highest chlorophyll content.

5.4.1.2 Effect of Seasons on Chlorophyll Content in Leaves

In the open field condition as well as rain shelter conditions, higher chlorophyll content was recorded during the first season (Table 8(c) and Table 8(d)). The higher chlorophyll content in leaves during first season might be due to the better growth of the plants. Similar variation in chlorophyll content with

respect to seasons was also reported by Ghosh and Pal, 2008; Prakash, 2015 in African marigold.

Highest chlorophyll content in the open field and rain shelter conditions was recorded in Local Yellow grown during the first season.

5.4.2 Xanthophyll Content in Flowers

5.4.2.1 Effect of Growing Conditions on Xanthophyll Content in Flowers

The xanthophyll content of the cultivars was not significantly influenced by growing conditions during both the seasons (Table 9(a) and Table 9(b)). Xanthophyll is one of the major carotenoid pigments found in the petals of African marigold (Balakrishanan *et al.*, 2007). Regardless of cultivars, significantly higher xanthophyll content was recorded in flowers obtained from open field condition compared to rain shelter condition, during the second season.

Among the cultivars, Local Orange grown in the open field condition recorded the highest xanthophyll content during the first season. During second season, the highest xanthophyll content was recorded in Sonata Orange and Local Orange grown in the open field condition.

5.4.2.2 Effect of Seasons on Xanthophyll Content in Flowers

In the open field condition, the xanthophyll content of the cultivars was not significantly influenced by growing seasons (Table 9(c) and Table 9(d)). Under rain shelter condition, most of the cultivars recorded higher xanthophyll content when grown during second season compared to the first season. Synthesis of more carotenoids at higher temperature on carrot was noticed by Banga and Bruyn (1968). This might be due to the exposure of the plants to high temperature and high light intensity conditions prevailed during the season. A variation in anthocyanin content in marigold flowers with respect to seasons was reported by Ghosh and Pal (2008). Rao *et al.* (2005) reported that the variation in the carotene content of African marigold might be due to the variations in growing season, and temperature.

In the open field condition, Sonata Orange and Local Orange grown during second season recorded the highest xanthophyll content. Under rain shelter condition, highest xanthophyll content was recorded in Local Orange grown during the first season.

5.4.3 Flavonoid Content in Flowers

5.4.3.1 Effect of Growing Conditions on Flavonoid Content in Flowers

During first season, growing condition had significant influence on the cultivars with regard to the flavonoid content in flowers. While during second season, the flavonoid content of the cultivars was not significantly influenced by the growing conditions (Table 9(a) and Table 9(b)). Regardless of cultivars, the flowers obtained from the open field condition recorded significantly higher flavonoid content, during both seasons. According to Winkel-Shirley (2002), the flavonoids are a group of secondary metabolites produced by plants in response to various environmental signals. The plants are protected from environmental conditions like high light intensity and high rainfall under plastic house (Khattak and Pearson, 1997). The exposure of plants to external environmental conditions might be the reason for higher production of flavonoids in the open field condition.

During both the seasons, the cultivar Sonata Orange grown in the open field condition recorded the highest flavonoid content.

5.4.3.2 Effect of Seasons on Flavonoid Content in Flowers

Both under open field and rain shelter conditions, the higher flavonoid content in flowers was observed during the second season compared to first season (Table 9(c) and Table 9(d)). This might be due to the high temperature and high light intensity conditions prevailed during the second season.

In the open field condition, Sonata Orange grown during the second season recorded highest flavonoid content. While, under rain shelter condition Sierra Yellow grown during second season recorded the highest flavonoid content.

5.5 CORRELATION STUDIES

During first season, the plant height was found to have significant positive correlation with plant spread, number of secondary branches, stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield. Positive correlation between plant height and plant spread in gerbera was reported by Rao and Vasudevan (2009). The plant spread had a significant and positive correlation with all other characters. The number of primary branches positively correlated with number of secondary branches, flower diameter, flower weight and total flower yield. The number of secondary branches positively correlated with stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield. Leaf area had a positive correlation with stem girth and days to first flowering. Stem girth was correlated with internodal length and all other floral characters. Internodal length had a significant and positive correlation with flower diameter, flower weight and total flower yield.

During second season, plant height was found to have significant positive correlation with all other characters except internodal length. The plant spread had a significant negative correlation with internodal length but it positively correlated with all other characters. The number of primary branches had no correlation with leaf area; it negatively correlated with internodal length and positively correlated with the remaining characters. The number of secondary branches had no correlation with internodal length but positively correlated with all other characters. The leaf area had a negative correlation with internodal length but a significant positive correlation with days to first flowering. Stem girth positively correlated with days to first flowering, flower weight and total flower yield. Internodal length showed significant correlation with flower diameter only. Days to first flowering and flower diameter had positive correlation with flower weight and total flower yield. Flower weight significantly and positively correlated with the total flower yield.

Summary

6. SUMMARY

An experiment entitled "Performance of African marigold (*Tagetes erecta* L.) under different growing conditions" was carried out during the year 2015-2016, at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, in two different seasons *viz.*, Season I or rainy season (July – November 2015) and Season II or winter sowing (January – April 2016). The objective of the study was to compare the growth and flowering of African marigold cultivars under open field and polyhouse conditions. The results generated from the study are summarized hereunder.

Eight cultivars of African marigold namely Sonata Orange, Sonata Yellow, Biocarve Orange, Biocarve Yellow, Local Orange, Local Yellow, Sierra Yellow and Orange Giant were grown in the open field and rain shelter conditions, as per the Package of Practices Recommendations (KAU, 2011) and the growth and flowering characters were observed in the two seasons (Season I and Season II).

Growing condition had significant influence on plant height of the cultivars during second season, but during first season, there was no significant influence. During first season, the plants recorded significantly higher plant height when grown under rain shelter condition, irrespective of the cultivars. The growing seasons also had significant influence on plant height of the cultivars under both growing conditions. In all the cultivars, significantly higher plant height was recorded during the first season.

During first season, the growing conditions had no significant influence on plant spread (NS) of the cultivars but, during second season, the cultivars were significantly influenced by the growing conditions. The plant spread (NS) of the cultivars was significantly influenced by the growing seasons. Better plant spread in all cultivars was recorded during the first season.

There was significant influence of growing conditions on plant spread (EW) of the cultivars during first season. During second season, the plant spread (EW) of the cultivars was not significantly influenced by the growing conditions. All

cultivars showed better plant spread (EW) during first season compared to second season under both the growing conditions.

The stem girth of the cultivars was significantly influenced by growing conditions during both the seasons.

During first season, Local Orange and Local Yellow recorded significantly higher internodal length (4.80 cm and 5.43 cm respectively) under rain shelter condition compared to open field condition. During second season, the growing conditions have no significant influence on internodal length of the cultivars. The internodal length of all the cultivars was significantly influenced by the growing seasons. The cultivars recorded better internodal length during first season compared to second season.

During first season, the growing condition had no significant influence on number of primary and secondary branches of the cultivars but, during second season, growing condition had significant influence on the cultivars with regard to the number of primary and secondary branches per plant.

The leaf area of the cultivars was also not significantly influenced by the growing conditions during first season. During second season, Sonata Yellow (9.92 cm^2) and Orange Giant (8.15 cm^2) recorded significantly higher leaf area under rain shelter compared to open field condition. Whereas, Sonata Orange (10.99 cm^2) and Local Orange (10.55 cm^2) recorded significantly higher leaf area in the open field condition. Growing season had no significant influence on leaf area of the cultivars in the open field condition, while most of the cultivars recorded significantly higher leaf area during first season under rain shelter condition.

The leaf colour of the cultivars varied from light green to dark green colour under rain shelter and open field conditions during both the growing seasons.

During both seasons, the cultivars recorded greater crop duration when grown under rain shelter condition compared to open field condition. Crop

duration of the cultivars was more during first season. While during second season the cultivars completed their growth within a short duration.

Regarding the incidence of pests and diseases, termite attack was observed during the establishment stage of the transplanted seedlings. Thrips attack was observed in the cultivar Local Orange, during first season. No pest attacks were noticed during the second season. Incidence of bacterial wilt was a serious problem especially during the first season which caused loss of many plants in the field. In general, the incidence of pests and diseases was found less under rain shelter condition compared to the open field condition.

Growing condition had significant influence on days to first flowering of the cultivars during both the seasons. Less number of days for first flowering was observed under rain shelter condition in all the cultivars during first season. During second season also all the cultivars under rain shelter condition took less number of days for first flowering. Growing seasons also have significant influence on days to first flowering of the cultivars. All cultivars took less number of days for first flowering during second season.

Days to 50 per cent flowering of the cultivars was significantly influenced by the growing conditions during both seasons. During first season, the cultivars Local Orange (68.75 days), Local Yellow (80.75 days) and Orange Giant (65.67 days) took less number of days for 50 per cent flowering under rain shelter condition while, all other cultivars took less number of days for 50 per cent flowering in the open field condition. During second season, all the cultivars took less number of days for 50 per cent flowering under rain shelter condition. Under both the growing conditions, all the cultivars took less number of days for 50 per cent flowering during second season.

During first season, Sonata Orange (6.87 cm) recorded significantly greater flower diameter under rain shelter condition compared to open field condition. The cultivars recorded significantly higher flower diameter during first season compared to second season.

Growing conditions had no significant influence on flower length and pedicel length of the cultivars during first season, whereas during second season, flower length and pedicel length of the cultivars were significantly influenced by the growing conditions. Growing seasons have significant influence on the flower length and pedicel length of the cultivars. All the cultivars recorded better flower length and pedicel length during the first season compared to second season under both the growing conditions.

Individual flower weight of the cultivars was significantly influenced by the growing conditions during both the seasons. During first season, all the cultivars except Local Orange recorded more flower weight under the rain shelter condition. The cultivar Biocarve Orange recorded greater flower weight in the open field condition (1.70 g) while, rest of the cultivars recorded better flower weight under the rain shelter condition, during second season. All the cultivars recorded significantly higher individual flower weight during first season under both the growing conditions.

During first season, the growing conditions have significant influence on cultivars with regard to the number of flowers per plant. But, during second season the number of flowers per plant of cultivars was not significantly influenced by the growing conditions. The number of flowers per plant was significantly influenced by the growing seasons. Under both growing conditions, all the cultivars recorded more number of flowers per plant during the first season.

The shelf life of the flowers was significantly influenced by the growing conditions during first season while, during second season, there was no significant influence on shelf life of the cultivars. Growing seasons have significant influence on shelf life of flowers under both the growing conditions. Higher shelf life under both growing conditions was recorded during the first season.

During the two seasons, total and marketable flower yield of the cultivars were significantly influenced by the growing conditions. All the cultivars recorded higher total and marketable flower yield under rain shelter condition, during both

the seasons. The total and marketable flower yield in all the cultivars were significantly influenced by the growing seasons. All the cultivars recorded higher total and marketable flower yield during first season, under both the growing conditions.

The flower colour of the cultivars varied from light yellow to sulphur yellow and from light orange to bright orange under rain shelter and open field conditions during both the growing seasons.

During the first and second seasons, greater duration of flowering was observed in all the cultivars grown under rain shelter condition compared to open field condition. Compared to second season, more duration of flowering was observed during first season in all the cultivars.

During both the seasons, growing conditions have no significant influence on seed yield of the cultivars. But, growing season had significant influence on seed yield of the cultivars, under both growing conditions. In all the cultivars, higher seed yield was recorded during the first season compared to second season.

The seed germination of the cultivars was not significantly influenced by the growing conditions during both the seasons. Growing seasons also have no significant influence on seed germination, under both growing conditions.

During both the seasons, growing conditions have significant influence on total chlorophyll content of the cultivars. Irrespective of cultivars, the plants recorded significantly higher chlorophyll content in the open field condition compared to rain shelter condition. Growing season had a significant influence on the chlorophyll content of the cultivars grown under open field and rain shelter conditions.

Growing condition had no significant influence on xanthophyll content of the cultivars during both the seasons. In the open field condition, growing seasons have no significant influence on xanthophyll content of the cultivars, but under rain

shelter condition, xanthophyll content of the cultivars was significantly influenced by the growing seasons.

Flavonoid content of the cultivars was significantly influenced by the growing conditions during first season, but during second season, there was no significant influence. During first season, Sonata Orange (50.80 A_{300}/g fresh wt), Local Orange (46.70 A_{300}/g fresh wt), Local Yellow (48.92 A_{300}/g fresh wt) and Sierra Yellow (49.20 A_{300}/g fresh wt) recorded significantly higher flavonoid content in the open field condition compared to rain shelter condition. The flavonoid content of the cultivars was significantly influenced by the growing seasons, under both growing conditions.

The plant height was found significantly and positively correlated with plant spread, number of secondary branches, stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield during first season. The number of primary branches was correlated with number of secondary branches, flower diameter, flower weight and total flower yield. The number of secondary branches was correlated with stem girth, internodal length, days to first flowering, flower diameter, flower weight and total flower yield. Leaf area had a positive correlation with stem girth and days to first flowering.

The plant height was found to have positive correlation with all other characters except internodal length during second season. A significant negative correlation between plant spread and internodal length was observed but, it had a positive correlation with all other characters. The leaf area had a negative correlation with internodal length but a significant positive correlation with days to first flowering. Internodal length showed significant correlation with flower diameter only. Days to first flowering and flower diameter had positive correlation with flower weight and total flower yield. Flower weight and total flower yield was significantly and positively correlated with one another.

The study clearly showed that growing conditions and growing seasons have significant influence on most of the vegetative as well as floral characters of

African marigold cultivars. Among the cultivars grown under both growing conditions, Orange Giant and Local Yellow were found superior over other cultivars in terms of total flower yield during first season. In the open field condition Orange Giant was superior with respect to total flower yield. During the winter season, Orange Giant was found superior to all other cultivars in terms of total flower yield under both growing conditions. In general, the cultivars showed better performance under rain shelter condition than in the open field condition during both the seasons. With regard to growing seasons, the performance of the crop was found superior during the first season when compared to second season. Therefore, higher yield and production of quality flowers in marigold can be achieved through rain shelter cultivation during July – November, which coincides with the rainy season in Kerala.

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Appendices

APPENDICES

Appendix 1. Monthly mean temperatures (°C) during the period from July 2015 to November 2015 and January 2016 to April 2016 in different growing conditions

Year	Months	Maximum		Minimum	
		Open field	Rain shelter	Open field	Rain shelter
2015	July	30.30	36.58	23.50	25.48
	August	31.00	35.26	23.70	24.18
	September	31.90	37.09	23.70	14.32
	October	32.50	37.84	24.10	26.45
	November	31.60	38.39	23.80	26.84
2016	January	33.20	41.25	23.00	26.75
	February	35.30	43.21	23.50	27.06
	March	36.30	44.75	25.20	28.65
	April	35.80	43.68	26.20	29.84

Appendix 2. Monthly mean relative humidity (%) during the period from July 2015 to November 2015 and January 2016 to April 2016 in different growing conditions

Year	Months	Open field	Rain shelter
2015	July	92.87	87.71
	August	90.41	83.37
	September	88.69	81.45
	October	85.28	80.07
	November	84.32	78.63
2016	January	56.36	54.36
	February	57.74	52.28
	March	67.82	64.15
	April	69.48	63.26

(Contd...)

Appendix 3. Monthly mean light intensity (lux) during the period from July 2015 to November 2015 and January 2016 to April 2016 in different growing conditions

Year	Months	Open field	Rain shelter
2015	July	71400.00	63720.00
	August	75277.42	64709.68
	September	78696.67	70823.33
	October	85077.42	78003.23
	November	92033.33	82713.33
2016	January	86803.23	72032.26
	February	89593.10	66920.69
	March	87577.42	70496.77
	April	87620.00	80225.00

Appendix 4. Monthly mean sunshine hours (h) and rainfall (mm) during the period from July 2015 to November 2015 and January 2016 to April 2016 in the experimental field

Year	Months	Sunshine hours (h)	Rainfall (mm)
2015	July	118.50	510.10
	August	180.60	320.80
	September	167.70	242.20
	October	174.10	203.80
	November	137.40	151.20
2016	January	266.20	23.80
	February	237.20	11.40
	March	247.50	9.80
	April	238.20	8.60

PERFORMANCE OF AFRICAN MARIGOLD (*Tagetes erecta* L.) UNDER DIFFERENT GROWING CONDITIONS

by

NIMISHA AUGUSTINE

(2014 – 12 – 105)

ABSTRACT OF THE 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 HORTICULTURE

VELLANIKKARA, THRISSUR – 680 656

KERALA, INDIA

2016

ABSTRACT

The experiment entitled "Performance of African marigold (*Tagetes erecta* L.) under different growing conditions" was undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the year 2015-2016. Performance of eight African marigold cultivars *viz.*, Sonata Orange, Sonata Yellow, Biocarve Orange, Biocarve Yellow, Local Orange, Local Yellow, Sierra Yellow and Orange Giant were evaluated under open field and rain shelter conditions during two seasons; Season I (from July – November 2015) and Season II (from January – April 2016). Observations were recorded on vegetative, floral and seed characters as well as chlorophyll content in leaves and xanthophyll and flavonoid contents in flowers.

The vegetative and floral characters of African marigold cultivars were found to be greatly influenced by the growing conditions and growing seasons. The plant height, internodal length, number of primary branches, number of secondary branches, flower diameter, individual flower weight, number of flowers/plant, shelf life, total flower yield and marketable flower yield were better in the rain shelter grown plants during both the seasons. Stem girth, leaf length, leaf breadth, leaf area and petiole length were the highest in plants grown in open field condition during the two seasons. The highest flower length and pedicel length were recorded in the open field condition during first season and under rain shelter condition during second season. During both the seasons, least number of days for first flowering and 50 per cent flowering were recorded in rain shelter grown plants. Highest seed yield was obtained from plants grown under rain shelter condition, whereas highest seed germination, chlorophyll, xanthophyll and flavonoid contents were recorded in plants grown in the open field condition.

Among the cultivars, Orange Giant recorded highest plant height (113.00 cm), internodal length (8.02 cm), number of secondary branches (35.38), flower diameter (6.56 cm), flower weight (12.29 g), total flower yield (668.06 g/plant) and marketable flower yield (606.74 g/plant) during the first season. The cultivar Local Yellow recorded highest seed yield (1.11g) and seed germination (90.00%).

Maximum shelf life (4.57 days) was noticed in Sonata Orange. The cultivar Biocarve Orange recorded least number of days for first flowering (43.92 days) and 50 per cent flowering (56.08 days). Highest chlorophyll content was recorded in cultivar Local Yellow, xanthophyll content in cultivar Orange Giant and flavonoid content in Sonata Orange.

During the second season, highest plant spread, stem girth (2.47 cm), number of primary branches (8.60), leaf length (12.55 cm), leaf area (13.79 cm^2) and seed yield (0.62 g) were recorded in Local Yellow. The cultivar Sonata Orange recorded highest plant height (47.97 cm) and number of secondary branches (22.93). Highest number of flowers/plant (51.27), shelf life (3.17 days), total flower yield (186.43 g/plant), marketable flower yield (182.94 g/plant) and seed germination (89.00%) were recorded in cultivar Orange Giant. The cultivar Biocarve Yellow took least number of days for first flowering and 50 per cent flowering among the cultivars. Highest chlorophyll content was recorded in cultivar Orange Giant, xanthophyll content in cultivar Local Orange and flavonoid content in Sonata Orange. Evaluation of cultivars under open field and rain shelter conditions during both the seasons revealed that, the cultivar Orange Giant was superior to all other cultivars.

All the vegetative, floral and seed characters were found to be better during the first season. Even though higher concentration of total chlorophyll was recorded in plants grown during first season xanthophyll and flavonoid contents were maximum during the second season. From the study it is concluded that African marigold can be very well grown under rain shelter condition during July – November, which coincides with the rainy season in Kerala.