EVALUATION OF GAILLARDIA (*Gaillardia pulchella* Foug.) GENOTYPES UNDER HILL ZONE OF KARNATAKA

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JUNE, 2015

Affectionately Dedicated

To My Ever Loving Parents

N. Gandhi & A. Nataraj,

Lovely Brother N. Anbu,

Friends and My Chairperson

S. Y. Chandrashekar

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF GAILLARDIA (*Gaillardia pulchella* Foug.) GENOTYPES UNDER HILL ZONE OF KARNATAKA"** submitted by **Mr. N. ARULMANI**, ID No. **MH2TAC003** in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FLORICULTURE AND LANDSCAPE ARCHITECTURE** to the University of Agricultural and Horticultural Sciences, Shivamogga, is a record of *bona-fide* research work carried out under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associate ship, fellowship or any other similar titles.

MUDIGERE
June, 2015

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June, 2015

(N. ARULMANI)

EVALUATION OF GAILLARDIA *(Gaillardia pulchella* Foug.) GENOTYPES UNDER HILL ZONE OF KARNATAKA

N. ARULMANI (MH2TAC003)

ABSTRACT

An investigation was carried out to evaluate genotypes of gaillardia (*Gaillardia pulchella* Foug.) for growth, flowering, yield, quality and genetic traits at experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Karnataka during the period from October 2014 to April 2015. Among eight genotypes studied, DGC-2 recorded maximum plant height (58.38 cm), number of branches per plant (14.17), number of leaves per plant (642.40), stem girth (22.85 mm), dry weight of plant (40.64 g), flower yield per plant (348.94 g) and vase life (7.06 days). The maximum plant spread both at E-W (53.29 cm) and N-S (51.35 cm) direction, leaf area (6046.68 cm^2) and whorls per flower (8.00) was found in genotype AGC-1. The genotype DGC-2 recorded minimum days for first flower appearance (48.00), 50 percent flowering (78.00) and maximum duration of flowering (146.67 days). The days taken for full bloom (4.33), seed setting (52.67) and shelf life (14.43 hr) of flowers were superior in genotype SGC-2. The genotype DGC-1 had recorded maximum number of flowers per plant (131.60) and flower yield per hectare (22.17 t/ha). The genotype SGC-1 exhibited maximum flower diameter (3.73 cm), flower weight (7.67 g) and seed yield per plant (17.12 g) as well as per hectare (1027.19 kg). The estimates on phenotypic coefficient of variation (PCV) were more than genotypic coefficient of variation (GCV) for all characters. High heritability estimates associated with high genetic advance (over mean) was noticed for most of the traits studied. The maximum B:C ratio was recorded in the genotype DGC-1 (1:3.32).

June, 2015

Floriculture and Landscape Architecture
College of Horticulture, Mudigere

S. Y. CHANDRASHEKAR
(Major Advisor)

ಕರ್ನಾಟಕದ ಗುಡ್ಡಗಾಡು ಪ್ರದೇಶದಲ್ಲಿ ಗೈಲಾರ್ಡಿಯಾ (*ಗೈಲಾರ್ಡಿಯಾ ಪಲಚೆಲ್ಲಾ* ಫೋಗ್) ಹೂವಿನ ತಳಿಗಳ ಕಾರ್ಯಕ್ಷಮತೆ.

ಎನ್. ಅರುಲ್‌ಮಣಿ (ಎಮ್‌ಎಚ್‌೨೬೪೦೦೩)

ಸಾರಾಂಶ

ಗೈಲಾರ್ಡಿಯಾ ಹೂವಿನ ಎಂಟು ತಳಿಗಳ ಬೆಳವಣಿಗೆ, ಹೂ ಬಿಡುವಿಕೆ, ಇಳುವರಿ, ಗುಣಮಟ್ಟ ಹಾಗೂ ಅನುವಂಶಿಕ ಗುಣಗಳನ್ನು ತಿಳಿದುಕೊಳ್ಳುವ ಕ್ಷೇತ್ರ ಸಂಶೋಧನೆಯನ್ನು ಪುಷ್ಪಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ಕಲಾಶಾಸ್ತ್ರ ವಿಭಾಗ, ತೋಟಗಾರಿಕಾ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆಯಲ್ಲಿ, ಅಕ್ಟೋಬರ್ ೨೦೧೪ ರಿಂದ ಎಪ್ರಿಲ್ ೨೦೧೫ನೇ ಸಾಲಿನಲ್ಲಿ ಹಮ್ಮಿಕೊಳ್ಳಲಾಯಿತು. ಸಂಶೋಧಿಸಿದ ಎಂಟು ತಳಿಗಳಲ್ಲಿ ಡಿಜಿಸಿ–೨ ತಳಿಯು ಗರಿಷ್ಠ ಸಸ್ಯದ ಎತ್ತರ (೫೮.೩೮ ಸೆಂ.ಮೀ), ಸಸ್ಯ ಶಾಖೆಗಳ ಸಂಖ್ಯೆ (೧೪.೧೭), ಎಲೆಗಳ ಸಂಖ್ಯೆ (೬೪೨.೪೦), ಕಾಂಡದ ಸುತ್ತಳತೆ (೨೨.೮೫ ಮಿ.ಮೀ), ಸಸ್ಯದ ಶುಷ್ಕ ತೂಕ (೪೦.೬೪ ಗ್ರಾಂ), ಪ್ರತಿ ಗಿಡದ ಹೂವಿನ ಇಳುವರಿ (೩೪೮.೯೪ ಗ್ರಾಂ), ಮತ್ತು ಹೂದಾನಿ (೭.೦೬ ದಿನಗಳು) ಜೀವನವನ್ನು ನೀಡಿತು. ಎಜಿಸಿ–೧ ತಳಿಯು ಗರಿಷ್ಠ ಸಸ್ಯ ಹರಡುವಿಕೆ (೬೦೪೬.೬೮ ಸೆಂ.ಮೀ), ಪ್ರತಿ ಹೂವಿನಲ್ಲಿ ಗರಿಷ್ಠ ಸುರುಳಿಗಳನ್ನು (೮) ಹೊಂದಿರುವುದಾಗಿ ಕಂಡುಬಂದಿತು. ಡಿಸಿಜಿ–೨ ತಳಿಯು ಕನಿಷ್ಠ ದಿನಗಳಲ್ಲಿ ಮೊದಲ ಹೂಬಿಡುವಿಕೆ (೪೮.೦೦ ದಿನಗಳು), ಪ್ರತಿಶತ ೫೦ ರಷ್ಟು ಹೂಬಿಡುವಿಕೆ (೭೮.೦೦ ದಿನಗಳು), ಹಾಗೂ ಕನಿಷ್ಟ ಕಾಲಾವಧಿಯ ಹೂಬಿಡುವಿಕೆಯನ್ನು (೧೪೬.೬೭ ದಿನಗಳು) ಪ್ರದರ್ಶಿಸಿತು. ಎಸ್‌ಜಿಸಿ–೨ ತಳಿಯು ಅರಳಲು ತೆಗೆದುಕೊಂಡ ದಿನ ಕನಿಷ್ಠ (೪.೩೩ ದಿನಗಳು), ಗರಿಷ್ಠ ಬೀಜೋತ್ಪತ್ತಿ (೫೨.೬೭) ಹಾಗೂ ಗರಿಷ್ಠ (೧೪.೪೩ ಗಂಟೆ) ಸಂಗ್ರಹಣೆ ಸಾಮರ್ಥ್ಯವನ್ನು ಪ್ರದರ್ಶಿಸಿತು. ಡಿಜಿಸಿ–೧ ತಳಿಯು ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಗರಿಷ್ಟ ಹೂವುಗಳ ಸಂಖ್ಯೆ (೧೩೧.೬೦) ಮತ್ತು ಪ್ರತಿ ಹೆಕ್ಟೇರಿನ ಹೂವಿನ ಇಳುವರಿಯನ್ನು (೨೨.೧೭ ಟನ್) ನೀಡಿತು. ಎಸ್‌ಜಿಸಿ–೧ ತಳಿಯು ಗರಿಷ್ಟ ಹೂವಿನ ವ್ಯಾಸ (೩.೭೩ ಸೆಂ.ಮೀ), ಹೂವಿನ ತೂಕ (೭.೬೭ ಗ್ರಾಂ), ಬೀಜದ ಇಳುವರಿ (೧೭.೧೨ ಗ್ರಾಂ) ಹಾಗೂ ಪ್ರತಿ ಹೆಕ್ಟೇರಿನ ಬೀಜದ ಇಳುವರಿಯನ್ನು (೧೦೨೭.೧೯ ಕೆಜಿ) ನೀಡಿತು. ಅಧಿಕ ಅನುವಂಶಿಕತೆ ಅಂದಾಜು ಎಲ್ಲಾ ಪಾತ್ರಗಳಿಗೆ ವಂಶವಾಹಿ ಗುಣಾಂಕಕ್ಕಿಂತ ಹೆಚ್ಚಿರುವುದಾಗಿ ಕಂಡುಬಂದಿತು. ಗರಿಷ್ಠ ಬಿ:ಸಿ ಅನುಪಾತವು ಡಿಜಿಸಿ–೧ ತಳಿಯಲ್ಲಿ (೧:೩.೩೨) ಕಂಡುಬಂದಿದೆ.

ಜೂನ್, ೨೦೧೫

ಪುಷ್ಪಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ಕಲಾಶಾಸ್ತ್ರ ವಿಭಾಗ

ತೋಟಗಾರಿಕಾ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆ

ಎಸ್.ವೈ. ಚಂದ್ರಶೇಖರ್

(ಮುಖ್ಯ ಸಲಹೆಗಾರ)

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INTRODUCTION

I. INTRODUCTION

Flowers are integral part of our day today life for religious, cultural and social rituals. Though their cultivation has been going on for centuries, only recently the increasing investments have been made it as a commercial activity. The availability of diverse climatic and physical conditions in India facilitate the production of a wide range of flowers throughout the year. At present, in India about 2,32,000 ha area is under floriculture and the production of flowers is estimated to be 1.72 million tonnes of loose flowers and 767.31 million cut flowers per annum (Anon., 2014).

India has a long history regarding the cultivation and use of loose flowers for religious, cultural and social activities. Some of the flowers that are part and parcel of the Indian traditional lifestyle are jasmine, rose, chrysanthemum, marigold, tuberose, etc. Today, there is a huge demand for flowers in the domestic market also. In this order, gaillardia is an emerging flower crop for loose flower production in southern and some parts of central India.

Gaillardia (*Gaillardia pulchella* Foug.), commonly known as 'Blanket Flower' because of its wide array of colours and patterns including Mexican blankets, gold-tipped with russet-red centers but recent introductions have expanded the colour range further. Sometimes gaillardia is referred to as fire wheel or Indian blanket or brown-eyed susan in European countries (Helen *et al*., 2007). It is one of the important hardiest annual flower crops which belongs to the family of Asteraceae and has a basic chromosomes number of X=18 and 2n=36 (Srivastava and Kandpal, 2006). It is native to Florida and western United States (Anon, 2007). The generic name of gaillardia was proposed in honour of Gaillard de Marentonneau in 18th century, a French supporter of botany (Bailey, 1929).

Gaillardia pulchella Foug. is a herbaceous annual or short-lived perennial growing up to a height of 30 to 150 cm. Out of twenty species available in the genus *Gaillardia*, only *Gaillardia pulchella* is annual and *Gaillardia aristata*, is a perennial one in cultivation (Anon., 1950). The annual type grows to a height of 30 to 90 cm. The leaves that appear in initial stages are large, up to15-20 cm length and more lobed than those that appear in the later stages. The characteristics such as leaf shape and size are highly variable in nature. Leaves may be basal and linear to lanceolate, grayish green, and very hirsute (Helen *et al*., 2007).

Flowers are small and numerous; born in solitary, usually showy heads which is stated as capitulam with 4 to 6 cm in diameter. Individual flowers in a capitulam are called florets which range from one to ten according to cultivars or genotypes. As a member of Asteraceae it has both ray and disc florets which are pistillate and hermaphrodite, respectively in nature. Flower has a long hairy stalk and single, semi-double and double types with single or multicolored heads (Cox and Klett, 1984). The crop produces flowers in a wide range of colours such as yellow, orange, cream, scarlet, bronze, brick-red and red and can be grown all around the year (Shreedhar, 1993).

Nowadays, gaillardia has gained importance for its profuse and long duration flowering habit (Johnkilmer, 1989). It is one of the hardiest annuals that can be grown in a variety of soils and under varied climatic conditions it tolerates temperature as low as -1°C. Gaillardia can withstand fairly high salinity and 50 per cent of yield could be obtained even at 8.7 ds/m salinity level and this can be tried as a new flower crop for saline soils (Khimani, 1991).

Commercial cultivation of gaillardia is found in Karnataka, Maharashtra, Madhya Pradesh, Gujarat, and Rajasthan. In Karnataka, cultivation of this crop is concentrated in districts such as Belgaum, Dharwad and Bijapur. The growing

popularity of this crop has led to expanding its cultivation to other parts of the state. The farmers in southern Karnataka are lured by the flower and are braced to take up cultivation of the same on a large scale. In North Karnataka, flowers are used for making *veni* and garlands.

Due to its attractive spectacular forms, bright coloured flowers and hardiness it is grown in flower beds, for edging and mixed borders besides being grown for loose flowers. Gaillardia is also good for cut flowers, as the flowers last long in water for more than six days. Besides its utility in landscape, it is useful in reducing soil erosion in coastal dune areas. It can be used as a substitute for chrysanthemum and China aster for loose flower purpose as it is a photo insensitive and hardy crop. The plant has anti-tumour activity owing to the presence of methyl caffeate distributed throughout the plant (Srivastava and Kandpal, 2006). Some other traits like tolerance to drought, resistance to pest and diseases and easy perpetuation from seed make it possibly more popular.

In view of the importance, popularity and potentiality of this crop, there is a lot of scope for identification of suitable varieties for local environment. Use of novel agro techniques and improved cultivars will enhance the yield even though the selection of proper genotype among the various species with desirable traits will increase the production considerably. Very meager work has been done in zone-9 of Karnataka with respect to evaluation of genotypes and also standardization of production technology.

Keeping the above points in view, the present investigation on “Evaluation of *Gaillardia pulchella* Foug. genotypes under hill zone of Karnataka” was taken-up with the following objectives:

1. To study the performance of different genotypes of gaillardia for growth, flowering, yield and quality.
2. To know the genetic variability among the genotypes of gaillardia.
3. To work out the economics of gaillardia cultivation under hill zone.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Gaillardia pulchella Foug. is an important hardy, summer and winter annual flower crop grown for both loose flower and landscape purpose. For successful crop production two things is decussate, the environment and selection of cultivar. Selection of genotype is better and effective option rather than control of environmental factors. Huge number of gaillardia genotypes was spread over India and in different parts of the world. Those performance vary depend on climatic conditions under which they growing.

So, available genotypes have to be undersee for their performance in terms of vegetative growth, flowering, yield and quality attributes. In this regard, there is a need for evaluation of genotypes for the particular agro-climatic region. For this reason, many workers have evaluated different genotypes for studying their performance under different regions. Hence, the literature pertaining to their work has been reviewed in gaillardia and other Asteraceae flower crops are presented under the following headings.

2.1 Performance of genotypes

2.2 Vegetative parameters

2.3 Flowering parameters

2.4 Yield and Quality parameters

2.5 Variability

2.6 Others

2.1 Performance of genotypes

Helen *et al.* (2007) evaluated twenty-three blanket flower ecotypes for landscape performance in North-Central Florida. Among these 'Torch Red Ember' received the highest rating for uniformity. 'Arizona Sun' and 'Lollipop Gold' received the highest rating for flowering, and 'Torch Red Ember' and the St. Lucie Co. ecotype received the highest rating for landscape impact.

Tamut (2013) evaluated twenty gaillardia genotypes for heritability and genetic advance. Which were observed for plant height, number of branches per plant, days taken for first flowering, flower yield per plant, flower yield per hectare, seed yield per plant, seed yield per hectare, flower diameter and stalk length in all the genotypes.

2.2 Vegetative parameters

2.2.1 Plant height

2.2.1.1 Marigold

According to Khanvilkar *et al*. (2003) plant height (86.43 cm) was maximum in the cv. 'Orange Boom' and minimum in cv. 'Yellow Supreme' (39.77 cm) among the cultivars assessed.

Maximum plant height (83.51 cm) among the African marigold cultivars was recorded in 'Excel Mixed', whereas, 'French Spanish Brocade' recorded the maximum plant height (57.50 cm) among the French marigold cultivars (Singh *et al.*, 2003).

The plant height was recorded highest in orange double (84.00 cm) cultivar followed by lemon yellow (72.00 cm) and Hyderabad local selection-1 (71.00 cm) while dwarf plants were observed in Hyderabad local selection - 4 (46.33 cm) (Chandrashekara *et al*., 2005).

Singh and Singh (2006) conducted a study on the performance of twenty six African marigold genotypes under Uttaranchal conditions. Among them Genotype-16 (112.30 cm) was the tallest and dwarfest is accession TEG-23 (67.50 cm).

Namita *et al.* (2008) opined that, among eleven selections of French marigold studied plant height was maximum in ‘French Selection-2’ (62.50 cm) while it was minimum in ‘French Selection-5' (31.40 cm).

Singh *et al.* (2008) assessed twenty nine lines of African marigold for various growth, flowering and seed attributes. Maximum plant height was recorded in the germplasm TEG-26 (73.10 cm), whereas, minimum was recorded in the germplasm TEG-4 (49.57 cm).

Forty four germplasm of three species of marigold *viz*., *Tagetes erecta, T. patula* and *T. minuta* under Tarai conditions of Uttarakhand were evaluated by Singh and Kumar (2008) and observed that, for plant height were ranges from 27.23 cm to 226.87 cm.

Maximum plant height in both seasons (127.23 and 127.80 cm, respectively) of evaluation of marigold was recorded in the cross 'Sutton Orange × Cracker Jack Mix' and the minimum (49.09 and 49.56 cm) were in 'Beauty Orange' (Singh and Misra, 2008).

Genotype Pakharsangavi Local had recorded significantly maximum plant height (114.64 cm) among ten genotypes studied, whereas, African Giant Double Mixed had the lowest (87.98 cm) under Marathwada conditions (Narsude *et al.*, 2010).

Pal and Kumar (2010) observed that, maximum plant height (80.00 cm) was recorded in genotype 'Pusa Basanti Gainda', while minimum was exhibited by 'Indam Orange' (30.90 cm) among the seventeen African marigold genotypes evaluated.

Pramila *et al*. (2011) have undertaken evaluation studies on 17 marigold genotypes thus showed plant height ranges from 27.60 cm (dwarf orange) to 104 cm (double orange).

Evaluation report of fourteen genotype of French marigold showed that, plant height was maximum in cv. 'Safari Queen' (35.80 cm), whereas the cv. 'Cupidon varie Yellow' recorded minimum plant height (20.07cm) (Raghuvanshi and Sharma, 2011).

Sapna *et al.* (2013) evaluated twenty-two genotypes of marigold (*Tagetes erecta* L.) and results revealed that, the maximum plant height was observed in genotype 'Af.Sel.14' (68.47 cm) whereas, minimum was in 'Af.Sel.5' (41.97 cm).

Bharathi and Jawaharlal (2014) assessed the twenty eight genotypes of African marigold for growth parameters. The highest plant height from this study was recorded in genotype Dharmapuri local (113.27 cm).

2.2.1.2 China aster

According to Kulkarni and Reddy (2006), China aster cv. PG white was tallest among different cultivars experimented.

Among the varieties, evolved by Munikrishnappa *et al.*, (2013) for growth and yield attributes cultivar Phule Ganesh Violet recorded the highest plant height of 30.72, 55.58, 70.82 and 74.56 cm at 45, 75, 105 DAT and at harvest, respectively and was on par with Mixed Variety Local (30.42) and cv. Phule Ganesh Purple (52.58) at 45 and 75 days after transplanting, respectively. While the variety Violet Cushion recorded the least plant height of 16.20 cm, 36.65 cm, 48.17 cm and 51.95 cm at 45, 75, 105 DAT and at harvest, respectively.

The maximum plant height, number of primary and secondary branches, plant spread and number of leaves at all stage of plant growth was perceived by china aster cv. Phule Ganesh Violet (Zosiamliana *et al.*, 2013).

2.2.1.3 Chrysanthemum

Kishan *et al*., (2008) (a) reported that, the chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Tata Centenary had maximum plant height (124.00 cm) followed by cv. Snow Don (123.99 cm).

Among the evaluated cultivars of *Dendranthema grandiflora* L. the cv. Raichur recorded maximum plant height (34.77 cm) (Peddi *et al.*, 2008).

Genotype Saifali recorded maximum plant height (149.71 cm), followed by Terry (132.92 cm) whereas, minimum was in Suneel (44.50 cm) according to investigations carried out by Parul *et al.* (2011) in fifteen genotypes of chrysanthemum.

2.2.1.4 Dahlia

Accession number 16 was vigorous in its growth throughout the growth period in terms of plant height (140.33). Whereas Accession number 8 was dwarf and recorded minimum plant height (73.67 cm) (Vikas *et al.*, 2011).

Highest plant height (59.27 cm) was noticed in dahlia cv. Nandini followed by Santasyma (57.27 cm) and S.P. Kamala (55.20 cm), whereas, lowest plant height (40.08 cm) was observed in S.P. Glory of India (Ajeetkumar *et al.*, 2015).

2.2.2 Plant spread

2.2.2.1 Marigold

Among ten genotypes of marigold studied, maximum plant spread (46.00 cm) was recorded in both genotypes 'Hybrid Local Selection-l and 'African Tall Double Orange' (Chandrashekara *et al*., 2005).

Singh and Singh (2006) evaluated twenty nine African marigold genotypes and revealed that, maximum plant spread was registered in the genotype TEG-21 (79.10 cm) while minimum was in TEG-23.

Namita *et al.* (2008) investigated eleven selections of French marigold for genetic analysis. The cv. 'French Selection -10' recorded maximum plant spread (69.60 cm) among the selections.

Forty four germplasm of three species of marigold viz., *Tagetes erecta, T. patula* and *T. minuta* were evaluated and plant spread from this study was in the range of 18.87 to 79.10 cm (Singh and Kumar, 2008).

Singh and Misra (2008), while assessing the diversity of forty five genotypes of marigold recorded maximum plant spread in the 'French Dwarf' in both the seasons (106.80 cm and 107.40 cm respectively).

Maximum spread of plant (64.48 cm) was found in genotype 'Tuljapur Local-2', whereas, minimum (51.98 cm) was in 'Marigold Orange Bunch' at the time of examining marigold genotypes (Narsude *et al.*, 2010).

Raghuvanshi and Sharma (2011) evaluated fourteen genotypes of French marigold. Maximum plant spread among them was recorded in the cv. 'Harmony Boy' (30.37 cm), whereas it was minimum in the cv. 'Cupidon Varie Yellow' (17.25 cm).

Sapna *et al.* (2013) evaluated twenty-two genotypes of marigold (*Tagetes erecta* L.) for growth and flowering traits. Results revealed that, the maximum plant spread was recorded in genotype 'Af.Sel.14' (62.00 cm) and minimum in 'Af.Sel.9' (39.17 cm).

According to Choudhary *et al.* (2014), genotype 'Hissar Jaffri-2' of marigold recorded maximum plant spread (77.72 cm) under semi-arid conditions of Haryana.

2.2.2.2 China aster

Munikrishnappa *et al.*, (2013) reported that, cv. Phule Ganesh Violet recorded the maximum plant spread (34.40, 37.35 and 40.95 cm at 45, 75, 105 DAT and at harvest, respectively). The performance of Phule Ganesh White and Phule Ganesh Purple was on par with Phule Ganesh Violet. The minimum plant spread was recorded in the variety Mixed Variety Local at 45, 75 and 105 DAT (22.27, 24.98 and 27.02 cm, respectively).

2.2.2.3 Chrysanthemum

Peddi *et al.* (2008) reported that, the cv. Basanthi recorded maximum plant spread (29.62 cm) compared to all other cultivars from study on evaluation of yellow chrysanthemum.

Parul *et al.* (2011), while studying performance of fifteen genotypes of chrysanthemum (*Chrysanthemum morifolium* Ramat.) under mid hill conditions of Garhwal Himalaya recorded maximum plant spread in genotype Paris White (45.04 cm), followed by Suneel (44.50 cm), whereas it was minimum in Saifali (25.96 cm).

Evaluation studies of forty accessions of chrysanthemum were carried out at Ludhiana by Simrat *et al.*, (2012) revealed that, accessions A-8, A-10, A-31, A-32, A-

39 and A-108 were suitable for growing in the garden preferably due to better plant spread.

2.2.2.4 Dahlia

Varietal evaluation studies of Ajeetkumar *et al.* (2015), observed maximum plant spread (53.52 cm) in the cv. Eternity sports followed by S.P. Kamala (50.32 cm) and Mangal pandey (49.85 cm), while minimum was (37.3 cm) in S.P. Sriradha.

2.2.3 Number of branches

2.2.3.1 Marigold

Verma *et al.* (2004) reported that among the *Tagetes* germplasm studied, the maximum number of branches per plant was recorded in the genotype NIC-14841 (25.80) and the least was in NIC-14856 (7.89).

Naik *et al.* (2005) noted highest number of primary branches in case of Marigold genotype 'African Marigold Orange'(27.36), whereas it was lowest in the genotype 'Raichur Local' (17.88).

Pal and Kumar (2010) observed that among the seventeen African marigold genotypes evaluated, the maximum number of primary branches (5.91) and secondary branches (19.14) were recorded by the genotype 'Pusa Basanti Gainda'.

Performance of the cv. Bidhan-1 was good with respect to number of primary and secondary branches per plant among the cultivars evaluated (22.40 and 41.47, respectively) (Bharathi and Jawaharlal, 2014).

Choudhary *et al.* (2014) studied the performance of thirty genotypes of marigold under semi-arid conditions of Haryana. The genotype Hissar Jaffri-2

exhibited best performance in terms of plant spread and numbers of secondary branches per plant (150.97).

2.2.3.2 China aster

Munikrishnappa *et al.,* (2013) evaluated the ten cultivars of China aster under Karnataka conditions. Result revealed that, the cv. Phule Ganesh Purple had maximum number of secondary branches per plant (27.40, 34.78 and 36.18 at 75, 105 DAT and at harvest, respectively). It was on par with Phule Ganesh Violet at 105 DAT (33.80 / plant) and at harvest (34.87 /plant). The lowest number of secondary branches per plant was recorded in Phule Ganesh Pink at 75, 105 and at harvest (13.97, 20.27 and 23.25, respectively).

2.2.3.3 Chrysanthemum

Kishan *et al*., 2008 (a) noted the maximum number of branches per plant (20.16) in case of chrysanthemum cv. Yellow Bangla while minimum (3.16) was in PC-39.

Peddi *et al.* (2008) reported that, among the cultivars of yellow chrysanthemum studied cv. Basanthi recorded maximum number of branches per plant (17.73).

Genotype Paris White produced maximum number of primary (15.16) and secondary branches (19.16) per plant while minimum, i.e. 4.41 and 8.16 was recorded in genotype Saifali (Parul *et al.,* 2011) in *Chrysanthemum morifolium.*

2.2.3.4 Dahlia

Maximum number of branches per plant (7.87) was found with hybrid S.P. Glory and followed by Kenya White (6.93) and S.P. Kamala (6.87), while minimum

number of branches per plant (4.13) was found in Santasyma according with result obtained by Ajeetkumar *et al.*, 2015.

2.2.4 Number of leaves

2.2.4.1 Marigold

Singh and Singh (2005, a) evaluated thirteen germplasm of French marigold *(T. patula* L.) and two germplasm of wild marigold and reported that, germplasm of *Tagetes minuta* i.e., TM-1 and TM-2 produced maximum number of leaves per plant.

Singh and Misra (2008) reported maximum number of leaves per plant in the marigold genotype 'Late Summer' during both the seasons (4318.33 and 5324.67 respectively) of study.

2.2.4.2 China aster

Poornima *et al.* (2006) studied five genotypes of china aster under hill zones of Karnataka. It was observed that, among them, maximum number of leaves was recorded in genotype 'Violet Cushion' (248.95), whereas, minimum was in genotype 'Kamini' (127.71).

Munikrishnappa *et al.* (2013) recorded highest plant height, plant spread and number of leaves in cultivar Phule Ganesh Violet. Least for all these parameters was noted in the cv. Violet Cushion.

According to Zosiamliana *et al.* (2013) study report on cultivars of China aster *(Callistephus chinensis* L. Ness), maximum number of leaves per plant was registered in cv. 'Phule Ganesh Violet' (192.73), whereas, minimum was in the 'Local cultivar' (146.67).

2.2.4.3 Chrysanthemum

Talukdar *et al.* (2006) examined the performance of eighteen standard chrysanthemum cultivars under polyhouse cum rain shelter and open conditions. Maximum number of leaves per plant under open conditions was recorded in the cv. 'Cavelia' (128.33), whereas, under polyhouse rain shelter, the cv. 'Stanly Gosling' recorded maximum number of leaves per plant (64.67).

2.2.4.4 Dahlia

Number of leaves produced per plant was found to be maximum in accession number 16 (49.65) whereas, accession number 8 (37.67) produced lesser number of leaves while evaluating dahlia hybrids (Vikas *et al.*, 2011).

Maximum number of leaves per plant (29.46) was observed in the dahlia genotypes Kenya blue followed by Kenya white (27.33) and Eternity Sports (27.2), while minimum number of leaves per plant (22.13) was observed in S.P. Glory of India (Ajeetkumar *et al.*, 2015).

2.2.4.5 Gerbera

Vasudevan and Rao (2010) evaluated gerbera genotypes under mid-hill conditions of Garhwal Himalayas. It was observed that, maximum number of leaves per plant was in genotype 'Sunglow' (26.33), whereas, the genotype 'Fiction' recorded the least number of leaves per plant (13.36).

Under bamboo made playhouse, highest number of leaves per plant was observed in gerbera cv. Mayonaise while it was lowest in cv. Pound Sterling (9.50) (Kumar and Deka, 2012).

Kumar (2013) noted that, gerbera cv. Manizales recorded maximum number of leaves (18.14) per plant whereas minimum was in genotype Figaro (11.08) under naturally ventilated polyhouse.

Kumar and Yadav (2013) examined the performance of seven gerbera genotypes under polyhouse conditions. This revealed that, genotype Monarch had maximum number of leaves per plant (23.22) while minimum was recorded in genotype and Piton (14.59).

2.2.5 Leaf length

2.2.5.1 Gerbera

Maximum length (42.58 cm) and breath of gerbera leaf (19.80 cm) was observed in Laurance and Vilassar, respectively while, these were minimum in Arianna and Soleada (33.50 cm and 11.95 cm, respectively) (Kumar, 2013).

According to Kumar and Yadav (2013) the gerbera genotype Monarch recorded longest leaf (38.75 cm) and these complement is genotype Magnum (25.79 cm).

2.2.6 Leaf area

2.2.6.1 Marigold

Singh and Singh (2005, a) examined the performance of marigold germplasm under Sub-Mountainous Tarai Conditions. Among them, genotype TM_1 had the maximum leaf area (21.82 cm^2) and Tp_{10} recorded the minimum leaf area (9.53 cm^2).

According to Singh *et al.* (2008) leaf area was the highest (28.84 cm^2) in cv. TEG-2 and the lowest (12.89 cm^2) in the cultivar TEG -1, among twenty nine lines of marigold computed.

2.2.6.2 Dahlia

Vikas *et al.* (2011) reported that, among the different accessions of dahlia assessed for vegetative and floral parameter, leaf area was maximum in accession number 16 (72.89 cm^2) and least in accession number 8 (30.86 cm^2).

2.2.7 Stem girth

2.2.7.1 Marigold

Among the twenty nine genotypes of African marigold assessed, the accession TEG 14 (1.73 mm) had maximum stem girth (Singh and Singh, 2006).

Study conducted by Singh and Kumar (2008) on genetic variability, heritability, genetic advance and correlation in marigold, registered stem diameter in the range of 0.43 to 1.93 cm.

Narsude *et al*. (2010) studied ten African marigold genotypes for their growth and yield attributes under Marathwada conditions. It was observed that, among the ten genotypes maximum stem girth (5.37 cm) was reported in genotype 'Pakharsangavi local', whereas, 'orange bunch' had showed minimum stem girth (4.00 cm).

2.2.7.2 Dahlia

Among dahlia accessions evaluated, Accession number 16 recorded significantly higher stem girth (1.46 cm) and it was least in accession number 8 (1.27 cm) (Vikas *et al.*, 2011).

2.2.8 Chlorophyll content

2.2.8.1 Chrysanthemum

Among the chrysanthemum accessions studied, the highest total chlorophyll (1.819 mg/g) content was reported in Acc- 49 (Deepa and Chezhiyan, 2002).

2.2.9 Dry weight

2.2.9.1 Marigold

Marigold cv. 'Golden Age' (African type) recorded highest dry matter among the cultivars studied. While, in the French type the maximum dry matter was accumulated by the 'Harvest Moon' cultivar (Pramila *et al*., 2011).

2.3 Flowering parameters

2.3.1 Days taken for appearance of first flower

2.3.1.1 Marigold

Chandrashekara *et al*. (2005) observed earliest flowering in cv. Orange double followed by Pusa Narangi Gainda while screening of African marigold (*Tagetes erecta* L.) cultivars for flower yield.

Genotype TEG 26 shows earliest flowering compared to other germplasm was observed by Singh *et al.* (2008) while assessing African marigold genotypes.

Singh and Kumar (2008) examined forty four germplasms of three species of marigold. From this study, the days taken for flower appearance were observed in the range of 13.67 to 36.67 days.

The earliest day taken for flower bud appearance and flower bud opening were recorded in Bangalore Local Tall (29.47 days) and Double Orange (46.00 days) was observed by Bharathi and Jawaharlal (2014) while evaluating African marigold genotypes.

Singh *et al.* (2014) studied the genetic variation for vegetative and floral traits in African marigold (*Tagetes erecta*). High range in mean performance has been observed for time taken for flowering 78.67-99.33 days.

2.3.1.2 China aster

Zosiamliana *et al.* (2013) assessed the performance of some cultivars of China aster in AP for various traits. With regards to flowering traits, Phule Ganesh Pink recorded minimum number of days for first flower bud initiation (57.20) and first flowering (66.73) compared with Local.

2.3.1.3 Chrysanthemum

Forty cultivars of chrysanthemum (*Dendranthema grandiflora*) were subjected to evaluation studies (Deepa and Chezhiyan, 2002) revealed that, genotype Acc- 1 (47.50 days) showed early bud initiating.

Cultivar PC-8 was found to be early flowering which took 79.49 day while cv. Poonam took 113.49 day for first flowering were obtained by Kishan *et al.* (2008, a).

Parul *et al.* (2011) evaluated different Chrysanthemum genotypes under mid hill conditions of Garhwal Himalaya. In which, earliest bud burst (9.33 days) was observed in genotype Red Queen, whereas genotype Charming was late (30.00 days).

2.3.1.4 Dahlia

Vikas *et al.* (2011) carried out genetic variability studies in dahlia (*Dahlia variabilis* L.). Among the twenty five accessions evolved Accession number 22 (42.0 days) took minimum number of days to initiate flower bud while accession number 18 (67.3 days) recorded highest.

Among nine Dahlia hybrids evaluated, minimum days taken for first flower bud appearance (38.00 days) was observed in hybrid Mangal pandey followed by S.P. Kamala (48.6 days) while maximum days taken for first bud appearance (61.6 days) were observed in Kenya blue (Ajeetkumar *et al.*, 2015).

2.3.1.5 Daisy

The genotypes Dwarf Pink, showed earliness in first flowering and 50 per cent flowering (57.09 and 64.18 days, respectively) followed by Dark Blue Dwarf (62.76 and 67.11 days, respectively according to result obtained by Shekara *et al.* (2013).

2.3.2 Days taken for 50 per cent of flowering

2.3.2.1 China aster

According to the result obtained by Zosiamliana *et al.* (2013) in an evaluation of some China aster cultivars revealed that, cv. Phule Ganesh Pink recorded minimum number of days for first flower bud initiation, first flowering and 50% flowering (85.67).

2.3.2.2 Daisy

Suma and Patil (2006) studied flower quality parameters in Daisy (*Aster amellus* L.) genotypes. In these genotypes, Purple Monarch took maximum number of days (71.66 days after planting) for 50 per cent flowering over rest of the genotypes.

2.3.3 Flowering duration

2.3.3.1 Marigold

Among the cultivars investigated, cv. Orange double recorded maximum duration of flowering (44 days), whereas the Hyderabad local selection had shorter duration (18 days) of flowering (Chandrashekara *et al*., 2005).

Singh and Kumar (2008) evaluated forty four ermplasms of three species of marigold viz., *Tagetes erecta, T. patula* and *T. minuta* and reported that the duration of flowering was in the range of 54.33 to 135.33 days.

Narsude *et al.* (2010) reported that, genotype 'Marigold Orange Bunch' recorded maximum duration of flowering (56.33 days), while the genotype 'Malegaon Local' had shorter duration (42.00 days) of flowering among the genotypes studied.

Cultivar 'Safari Tangerine' recorded maximum duration of flowering (39.67 days), whereas, minimum in the cv. 'Honey Comb' (18.33 days) were reported by Raghuvanshi and Sharma, 2011.

Among thirty genotypes studied, Hissar Jaffri-2 exhibited longest flowering duration (76.53 days) under semi-arid climatic conditions of Haryana (Choudhary *et al.*, 2014).

Singh *et al.* (2014) studied the genetic variation for vegetative and floral traits in African marigold (*Tagetes erecta*). High range in mean performance has been observed for duration of flowering 6.00-44.83 days.

2.3.3.2 China aster

Longest flowering duration (60.96 days) was obtained in cultivar Phule Ganesh Pink while minimum was in cv. Local were reported by Zosiamliana *et al.* (2013) at the time of studying performance of China aster cultivars under AP conditions.

2.3.3.3 Chrysanthemum

Acc- 3 had the longest duration of flowering (89.50 days) among the genotypes evolved in chrysanthemum (Deepa and Chezhiyan, 2002).

Kishan *et al.* (2008, a) were recorded the maximum duration of flowering (56.83 day) in cv. Flirt by studying twenty genotypes of chrysanthemum.

2.3.3.4 Dahlia

Accession 22 had maximum duration of flowering (53.3 days) which is on par with accession number 6 and accession number 19 (52.0 days) whereas, accession number 15 recorded minimum duration of 32.00 days (Vikas *et al.*, 2011).

Ajeetkumar *et al.* (2015) reported that, the maximum flower duration (14.06 days) were found in hybrid Eternity sports and followed by S.P. Glory of India (14 days) and Kenya white (13.46 days), while minimum flowering duration (10.8 days) was found in Nandini at the time studying hybrids of dahlia under Allahabad conditions.

2.4 Yield and Quality parameters

2.4.1 Diameter of flower

2.4.1.1 Marigold

Among the African marigold cultivars assessed, maximum diameter of flower was observed in the cv. 'Giant Mixed' (7.87 cm), whereas in case of French marigold cultivars it was recorded in the cv. 'Orange Gate' (5.22 cm) (Singh *et al.*, 2003).

Chandrashekara *et al.* (2005) reported that, among the ten African marigold cultivars evaluated, the cv. 'Orange Double' recorded maximum flower diameter (13.40 cm) whereas, Hyderabad local sel-3 (5.90 cm) recorded minimum flower diameter.

Naik *et al.* (2005) observed that, the genotype 'African marigold Orange' recorded the maximum flower diameter (10.03 cm), whereas, it was least in the genotype 'Vanilla' (4.63 cm).

Singh *et al*. (2008) evaluated twenty nine genotypes of French marigold and results revealed that, maximum flower diameter was recorded in the cv. TEG-26 (10.80 cm), whereas, minimum was in the genotype TEG-7 (2.70 cm).

Singh and Kumar (2008) reported that, the variation in flower diameter of forty four marigold genotypes was in the range of 0.40 to 10.83 cm.

Among the genotypes of marigold assessed, the cross 'Pusa Narangi Gainda '×' Late Summer' registered maximum flower diameter (13.00 and 13.00 cm, respectively) (Singh and Misra, 2008).

Among the African marigold genotypes examined 'Malegaon Local' recorded the maximum flower diameter (8.83 cm) and least was in genotype ‘Marigold Orange Bunch' (5.70 cm) (Narsude *et al.*, 2010).

Patil *et al*. (2011) reported that, among the African marigold cultivars studied, the cv. AMC-6 (9.97 cm), AMC-7 (9.42 cm) and AMC-20 (9.23 cm) recorded maximum flower diameter whereas, least was in AMC -13 (5.11 cm).

According to the results obtained by Raghuvanshi and Sharma (2011), maximum flower diameter was found in the marigold cv. 'Bonanza Bolero' (5.26 cm), whereas, minimum in the cv. 'Golden Boy' (3.01 cm).

2.4.1.2 China aster

Zosiamliana *et al.* (2013) clearly indicated that, the China aster cv. Phule Ganesh White is best to get maximum flower diameter (7.37 cm), as cut and loose flower under Andhra Pradesh conditions.

2.4.1.3 Chrysanthemum

Kishan *et al.* (2008, a) reported that among the twenty germplasm assessed, the cv. Snow Don recorded maximum flower diameter (10.58 cm) compared with others.

Baskaran *et al.* (2010) evaluated the ten cultivars of chrysanthemum for various traits. Among those, the highest flower diameter (8.14 cm) was recorded in cv. Ravikiran and the lowest was in Button Type Local (2.07 cm) cultivar.

2.4.1.4 Dahlia

Among twenty five genotypes of dahlia evaluated by Vikas *et al.* (2011) unveiled that, higher diameter of flower was observed in accession number 10 (19.30 cm) whereas, accession number 3 recorded least (8.60 cm).

Ajeetkumar *et al.* (2015) studied the performance of hybrids of dahlia. Among these maximum diameter of fully opened flower (24.5 cm) was found in hybrid Kenya blue followed by Kenya white (23.72 cm) and Eternity sports (23.70 cm), while minimum diameter of fully opened flower (18.30 cm) was observed in Nandini.

2.4.2 Number of whorls per flower

2.4.2.1 Gaillardia

Tamut (2013) found maximum number of whorls per flower in the genotypes AGS-8 (12.10) .Whereas, minimum in the genotypes AGS-3, AGS-5, AGS-6, AGS-12 and AGS-20 (1.00) at the time of evaluating gaillardia genotypes for genetic variability study.

2.4.2.2 Chrysanthemum

Twenty germplasms of *Dendranthema grandiflora* were assessed for number of traits which revealed that, highest number of ray florets per flower (287.99) was recorded by cv. Thai Chin Queen (Kishan *et al.*, 2008 (a)).

Number of ray florets per head showed a very wide range of variation ranging from a minimum of 47.33 in cv. Cadda and maximum of 253.20 in cv. Nilima were reported by Baskaran *et al.* (2010) by studying some cultivars of chrysanthemum.

2.4.2.3 Dahlia

Vikas *et al.* (2011) reported that among the genotypes assessed, Accession number 15 (271.3) recorded significantly higher ray floret whereas least was observed in Accession number 56.7.

2.4.3 Flower weight

2.4.3.1 Marigold

Singh *et al.* (2003) evaluated twelve cultivars each of African and French marigold. It was observed that among African marigold cultivars, maximum weight of fresh flower was recorded in 'African Double Perfection' (15 g), whereas among the French cultivars, it was maximum in 'Orange Gate' (6.6 g).

Chandrashekara *et al.* (2005) observed that among the ten African marigold cultivars assessed, the cv. 'Orange Double' recorded the highest flower weight (16.67 g).

Singh and Singh (2006) reported that among twenty nine genotypes of African marigold, the germplasm TEG-17 recorded maximum fresh and dry weight of flower.

Narsude *et al.* (2010) assessed ten African marigold genotypes for their growth and yield attributes under Marathwada conditions. It was observed that among the ten genotypes, maximum weight of single flower (12.56 g) was recorded in genotype 'Malegaon Local', whereas, genotype 'Marigold Orange Bunch' recorded minimum weight of flower (5.79 g).

Raghuvanshi and Sharma (2011) evaluated fourteen French marigold genotypes and recorded maximum weight of hundred loose flowers in the cv.

'cupidon Varie Orange' (620.33 g), whereas, minimum was recorded in the cv. 'Singh: Petal Red' (184.00 g).

2.4.3.2 Chrysanthemum

Kishan *et al.* (2008, a) evaluated the Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) germplasm in winter season under Delhi conditions in this maximum fresh weight of single flower (10.24 g) was recorded by cv. Thai Chin Queen**.**

Baskaran *et al.* (2010) recorded the highest individual flower weight (3.59 g) in cv. Cassa, while button type local exhibited the lowest value (0.48 g) among the cultivars studied.

2.4.3.3 Dahlia

Vikas *et al.* (2011) reported that the Accession number 12 recorded maximum (29.3 g) flower weight followed by accession number 14 (28.3 g) whereas minimum individual flower weight was observed in Accession number 8 (13.7 g) at the time of evaluating twenty five genotypes of Dahlia.

Ajeetkumar *et al.* (2015) opined that, among nine hybrids of Dahlia studied individual flower weight was maximum in variety Kenya white (107.74 g) which was closely followed by Kenya blue (93.16 g) and Eternity sport (91.79 g) while minimum weight of single flower (42.67 g) was observed in Nandini.

2.4.4 Length of stalk

2.4.4.1 China aster

Balaji *et al.* (2004) studied the different cultivars of China aster for growth and yield parameters. From the result obtained, the stalk length was highest in cv. Phule Ganesh Pink followed by cv. Phule Ganesh White and Phule Ganesh Violet.

Zosiamliana *et al.* (2013) revealed that, cv. Phule Ganesh White is best in concern of maximum flower diameter, stalk length (34.78 cm) and vase life both as cut and loose flower under Andhra Pradesh conditions. Least for all these traits was observed in cv. Local.

2.4.4.2 Chrysanthemum

Baskaran *et al.* (2010) evaluated ten cultivars of Chrysanthemum for post-harvest quality. Thus showed, the maximum length of the stalk was observed in cv. Nilima (17.52 cm) followed by Arka Ravi (15.58 cm) and Yellow star (15.05 cm) whereas, minimum length was observed in Button Type Local (4.67cm) cultivar.

2.4.4.3 Dahlia

Accession number 21 recorded higher stalk length of 22.70 cm which was on par with accession number 3 (22.20) and accession number 25 (21.00) whereas, accession number 4 (5.20 cm) (Vikas *et al.*, 2011).

2.4.5 Shelf life

2.4.5.1 Marigold

Patil *et al*. (2011) studied the yield and quality parameters as influenced by seasons and genotypes in marigold. Among these genotypes AMC -6 (6.39days) recorded maximum shelf life, followed by AMC -7 (6.28 days) and AMC -8 (5.39 days) and it was less (3.56 days) in genotypes AMC -2 and Vigro Hybrid Orange.

Raghuvanshi and Sharma (2011) studied on vase life of different cultivars of marigold was recorded maximum storage duration 8.67 days and 4.00 days was obtained in cv. Cupid on variety Orange under cold store and ambient conditions respectively.

2.4.6 Vase life

2.4.6.1 China aster

Zosiamliana *et al.* (2013) evaluated the some cultivars of China aster in Andhra Pradesh condition. Result revealed that, cv. Phule Ganesh White recorded maximum flower diameter; stalk length and vase life both as cut (9.13 days) and loose (4.37 days) flower whereas least for all these character was observed in cv. Local.

2.4.6.2 Chrysanthemum

Study conducted by Baskaran *et al.* (2010) on post-harvest quality of some cultivars of Chrysanthemum revealed that, Cultivar Arka Swarna recorded longer duration of vase life with 16 days followed by cv. Ravikiran (10 days) and cv. Red gold (9 days). Shortest duration of vase life was recorded in cv. Cassa (4 days).

Parul *et al.* (2011) evaluated Fifteen different Chrysanthemum *(Chrysanthemum morifolium)* genotypes under mid hill conditions of Garhwal Himalaya. Among that, extended period of vase life was recorded in genotype Gauri (24.66 days), followed by Shanti (22.00 days), while it was low with Red Queen (5.33 days).

2.4.6.3 Dahlia

According to Vikas *et al*. (2011), accession number 14 had longer vase life (28.30 days) which is followed by accessions 10 (26.60 days) and 17 (26.50 days) are on par with each other whereas, least was noticed in accession 8 (13.70days) while examining performance of Dahlia genotypes.

2.4.7 Number of flowers per plant

2.4.7.1 Marigold

Naik *et al*. (2005) observed that, the maximum number of flowers per plant was recorded in the marigold genotype 'African Marigold Orange' (90.79), whereas, the genotype 'AkkiChandhoo' recorded the least number of flowers per plant (45.83).

Singh and Singh (2006) evaluated twenty nine genotypes of African marigold and reported that the number of flowers per plant was in the range of 20.00 to 77.00.

Namita *et al.* (2008) evaluated eleven French marigold selections for various parameters and reported that, the maximum number flowers per plant were produced by 'French Selection-2' (144.67), while minimum was in 'French Selection-3' (30.00).

Narsude *et al*. (2010) observed that among the ten African marigold genotypes, Tuljapur local -1 (71.00) recorded maximum number of flower per plant and minimum was in Akolner local (36.47).

Patil *et al.* (2011) studied the yield and quality parameters of twenty African marigold genotypes. The studies revealed that the maximum number of flowers per plant were produced by the genotype AMC-8 (84.10), whereas, minimum was by the genotype AMC-4 (36.95).

2.4.7.2 China aster

The China aster cultivars Phule Ganesh Pink, Phule Ganesh Violet and Phule Ganesh White produced more number of flowers per plant were reported according the result obtained by Balaji *et al.* (2004).

Poornima *et al.* (2006) evaluated the different cultivars of China aster under hill zone of Karnataka. Among those, maximum number of flowers was obtained in cv. Shashank (50.22) whereas cv. Poornima produced least number of flowers (45.30) per plant.

Munikrishnappa *et al.* (2013) assessed ten cultivars of China aster for various growth and yield traits. Result revealed that, number of cut flower production was maximum (55.43) in variety Phule Ganesh Violet and it was on par with Phule Ganesh White (53.29) and Violet Cushion (53.29). The lowest number of cut flowers per plant was produced in Shashank (40.92).

Zosiamliana *et al.* (2013) studied the performance of some varieties of China aster in AP. Cultivar Phule Ganesh White gave maximum number of flower per plant (36.73) and yield both per plant (208.81 g) and per hectare (23.20 t/ha). The minimum values for all these characters were recorded by cv. Local.

2.4.7.3 Chrysanthemum

Kishan *et al.* (2008, a) assessed the twenty germplasm of *Dendranthema grandiflora* in winter season under Delhi conditions. Among that, the maximum number of flowers per plant (56.50) was obtained by genotype PC-28 followed by White Prolific (52.16) and PC-10 (51.83) and minimum (10.33) by Kundan.

Deepa and Chezhiyan (2002) evaluated the forty accessions of chrysanthemum for yield and its related traits. Among those, Acc - 4 and Acc - 32 were the highest yielders with respect to number of flowers per plant, per plot and calculated yield per ha.

The highest number of flowers per plant was obtained in cv. Paris White (301.00) and minimum was recorded with genotype Suneel (66.33) was reported by

Parul *et al.* (2011) at the time of studying fifteen genotypes of *Chrysanthemum morifolium* under mid hill conditions of Garhwal.

2.4.7.4 Dahlia

Vikas *et al*. (2011) reported that, out of twenty five Accession viz., from one to twenty five (1 to 25) evolved Accession number 16 has highest number of flowers per plant (37.7) followed by Accession 12 and 24 while it is minimum under Accession number 6 (16.0).

Ajeetkumar *et al.* (2015) studied the performance of nine Dahlia hybrids under Allahabad conditions. Among these, maximum number of flowers per plant (9.06) was found in hybrid S.P Glory of India and followed by Kenya white (8.2) and S.P. Kamala (8) were minimum number of flowers per plant (5.46 days) was found in Santasy ma

2.4.8 Flower yield

2.4.8.1 Marigold

Naik *et al.* (2005) observed that the genotype 'African Marigold Orange' recorded the maximum number of flowers per plant (90.79) and maximum flower yield per hectare (16.47 tons).

Singh and Misra (2008) observed that among forty five genotypes of marigold, cross 'Pusa Narangi Gainda' × 'Late Summer' recorded maximum flower yield per plant (1821.34 g and 1087.21 g respectively), flower yield per ha (182.13 q and 168.72 q, respectively) in both the seasons.

Significantly number of flowers per plant (71.00), yield per plant (630.48 g) and yield per hectare (24.67 MT) was maximum in the cv. 'Tuljapur Local-l ' was reported by Narsude *et al.* (2010).

According to Raghuvanshi and Sharma (2011), French marigold cv. 'Safari Queen' recorded maximum flower yield per square meter (8.27 kg), whereas minimum yield per square meter was recorded by the cv. 'Cupidon Varie Yellow' (1.68 kg) under mid-hill zone of Himachal Pradesh.

2.4.8.2 China aster

The average yield on weight basis of two seasons was highest in cv. Phule Ganesh Pink followed by Phule Ganesh White. Were studied and reported by Balaji *et al.* (2004).

Kulkarni and Reddy (2006) evaluated the China aster (*Callistephus chinensis* (l) ness.) varieties for growth and flower yield. Among those, flower yield per plant was maximum in cultivar PG white (327.90 g/plant) which was on par with PG purple (284.00 g/plant) and PG Pink (249.1 g/plant).

Poornima *et al.* (2006) recorded highest flower yield in cv. Shashank (9.51 tonnes/ha) while lowest in cv. Poornima (5.03 tonnes/ha) at the time of assessing China aster cultivars.

Munikrishnappa *et al.* (2013) reported that among ten cultivars of China aster examined, highest and lowest flower yield per hectare were recorded in cv. Phule Ganesh White (37.9 ton) and Local (9.97 ton), respectively.

Zosiamliana *et al.* (2013) studied the performance of some varieties of China aster in AP. Cultivar Phule Ganesh White gave maximum flower per yield both per plant (208.81 g) and per hectare (23.20 t/ha) whereas minimum values for these were recorded by cv. Local.

2.4.8.3 Dahlia

Ajeetkumar *et al.* (2015) studied the performance of nine Dahlia hybrids *viz.*, Santasyma, S.P. Kamala, Kenya blue, S.P. Glory of India, Kenya white, Nandini, S.P. Sriradha, Mangal pandey and Eternity sport under Allahabad conditions and found that maximum flower yield per plant (881.42 g) was recorded in hybrid Kenya white and followed by Kenyablue (720.37 g) and Eternity sport (678.79 g), while minimum flower yield per plant (278.72 g) was recorded in S. P. Sriradha.

2.4.9 Seed yield

2.4.9.1 Gaillardia

Tamut (2013) reported that, genotype AGS-8 and AGS-1 had maximum (16.80 g & 1241.47 kg) and minimum (8.80 g & 651.20 kg) seed yield per plant and hectare.

2.5 Variability

2.5.1 Gaillardia

According to the results obtained by Hegde and Gopinath (2003) in gaillardia, phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all characters studied. High genotypic and phenotypic coefficients of variation were obtained for number of ray florets per flower and dry weight of flowers. The highest heritability was recorded by number of leaves per plant, leaf area per plant, plant height and dry weight of flowers. High genetic advance was recorded for number of leaves and number of ray florets per flower.

2.5.2 Marigold

Mathad *et al*. (2005) studied on correlation and path co-efficient analysis in African marigold revealed that, flower yield per plant had significantly positive

correlation with plant height, number of branches, plant spread, duration of flowering, number of flowers per plant, flower weight, flower diameter, number of seeds per flower head and seed yield per plant. The maximum positive direct effect on flower yield was shown by flower weight, seed yield per plant and plant height.

Correlation and path analysis studies in marigold revealed that, number of flower buds and fresh weight of the flower showed highest positive direct effect while number of branches showed lowest positive direct effect on flower yield. Similarly number of flowers per plant and flower yield showed highest positive direct effect (Mathew *et al*., 2005).

Namita *et al.*, (2008) reported the results of heritability studies on eleven selections of French marigold (*Tagetes patula*). The coefficient of variation was minimum for number of seeds per head (GCV =12.15, PCV =13.66) and maximum for number of flowers per plant (GCV =40.23, PCV =42.70). High heritability along with high genetic advance was observed for flower yield (h^2 =81.49. GA =117.87) and number of flowers per plant (h^2 =88.75, GA =75.42). High genetic advance was observed for number of flowers per plant (78.08). However, low genetic advance as per cent mean was observed for 1000 seed weight (18.37).

Results of correlation studies in marigold indicated that, the flower yield per plant was found to be significantly and positively correlated with number of branches per plant, flower size, flower weight, number of flowers per plant whereas, days to first flowering showed a negative association with flower yield per plant. Path analysis has shown that number of flowers per plant has high positive direct effects (Karuppaiah and Kumar, 2010).

Pal and Kumar (2010) reported that, coefficient of variation was minimum for duration of flowering (GCV-13.27, PCV=13.33) and maximum for seed yield per plant (GCV=53.57, PCV=53.61). High heritability along with high genetic advance

was observed for fresh weight of flowers per plant (268.83), seed yield per plant (19.20), number of flowers per plant (33.43), days commencement to flowering (20.93) and plant spread at peak flowering period (20.11). However, moderates to low genetic advance along with high heritability were observed for flower stalk length (3.50) and flower diameter (2.54) by studying seventeen marigold genotypes.

Kumar *et al.,* (2014) opined that, estimates of phenotypic coefficient of variation (PCV) were found to be higher than their corresponding genotypic coefficient of variation (GCV) in marigold. High broad sense heritability coupled with high genetic advance was reported for number of flowers per plant (h^2 = 99.62%, GA = 59.78) and flower yield per plant (h^2 = 99.53%, GA = 133.82). The yield of flowers per plant exhibited highly significant and positive correlation with number of branches, number of flowers per plant (0.862) and flower weight (0.732).

Panwar *et al.* (2014) assessed the twenty-two genotypes of marigold (*Tagetes erecta* L.) for 16 quantitative traits. The results revealed that, flower yield per plant (genotypic) was found to be positively correlated with plant height, flowering duration, number of flowers per plant, and flower diameter.

Twenty-one genotypes of African marigold were (*Tagetes erecta* L.) evaluated to study their genetic parameters by Singh *et al.,* (2014). Higher genotypic and phenotypic coefficient of variation found for most of all for all traits. The high value (>90%) of heritability was observed for all traits except plant height, plant spread and stem girth. High values of genetic advance as per cent of mean were recorded for number of flowers (59.79%). Path coefficient analysis revealed that the number of primary branches per plant contributed highest and has significantly positive direct effect on fresh flower weight per plant.

2.5.3 China aster

Ravikumar and Patil (2003) in an evaluation of eleven genotypes of China aster for 14 quantitative characters are recorded. High heritability and high genetic advance as per cent of mean were observed for plant spread (99.09% and 75.19%), flower yield per plant (99.06% and 73.25%) and average weight of fresh flower (97.34% and 58.78%), indicating additive gene action. While, time taken for first flower bud initiation showed high heritability with low genetic advance (77.89% and 21.63%),indicating non additive gene action.

Eleven genotypes of China aster (*Callistephus chinensis*) were evaluated for 14 quantitative characters. The genotypic coefficient of variation was high for plant spread, leaf area per plant, average weight of fresh flower and flower yield per plant. Heritability estimates for these characters were also relatively high. The correlation studies revealed that flower yield was positively and significantly correlated with the diameter of flower and number of flowers per plant (Naik *et al.*, 2004).

The flower yield per plant in China aster was significantly and positively associated with the plant spread, branch number and leaf number per plant. A significant and positive correlation was observed between the flower diameter and weight of 25 flowers both at genotypic and phenotypic levels. The plant height and flower yield per plant had high total direct on the stalk length (Poornima *et al.*, 2006).

Studies of Sreenivasulu *et al*. (2007) on correlation in china aster revealed that, number of flowers per plant was positively and significantly associated with plant height , primary and secondary branches , days taken for 50 per cent flowering, diameter of flower, fresh weight of flower and dry weight of plant. The fresh weight of flower was positively and significantly associated with dry weight of plant.

2.5.4 Chrysanthemum

Pal and Santhy (2002) studies on variability estimates, heritability and correlation in twelve standard type chrysanthemum (*Dendranthema morifolium*) genotypes consisting of 2 indigenous and 10 exotics were carried out for vegetative and flowering characters. The genotypes showed significant differences for all the characters.

Talukdar *et al*. (2003) found genetic variation for growth and floral characters in chrysanthemum. High heritability with high genetic advance over per cent of mean was observed for the characters like number of flowers per plant (99.74% and 185.38%), leaf number (99.97% and 160.66%) and number of ray florets (99.54% and 156.63%), indicating additive gene effects.

Studies on genetic variability, heritability and genetic advance were carried out in ten genotypes of chrysanthemum by Baskaran *et al.*, (2010). The results showed high phenotypic and genotypic co-efficient of variations for traits like number of suckers per plant (GCV=90.13; PCV=95.67) and flower disc diameter (GCV=63.19; PCV=66.76). In high heritability estimate coupled with high genetic advance as per cent of mean was observed for number of suckers per plant (174.91), flower disc diameter (123.23) and number of flowers per plant (114.81).

Twenty five germplasm of spray chrysanthemum were evaluated to determine correlation and path coefficient. Number of primary branches per plant had the highest correlation (0.998) followed by number of secondary branches per plant (0.997). Path coefficient analysis revealed that number of primary branches per plant had the highest direct effect on flower yield (0.6010) followed by number of secondary branches per plant (0.2452) and number of leaves per plant (0.1631), Misra *et al*. (2013).

2.5.5 Dahlia

The association between fourteen vegetative and floral parameters along with their magnitude towards number of flowers per plant was studied in twenty five accessions of dahlia by Vikas *et al*. (2011). Correlations revealed that, number of flowers per plant had positive and highly significant correlation with plant height, number of leaves, leaf area, stem girth, number of days for flower bud initiation, number of days for flowering, diameter of flower, number of ray florets per flower, individual flower weight, longevity of flower and vase life. Since these associations are in desirable direction and selection of these traits may ultimately improve the yield.

Vikas *et al*. (2011) reported that, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) in dahlia for all the characters studied. However higher PCV and GCV estimates were found for stalk length of the flower, duration of flowering, number of ray florets/flower and individual flower weight. High heritability with high genetic advance was observed for vase life, diameter of flower, stalk length of the flower and individual flower weight.

2.6 Others

2.6.1 Economics

Economics were analysed for cultivation of wild marigold and compared with other common crops on the basis of net returns and benefit cost ratio. Results revealed that, wild marigold as pure crop as well as intercrop in maize is more profitable than the other crops was considered (Singh, 2001).

Mahawer *et al.* (2010) reported that, among the dahlia cultivars assessed net return per rupee investment (B:C ratio) was maximum in the cv. NT pompon (Rs. 1.50).

2.6.2 Pest and Diseases

Garibaldi *et al*., (2004) observed that, gerbera plants that were grown for cut flowers in a soilless cultivation system exhibiting symptoms of wilt disease. Subsequent years also this was noticed under bed cultivation. From these plants, *Fusarium* spp. was consistently isolated onto a *Fusarium*-selective medium and colonies were identified as *Fusarium oxysporum*.

Tamut (2013) evaluated twenty gaillardia genotypes for screening of *Cercospora* leaf spot disease, among these minimum score was obtained in genotypes AGS-8 and AGS-16. Hence, these genotypes were resistant to *cercospora* leaf spot disease whereas, the high score obtained by genotypes (AGS-14 and AGS-19) were highly susceptible.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation on "Evaluation of *Gaillardia pulchella* Foug. genotypes under hill zone of Karnataka" was carried out at experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, (University of Agriculture and Horticultural Sciences, Shivamogga) during the period from October 2014 to April 2015 to study the performance of eight gaillardia genotypes for growth, flowering, yield and quality parameters.

The details of the experiment, materials used, methodology followed, statistical analysis adopted for conducting the experiment and observations recorded during the course of the investigations are described in this chapter.

3.1 Geographical location of the experimental site

The experiment was carried out in the experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, which is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region-V) of Karnataka and lies at 13^{0} 25' North latitude and 75^{0} 25' East longitude with an altitude of 980 m above mean sea level.

3.2 Climate

The mean monthly weather data for the year 2014-2015 recorded at Zonal agricultural and horticultural research station (ZAHRS), Mudigere are presented in Appendix-I.

The climate in the region is cool and pleasant throughout the year with an average rainfall of 2350 mm, mainly distributed in about 100 days during the period from April to November with three peaks during June, July and August. The average annual maximum temperature is 31.61°C and minimum temperature is 17.09°C.

Morning and evening average mean relative humidity is 87.63 and 60.12 per cent, respectively.

3.3 Soil characteristics of experimental site

The soil of the experiment site was medium sandy loam. The soil samples were collected from the depth of 10-30 cm in randomly selected spots and analysed for various physical and chemical composition. The results of the analysis are presented in Appendix-II.

3.4 Experimental details

3.4.1 Planting materials

Eight genotypes of gaillardia were used for the experiment**.** Among these**,** two genotypes were collected from Department of Floriculture and landscaping Architecture, K.R.C. College of Horticulture, Arabhavi, two from University of Agricultural Science (UAS), Dharwad and the remaining four genotypes were procured from Sarpan Seeds Pvt. Ltd., Dharwad.

3.4.2 Design and experimental layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications (Fig. 1). The treatments in each replication were allotted randomly.

3.4.3 The experimental details are as follows

Location	: College of Horticulture, Mudigere
Number of treatments	: 8
Number of replications	: 3
Plot size	: 3 m x 3 m

Spacing	: 45 cm x 30 cm
Number of plants per plot	: 54
Planting method	: Raised bed system
RDF	: 15 tonnes of FYM/ha and 75:80:60 kg of NPK/ha

3.4.4 Treatment details

The eight gaillardia genotypes used, were considered as the treatments in the study. Details of treatments and the corresponding symbols used during the study are as follows.

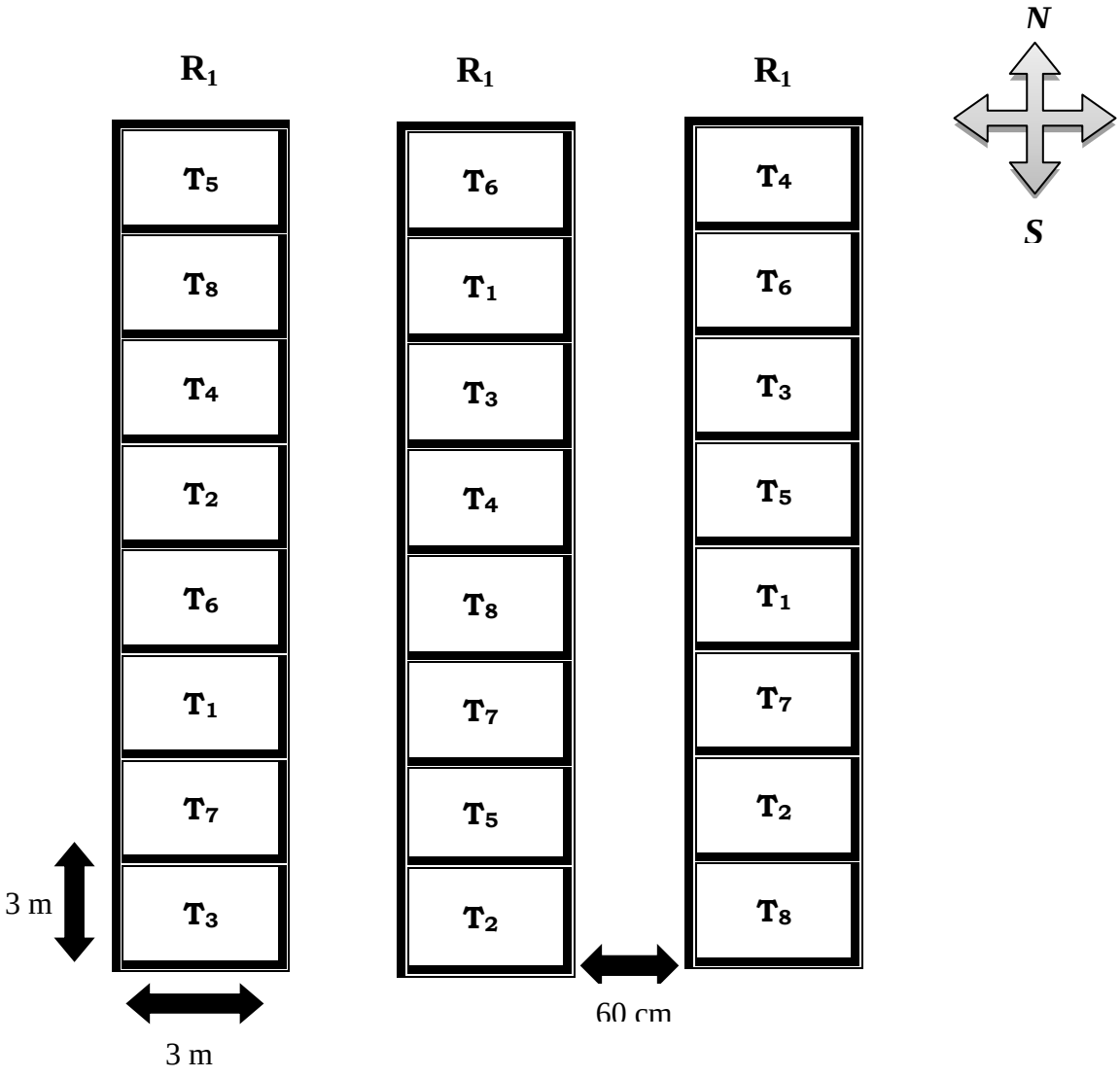
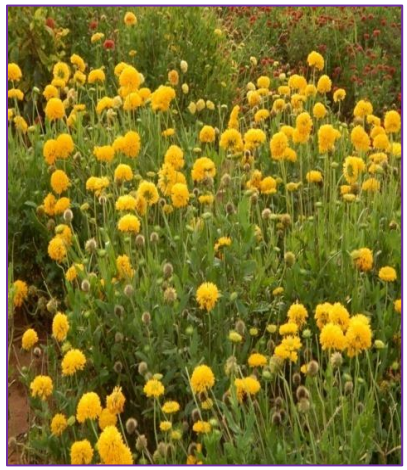


Fig. 1. Plan and Layout of the experimental plot

Plate 1. General view of experimental site at various stage



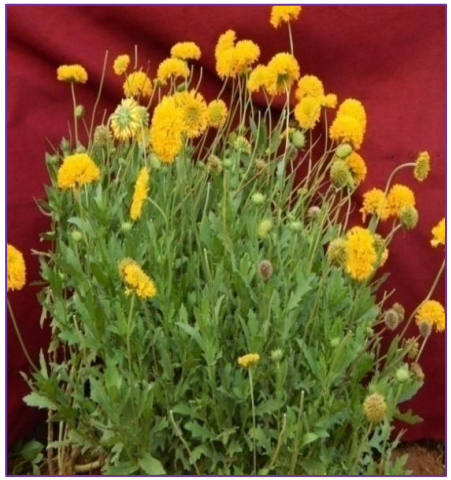

AGC- 1


AGC- 2


SGC- 1


SGC- 2

Plate 2. General view of different *Gaillardia pulchella* foug. genotypes with flowers.



SGC-3

SGC-4

DGC-1

DGC-2

Plate 2a. General view of different *Gaillardia pulchella* foug. genotypes with flowers.

V_1- Dharwad Gaillardia Collection-1 (DGC-1)

V_2- Arabhavi Gaillardia Collection-1 (AGC-1)

V_3- Sarpan Gaillardia Collection-4 (SGC-4)

V_4- Dharwad Gaillardia Collection-2 (DGC-2)

V_5- Sarpan Gaillardia Collection-3 (SGC-3)

V_6- Sarpan Gaillardia Collection-2 (SGC-2)

V_7- Sarpan Gaillardia Collection-1 (SGC-1)

V_8- Arabhavi Gaillardia Collection-2 (AGC-2)

Sl. No.	Genotypes	Type	Colour	Source
1	AGC-1	Double	Yellow	KRCCH, Arabhavi
2	AGC-2	Double	Reddish centre with outer yellow	KRCCH, Arabhavi
3	DGC-1	Double	Bright yellow	UAS, Dharwad
4	DGC-2	Double	Red tinged with yellow	UAS, Dharwad
5	SGC-1	Double	Bright red	M/s. Sarpan Seeds, Dharwad
6	SGC-2	Double	Bright pink	M/s. Sarpan Seeds, Dharwad
7	SGC-3	Double	Bright yellow	M/s. Sarpan Seeds, Dharwad
8	SGC-4	Double	Yellow tinged with red	M/s. Sarpan Seeds, Dharwad

3.5 Cultural Practices

The details of various cultural operations carried out during the course of investigation are furnished below.

3.5.1 Nursery operations

The seeds were sown in pro trays in the last week of August 2014 and were kept in polyhouse. The seedlings were watered regularly and weeding was done in pro trays as and when required. Seedlings were maintained carefully up to 45 days till the seedlings were ready for transplanting.

3.5.2 Preparation of experimental site

Land was thoroughly ploughed to a depth of 30 cm and brought to fine tilth. All the weeds, stubbles and stones were removed. Raised beds of 3 m x 3 m were prepared with 60 cm spacing between the beds.

3.5.3 Transplanting

Forty five days old healthy and uniformly grown seedlings were transplanted to the field. The seedlings were hardened before transplanting for two days by withholding water and transplanting was done with a spacing of 45 cm x 30 cm at the rate of one seedling per hill during the morning hours. Optimum soil moisture condition was maintained by irrigating the crop once or twice a week depending on prevailing climate conditions.

3.5.4 Manuring and fertilizer application

Farm yard manure @ 15 tonnes per hectare and N, P and K @ 75, 80 and 60 kg per hectare were applied as per the recommendations of the package of practices of UAS, Dharwad (Anon., 2008). NPK in the form of urea, rock phosphate and muriate of potash were used. FYM was applied at the time of land preparation. Half dose of N, full dose of P and K were applied to the soil at the time of land preparation and remaining half dose of N was applied 30 DAT as a top dress to the plants.

3.5.5 Intercultural operations

The plots were kept free from weeds by hand weeding at 30 days interval. Irrigations were given at an interval of 4-5 days throughout the period of experimentation, depending on the soil moisture status and prevailing climatic conditions.

3.5.6 Gap filling

Gap filling was done a week after transplanting with fresh seedlings, in order to maintain minimum per cent of population in all the treatments.

3.5.7 Plant protection measures

There was no serious pest or disease noticed in the experimental plot except aphids. Nevertheless, protection measures were taken up with appropriate chemicals as and when the incidence of aphids was noticed.

3.5.8 Harvesting

The flowers were harvested from each treatment and replication when the ray and disc florets were fully opened and attained full size.

3.6 Recording of experimental data

Five plants were selected randomly from each treatment and a selected plant was tagged in each treatment and replication, for the purpose of recording the observations. The mean value of the data obtained from five plants in each treatment was worked out to represent particular genotype with respect to a particular character.

3.6.1 Vegetative parameters

Observations on vegetative parameters were recorded at three different stages, i.e., 30, 60 and 90 days after transplanting.

3.6.1.1 Plant height (cm)

The height of the tagged plants was measured from the base of the plant to the tip of the plant in centimetres and average was worked out. This was done at all the three stages of plant growth i.e., at 30, 60 and 90 days after transplanting.

3.6.1.2 Number of branches per plant

The number of main branches arising from the main stem was counted at 30, 60 and 90 days after transplanting.

3.6.1.3 Plant Spread (cm) (E-W)

The spread of the plant was measured from east to west direction of the plant with help of meter scale and expressed in centimeters.

3.6.1.4 Plant Spread in (cm) (N-S)

The spread of the plant was measured from north to south direction of the plant with help of meter scale and expressed in centimetres.

3.6.1.5 Number of leaves per plant

Actual number of leaves produced per plant was counted at 30, 60 and 90 days after transplanting and average was worked out.

3.6.1.6 Leaf length (cm)

Length of the leaf was measured from tagged plant at 30, 60 and 90 days after transplanting and expressed in centimeters.

3.6.1.7 Stem girth (mm)

Stem girth was measured by leaving 5 cm from the ground level with the help of verniercalipers at 30, 60 and 90 days after transplanting from all the tagged plants and average was worked out. It was expressed in millimetres.

3.6.1.8 Dry weight (g)

Dry matter production (g/plant) of different plant parts at 30, 60 and 90 days after transplanting was estimated by uprooting three plants randomly in each treatment. The leaves, stem, flowers and roots were separated and fresh weight was recorded. Then they were oven dried separately at a temperature of 65^0C till it reached constant weight. The total dry matter production (above the ground plant parts only) was calculated by adding dry weight of leaves, stem and flowers.

3.6.1.9 Chlorophyll estimation (mg/g)

Chlorophyll content of leaf was analyzed by collecting the healthy, fully opened and matured leaves from the center portion of the plant at peak growth stage. Chlorophyll 'a', Chlorophyll 'b' and total chlorophyll contents of leaf tissue were determined by non-destructive method of chlorophyll estimation using Dimethyl sulphoxide (DMSO) as suggested by Shoaf and Lium (1976).

The harvested leaves were brought in polyethylene bags from the field and were cut into small pieces in laboratory. Known weight of sample (100 mg) was incubated in 7.0 ml DMSO for 24 hours and kept in dark place. After the incubation, supernatant was collected by decanting. Then the volume of supernatant was made up to 10 ml using DMSO.

The absorbance of extract was measured at 645 nm and 663 nm using DMSO as blank in spectrophotometer. The chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents were calculated by using the following formulae.

Chlorophyll 'a'=12.7(A633)-(12.69×A645) V/1000×W

Chlorophyll 'b'=22.9(a645)-(4.68×a663) V/1000×W

Total chlorophyll (mg/g fresh weight)=12.7(A663)-(12.69×A645)V/1000×W×a

Where in,

A= Absorbance at specific wave length (645 nm and 663nm)

B= Volume of the extract (10 ml)

C= Fresh weight of the sample (100 mg)

a= Path of light in cuvette (1 cm)

3.6.1.10 Leaf area per plant (cm^2/plant)

Leaf area was estimated by using leaf area meter (Leaf area meter model 211) once at peak stage of growth and expressed in square centimetres.

3.6.2 Flowering parameters

3.6.2.1 Days taken for appearance of first flower (days)

This was recorded by counting the number of days from the date of transplanting to the stage at which the first flower appeared.

3.6.2.2 Days taken for 50 per cent flowering (days)

The number of days taken for 50 per cent of plants to produce flowers was recorded from each treatment by counting the days from the date of transplanting.

3.6.2.3 Duration of flowering (days)

Number of days taken from the first flowering to the last flowering was observed from tagged plants and recorded as total duration of flowering.

3.6.2.4 Days taken for full bloom (days)

This was recorded by counting number of days taken from flower bud to fully opening of flower in each treatment.

3.6.2.5 Days taken for seed setting (days)

Number of days taken from full bloom to seed set was observed and recorded as days taken for seed setting in each treatment.

3.6.3 Yield parameters

3.6.3.1 Number of flowers per plant

Number of flowers produced in each tagged plants was recorded and the average number of flowers produced per plant was worked out for different genotypes.

3.6.3.2 Number of flowers per plot

This was worked out on the basis of number of flowers obtained from tagged plants and computed for plot.

3.6.3.3 Flower yield per plant (g)

From the tagged plants, yield per plant was worked out by recording the fresh weight of flowers from every harvest and the mean value was worked out and expressed in grams.

3.6.3.4 Flower yield per hectare (t/ha)

This was worked out on the basis of flower weight obtained from the each plot and computed for hectare area.

3.6.3.5 Seed yield per plant (g)

Flower heads were harvested from the tagged plants after complete drying. Seeds obtained from these plants were weighed and average seed weight per plant was worked out and expressed in grams.

3.6.3.6 Seed yield per hectare (kg)

Seed yield per hectare was worked out on the basis of average seed weight obtained from five plants in each treatment and computed for hectare area.

3.6.4 Quality parameters

3.6.4.1 Diameter of flower (cm)

The longest distance between any two points on the margin of the flower was recorded at peak flowering stage and expressed in centimetres.

3.6.4.2 Number of whorls per flower

Number of whorls in a flower was counted at peak flowering stage and recorded from each genotype.

3.6.4.3 Length of stalk (cm)

Length of stalk was measured at peak flowering stage from the base of the last leaf on the stalk of the flower to the base of the flower head and expressed in centimetres.

3.6.4.4 Flower weight (g)

Flowers were selected from the tagged plants at full bloom stage and weight of these flowers was recorded. The average weight of individual flower was worked out in grams.

3.6.4.5 Shelf life (hours)

Fully opened flowers were harvested and kept in plates under laboratory conditions. Number of hours was counted until the flowers lost their marketable quality.

3.6.4.6 Vase life (days)

The flowers were harvested at fully opened stage with stalks and these were cut again to have a uniform stem length. Then the flowers were kept in conical flasks containing 500 ml of tap water. Flowers were observed daily till they were found unfit for holding in vase (which was characterized by falling of florets) and was expressed in terms of days.

Others

3.6.4.6 Incidence of pest and diseases

There were no serious pest and disease noticed during the course of investigation. However, sucking pests like aphids incidence were found sporadically.

3.7 Statistical analysis

The statistical analysis of the data obtained during the course of investigation was done by following statistical models as under.

3.7.1 Analysis of variance

Variance is the measure of variability and is defined as the average of the square deviation from the mean. It helps in working out the variance due to different sources and also provides the basis for test of significant (Singh and Choudhary, 1979).

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967) using the mean values of random plant in each replication from all treatments to find out the significance of treatment effect.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	'F' ratio
Replication	(r-1)	RSS	Mr	Mr/Me
Treatment	(t-1)	TSS	Mt	Mt/Me
Error	(r-1) (t-1)	ESS	Me	
Total	(rt-1)		Mr+Mt+Me	

Where,

r = Number of replications

t = Number of genotypes

RSS, TSS and ESS = Sum of squares of replications, genotypes and error respectively

Mr, Mt and Me = Mean squares of replications, genotypes and error respectively

Variation due to genotype was tested by comparing calculated values to Table 'F' value at five per cent.

3.7.2 Estimation of genetic parameters

3.7.2.1 Genotypic, phenotypic and environmental variances

Genotypic variance ($\sigma^2 g$) = $\frac{\text{Treatment MSS} - \text{Error MSS}}{r}$

Environment variance ($\sigma^2 e$) = Error mean sum of squares

Phenotypic variance ($\sigma^2 p$) = Genotypic variance + Environment variance

3.7.2.2 Coefficient of variation

The coefficient of variation (CV) being a standardized form of variance is useful for comparing the extent of variation between different characters with different scales (Singh and Choudhary, 1979). Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953) based on estimate of genotypic and phenotypic variance.

$$\text{Genotypic coefficient of variation (\%)} = \sqrt{\frac{\sigma^2 g}{\bar{X}}} \text{ X } 100$$

$$\text{Phenotypic coefficient of variation (\%)} = \sqrt{\frac{\sigma^2 p}{\bar{X}}} \text{ X } 100$$

Where,

$\bar{X}$= General mean of the character

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

PCV and GCV were classified as suggested by Shivasubramanian and Menon (1973) as follows.

0 – 10% - Low

10-20 - Moderate

20% and above - High

3.7.2.3 Heritability (h^2)

Heritability, in broad sense was calculated as the ratio of genotypic variance to the phenotypic variance and expressed in percentage.

Heritability (h^2) = $\frac{\sigma^2 g}{\sigma^2 p}$

Where,

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

3.7.2.4 Genetic advance (GA)

This was calculated using formula given by Robinson *et al.* (1949)

$GA = i \times h^2 \times \sigma p$

Where,

i = Selection of differential (i=2.06) at 5 per cent selection intensity.

h^2 = Heritability in broad sense

σp = Phenotypic standard deviation of the trait

3.7.2.5 Correlation

Genotypic (rg) and phenotypic (rp) coefficient of correlation were estimated as suggested by Al-Jibourie *et al.* (1958)

$$\text{Genotypic correlation} = \frac{\text{Co V xy (G)}}{\sqrt{\text{Vx (G)} \times \text{Vy(G)}}}$$

$$\text{Phenotypic correlation} = \frac{\text{Co V xy (P)}}{\sqrt{\text{Vx (P)} \times \text{Vy(P)}}}$$

Where,

CoVxy (G) = Genotypic covariance between x and y

CoVxy (P) = Phenotypic covariance between x and y

Vx (G) = Genotypic variance of character x

Vx (P) = Phenotypic variance of character x

Vy (G) = Genotypic variance of character y

Vy (P) = Phenotypic variance of character y

Test of significance of correlation was tested by comparing the 'r' value with obtained value.

3.7.2.6 Path coefficient analysis

The concept of path coefficient analysis developed by Wright (1921) and illustrated by Dewey and Lu (1959) was carried out separately to know the direct and indirect effects of the important components, which are the standardized partial regression. Coefficients were obtained by solving the following set of 'p' simultaneous equations through the use of 'Doo-little techniques' as given by Goulden (1959).

$P_{01} + P_{02}r_{12} + \ldots\ldots\ldots\ldots\ldots\ldots + P_{op}r_{1p} = r_{01}$

$P_{01}r_{12} + P_{02} + \ldots\ldots\ldots\ldots\ldots\ldots + P_{op}r_{2p} = r_{02}$

.

.

$P_{01}r_{1p} + P_{02}r_{2p} + \ldots\ldots\ldots\ldots\ldots\ldots + P_{op} = r_{op}$

Where P_{01}, P_{02}…….P_{0p} are the direct path effects of 1,2,……P variables between dependent variable and independent variable and r_{01}, r_{02}…….r_{0p} are the correlation coefficients between dependent variable and independent variable. The indirect effect of 'i' th variable through 'j' th variable was worked out as $P_{0j} \times r_{ij}$.

The contribution of the remaining unknown factors is measured as the residual factor and calculated as

$$P^2_{0x} = 1 (P^2_{01} + 2P_{o1} P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \ldots\ldots..P^2_{02} + 2P_{02} P_{03}r_{23} + \ldots\ldots P^2_{0}p)$$

Residual factor = $\sqrt{P_{ox^2}}$

The direct and indirect effects were classified based on the scale given by Lenka and Misra (1973).

More than 1.0 - Very high

0.30 to 0.99 - High

0.20 to 0.29 - Moderate

0.10 to 0.19 - Low

0.00 to 0.009 - Negligible

3.8 Economics

Economics of cultivation of gaillardia, irrespective of the genotypes were worked out based on prevailing market price and are furnished in Appendix-III.

3.8.1 Gross income

The gross income was worked out based on the prevailing market price of fresh flower.

3.8.2 Net income

Net returns (Rs./ha) = Gross returns (Rs./ha) – Cost of cultivation (Rs./ha)

3.8.3 Benefit: Cost ratio

Benefit: Cost ratio was worked out by using the formula.

$$\text{Benefit: Cost ratio} = \frac{\text{Net returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results obtained in the present investigation on "**Evaluation of *Gaillardia pulchella* Foug. genotypes under hill zone of Karnataka"** with respect to growth, flowering, yield, quality and biometrical parameters are presented in this chapter.

4.1 Growth parameters

4.2 Flowering parameters

4.3 Yield parameters

4.4 Flower quality parameters

4.5 Biometrical parameters and

4.6 Economics

4.1 Growth parameters

Growth parameters such as plant height, number of branches, plant spread, number of leaves, leaf length, stem girth and dry weight of gaillardia genotypes were measured at monthly intervals from forty five days after transplanting to till end of the experiment. Whereas, the chlorophyll content and leaf area were measured only at peak growth stage. The results obtained from these characters were analysed and are presented in tables from 1 to 5.

4.1.1 Plant height (cm)

The data pertaining to plant height of different genotypes of gaillardia at various stages of growth are presented in table 1.

A significant difference was observed with respect to plant height in different genotypes of gaillardia at 30 days after transplanting (DAT). Among the different genotypes, AGC-1 recorded the maximum plant height (18.97 cm) which was on par

Table 1. Plant height and number of branches per plant of *Gaillardia pulchella* Foug. genotypes at various stages of growth

Sl. No.	Genotypes	Plant height (cm)			Number of branches per plant		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	16.73	33.81	52.60	1.47	8.80	13.83
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	18.97	39.07	57.50	2.00	11.33	14.13
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	12.90	27.64	45.29	0.80	6.07	10.53
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	18.83	42.60	58.38	4.67	10.22	14.17
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	10.47	22.94	38.47	1.20	7.27	13.40
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	16.65	35.13	49.37	1.27	7.47	12.80
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	11.68	31.31	54.28	1.27	7.27	11.47
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	12.46	29.64	48.59	1.47	7.93	13.00
S. Em±		**0.48**	**0.79**	**0.94**	**1.11**	**0.35**	**0.30**
CD @ 5%		**1.47**	**2.38**	**2.86**	**NS**	**1.06**	**1.00**

*** DAT**: Days After Transplanting

with genotype DGC-2 (18.83 cm) whereas it was minimum under genotype SGC-3 (10.47 cm).

At 60 DAT significantly maximum plant height was recorded in the genotype DGC-2 compared to the rest of genotypes (42.60 cm) evaluated, followed by genotypes AGC-1 (39.07 cm) and SGC-2 (35.13 cm). It was found minimum in genotype SGC-3 (22.94 cm).

The genotype DGC-2 vigorous in its growth and recorded significantly maximum plant height (58.38 cm) and it was on par with AGC-1 (57.50 cm), while the genotype SGC-3 (38.47 cm) was dwarf and recorded minimum plant height at 90 DAT.

4.1.2 Number of branches per plant

The data on number of branches produced per plant in various growth stages by different genotypes are presented in table 1. Significant differences were obtained for this character at 60 and 90 DAT.

Genotype AGC-1, recorded significantly maximum number of branches per plant (11.33) at 60 DAT followed by DGC-2 (10.22). Genotype SGC-4 recorded least number of branches (6.07) per plant.

At 90 DAT maximum number of branches per plant was produced by genotype DGC-2 (14.17) and it was on par with genotypes AGC-1 (14.13), DGC-1 (13.83) and SGC-3 (13.40) whereas, minimum numbers of branches per plant were produced in genotype SGC-4 (10.53).

4.1.3 Plant spread (cm)

The data pertaining to plant spread at various stages of growth in two different directions, as influenced by genotypes are furnished in table 2.

Table 2. Plant spread (E-W and N-S) of *Gaillardia pulchella* Foug. genotypes at various stages of growth

Sl. No.	Genotypes	Plant spread (E-W) (cm)			Plant spread (N-S) (cm)		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	13.77	33.51	46.89	13.51	33.41	45.16
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	13.36	41.38	53.29	15.69	41.96	51.35
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	11.95	29.57	39.47	10.53	31.05	38.45
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	15.28	38.09	50.82	15.94	34.74	50.55
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	12.56	30.70	39.62	14.89	28.64	40.85
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	13.88	34.57	43.77	16.02	35.39	43.95
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	13.44	35.78	48.74	15.44	34.49	48.39
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	12.76	33.91	45.26	13.03	34.71	45.35
S. Em±		**1.17**	**0.77**	**0.67**	**0.61**	**0.91**	**0.92**
CD @ 5%		**NS**	**2.34**	**2.03**	**1.85**	**2.76**	**2.79**

*** E-W**: East to West direction, * **N-S**: North to South direction

4.1.3.1 East to west (cm)

At 60 DAT, genotype AGC-1 recorded significantly maximum plant spread (41.38 cm) followed by DGC-2 (38.09 cm) and SGC-1 (35.78 cm) whereas genotype SGC-4 recorded minimum plant spread of 29.57 cm at this stage.

Significantly maximum plant spread at 90 DAT was found in genotype AGC-1 (53.29 cm) followed by DGC-2 and SGC-1 (50.82 cm and 48.74 cm, respectively) whereas least plant spread was recorded in genotype SGC-3 (39.47 cm).

4.1.3.2 North to South (cm)

Plant spread (N-S) varied significantly among the genotypes at various stages of crop growth.

Significantly it was maximum in the genotype SGC-2 (16.02 cm) at 30 days after transplanting and it was statiscally on par with DGC-2 (15.94 cm), AGC-1 (15.69 cm), SGC-1 (15.44 cm) and SGC-3 (14.89 cm). Genotype SGC-4 recorded the lowest plant spread of 10.53 cm at 30 DAT.

At 60 DAT significantly maximum plant spread was registered in genotype AGC-1 (41.96 cm) followed by SGC-2 (35.39 cm) and DGC-2 (34.74 cm). It was minimum in genotype SGC-3 with 28.64 cm.

At 90 DAT also genotype AGC-1 recorded significantly maximum plant spread (51.35 cm) from other genotypes studied, which was on par with genotype DGC-2 (50.55 cm) and least was in SGC-4 (38.45 cm).

4.1.4 Number leaves per plant

The data on number of leaves produced per plant differed significantly at all the stages of crop growth and are furnished in table 3.

Table 3. Number of leaves per plant and leaf length of *Gaillardia pulchella* Foug. genotypes at various stages of growth

Sl. No.	Genotypes	Number of leaves per plant			Leaf length (cm)		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	32.60	288.80	373.47	14.89	16.68	8.21
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	27.87	334.33	504.20	13.17	11.90	8.25
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	22.60	201.33	330.40	10.89	14.55	10.18
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	42.87	368.47	642.40	12.42	12.57	7.45
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	22.73	234.93	366.40	10.95	13.76	9.13
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	18.00	270.93	380.00	12.13	13.88	7.13
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	24.80	231.60	369.93	12.33	15.95	7.75
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	29.20	213.60	327.53	14.93	15.30	7.02
S. Em±		**0.68**	**3.55**	**4.68**	**0.43**	**0.55**	**0.20**
CD @ 5%		**2.05**	**10.78**	**14.22**	**1.30**	**1.65**	**0.60**

*** DAT**: Days After Transplanting

During the experimental period at 30 DAT, significantly maximum number of leaves per plant was recorded in the genotype DGC-2 (42.87) followed by genotype DGC-1 (32.60) and AGC-2 (29.20). Genotype SGC-2 (18.00) exhibited minimum number of leaves per plant.

At 60 DAT, genotype DGC-2 noticed with maximum number leaves per plant (368.47) followed by AGC-1 and DGC-1 (334.33 and 288.80, leaves per plant respectively) whereas, it was minimum in genotype SGC-4 (201.33).

At 90 DAT, genotype DGC-2 recorded significantly maximum number of leaves per plant (642.40) followed by genotype AGC-1 (504.20) and SGC-2 (380.00) and it was least in genotype AGC-2 (327.53).

4.1.5 Leaf length (cm)

The data recorded on leaf length at different stages of crop growth showed significant variation among the gaillardia genotypes and are presented in table 3. As the growing period advanced, the length of leaf was decreased to certain extent.

At 30 DAT increased leaf length was recorded in genotype AGC-2 (14.93 cm) and it was on par with genotype DGC-1 (14.89 cm). However at this stage genotype SGC-4 (10.89 cm) had minimum leaf length.

Genotype DGC-1 exhibited maximum leaf length (16.68 cm) at 60 DAT and it was on par with SGC-1 (15.95 cm) and AGC-2 (15.30) genotypes. AGC-1 had minimum leaf length (11.90 cm).

Genotype SGC-4 has noted with maximum leaf length (10.18 cm) at 90 DAT followed by genotypes SGC-3 (9.13 cm) and AGC-1 (8.25 cm). However genotype AGC-2 showed minimum leaf length (7.02 cm) at this stage.

4.1.6 Stem girth (mm)

The data pertaining to the stem girth at varying stages of plant growth differed within the genotypes and are furnished in table 4. At 90 DAT maximum stem girth was recorded in genotype DGC-2 (22.85 mm) and it was statiscally on par with genotypes DGC-1 and SGC-1 (22.75 mm and 21.92 mm, respectively). Genotype SGC-4 recorded minimum stem girth (17.74 mm) at this stage.

4.1.7 Dry weight of plant (g)

The data related to total dry matter production (TDM) at various stages of plant growth showed significant differences within the genotypes and are furnished in table 4. Genotype AGC-1 recorded maximum dry weight of plant (19.60 g) at 30 DAT and it was on par with genotype DGC-2 (19.30 g) whereas, it was registered minimum in SGC-1 (9.06 g) at this stage.

At 60 DAT, genotype DGC-2 registered maximum dry weight (26.42 g) and it was statistically on par with genotype AGC-1 (25.10 g) while, SGC-1 recorded minimum (19.17 g) dry weight of plant.

Whereas, at 90 DAT genotype DGC-2 recoded maximum dry weight of plant (40.64 g) which is on par with genotype AGC-1 (40.18 g). However, it documented minimum in genotype SGC-1 (32.02 g).

4.1.8 Chlorophyll content (at peak growth) (mg/g)

The data pertaining to chlorophyll content of leaf at peak growth stage are presented in the table 5.

4.1.8.1 Chlorophyll ‘a’

Significant differences were observed among different genotypes of gaillardia for chlorophyll content in leaf. Chlorophyll-a content was significantly maximum in

Table 4. Stem girth and dry weight of *Gaillardia pulchella* Foug. genotypes at various stages of plant growth

Sl. No.	Genotypes	Stem girth (mm)			Dry weight of plant (g)		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	10.01	14.77	22.75	12.10	20.00	34.73
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	8.75	12.86	20.49	19.60	25.10	40.18
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	9.23	13.43	17.74	14.51	23.68	37.42
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	9.86	14.58	22.85	19.30	26.42	40.64
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	10.00	14.40	20.33	12.36	20.67	36.59
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	8.59	13.38	19.37	11.30	19.20	32.48
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	8.91	15.34	21.92	9.06	19.17	32.02
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	9.11	13.98	20.54	14.20	21.50	32.51
S. Em±		**0.54**	**0.70**	**0.58**	**0.57**	**0.59**	**0.57**
CD @ 5%		**NS**	**NS**	**1.75**	**1.73**	**1.80**	**1.73**

*** DAT**: Days After Transplanting

genotype SGC-1 (9.35 mg/g) and it was on par with AGC-1 (9.00 mg/g) followed by SGC-2 (8.30 mg/g) whereas, it was minimum in SGC-4 (4.97 mg/g).

4.1.8.2 Chlorophyll 'b'

Chlorophyll-b content of leaf varied significantly among different genotypes studied during the experiment. Genotype SGC-1 recorded highest (4.72 mg/g) chlorophyll-b content and it was statistically on par with SGC-2 and AGC-1 (4.35 mg/g and 4.22 mg/g, respectively) whereas, it was least under genotype SGC-4 (2.41 mg/g).

4.1.8.3 Total chlorophyll

Total chlorophyll content of leaf varied significantly among different genotypes evaluated. Maximum total chlorophyll content was recorded in genotype SGC-1 (13.18 mg/g) which was on par with genotypes AGC-1 (13.06 mg/g) and SGC-2 (12.60). However genotype SGC-4 had least for total chlorophyll content (6.17 mg/g).

4.1.9 Leaf area (at peak growth) (cm^2)

The data related to leaf area (cm^2) of plant during a peak stage (90 DAT) of crop growth by different genotypes is presented in table 5. Leaf area varied significantly among the genotypes at peak stage of crop growth.

At peak stage of growth, genotype AGC-1 had significantly maximum leaf area (6046.68 cm^2) among the genotypes studied, followed by DGC-2 (5813.15 cm^2), DGC-1 (4872.93 cm^2), SGC-2 (4239.48 cm^2) and SGC-1(4204.95 cm^2) and it was minimum in genotype AGC-2 (3453.85 cm^2).

Table 5. Chlorophyll content and leaf area of *Gaillardia pulchella* Foug. genotypes at peak stage of plant growth

Sl. No.	Genotypes	Chlorophyll content (mg/g)			Leaf area (cm^2/plant)
		a	b	Total	
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	6.11	3.39	9.28	4872.93
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	9.00	4.22	13.06	6046.68
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	4.97	2.41	6.17	3830.88
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	5.26	2.71	6.99	5813.15
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	5.04	2.71	7.32	3634.36
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	8.30	4.35	12.60	4239.48
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	9.35	4.72	13.18	4204.95
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	6.13	3.19	9.09	3453.85
S. Em±		**0.23**	**0.21**	**0.86**	**69.40**
CD @ 5%		**0.69**	**0.64**	**2.60**	**210.49**

4.2 Flowering parameters

Data pertaining to flowering characters like days taken for appearance first flower, days taken for 50 per cent flowering, duration of flowering, days taken for full bloom and days taken for seed setting are furnished in table 6.

4.2.1 Days taken for appearance of first flower

The data pertaining to number of days taken for appearance of first flower in different genotypes of gaillardia are presented in table 6.

Genotypes varied significantly with respect to days taken for appearance of first flower. Among the different genotypes studied, DGC-2 recorded least number of days for first flower appearance (48.00 days) and it was on par with genotypes AGC-1 (49.00 days), SGC-2 (51.00 days) and AGC-2 (53.00 days) whereas, genotype DGC-1 recorded the highest number of days taken for first flower appearance (59.00 days).

4.2.2 Days taken for 50 per cent flowering

The data pertaining to number of days taken for 50 per cent flowering in different genotypes of gaillardia are presented in table 6.

Significant differences were observed among different genotypes of gaillardia with respect to number of days taken for 50 per cent of flowering. Genotype DGC-2 (78.00 days) took significantly lesser number of days for 50 per cent of flowering and it was on par with genotypes AGC-1 (81.67 days), SGC-2 (85.67 days), SGC-3 (86.00 days) and SGC-1 (87.33 days) whereas, SGC-4 (95.33 days) took maximum number of days for 50 per cent flowering.

4.2.3 Flowering duration (days)

The data related to duration of flowering in different genotypes of gaillardia are provided in the table 6.

Table 6. Performance of *Gaillardia pulchella* Foug. genotypes for different flowering parameters

Sl. No.	Genotype	Days taken for appearance of first flower	Days taken for 50 per cent flowering	Flowering duration (days)	Days taken for full bloom	Days taken for seed setting
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	59.00	92.00	136.67	5.00	60.00
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	49.00	81.67	128.33	5.33	56.33
3	T_3 - Sarpan Gaillardia Collection - 4 (SGC-4)	55.33	95.33	119.67	5.33	71.00
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	48.00	78.00	146.67	4.67	63.00
5	T_5 - Sarpan Gaillardia Collection - 3 (SGC-3)	55.67	86.00	125.33	5.00	55.00
6	T_6 - Sarpan Gaillardia Collection - 2 (SGC-2)	51.00	85.67	126.67	4.33	52.67
7	T_7 - Sarpan Gaillardia Collection - 1 (SGC-1)	53.67	87.33	140.33	6.33	71.67
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	53.00	87.67	139.67	4.67	61.67
S. Em±		**1.74**	**3.16**	**2.85**	**0.37**	**1.92**
CD @ 5%		**5.29**	**9.58**	**8.66**	**1.11**	**5.82**

There was a significant difference among the genotypes with respect to flowering duration. Significantly longest flowering duration was recorded in genotype DGC-2 (146.67 days) and it was on par genotypes SGC-1 (140.33 days) and AGC-2 (139.67 days) whereas, the genotype SGC-4 recorded the shortest flowering duration (119.67 days).

4.2.4 Days taken for full bloom

The data related to days taken for full bloom in different genotypes of gaillardia are presented in the table 6.

A significant difference was obtained in different genotypes for number of days taken for full bloom. Genotype SGC-2 took minimum number of days for full bloom (4.33) from rest genotypes studied and it was on par with genotypes DGC-2 (4.67 days), AGC-2 (4.67 days), DGC-1 (5.00 days), SGC-3 (5.00 days), AGC-1 (5.33 days) and SGC-4 (5.33 days) whereas, genotype SGC-1 registered highest (6.33) number of days for full bloom.

4.2.5 Days taken for seed setting

Data pertaining to number of days taken for seed setting in different genotypes of gaillardia are furnished in table 6.

There was a significant difference among the genotypes with respect to days taken for seed setting. Genotype SGC-2 took significantly minimum number of days for seed set (52.67 days) and it was on par with genotypes SGC-3 (55.00 days) and AGC-1 (56.33 days) whereas, SGC-1 took maximum number of days (71.67).

4.3 Yield parameters

The data pertaining to yield characters of different genotype of gaillardia are provided in tables 7 & 8.

Table 7. Number of flowers per plant, number of flowers per plot and flower yield per plant in different genotypes of *Gaillardia pulchella* Foug.

Sl. No.	Genotype	Number of flowers per plant	Number of flowers per plot	Flower yield per plant (g)
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	131.60	7899.73	344.68
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	99.40	5115.60	271.62
3	T_3 - Sarpan Gaillardia Collection - 4 (SGC-4)	94.87	5222.80	270.61
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	115.27	6251.07	348.94
5	T_5 - Sarpan Gaillardia Collection - 3 (SGC-3)	111.27	6035.07	279.09
6	T_6 - Sarpan Gaillardia Collection - 2 (SGC-2)	129.33	6264.00	334.39
7	T_7 - Sarpan Gaillardia Collection - 1 (SGC-1)	98.07	5426.27	296.79
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	121.27	6566.40	339.11
S. Em±		**0.71**	**105.23**	**7.26**
CD @ 5%		**2.17**	**319.20**	**22.06**

Table 8. Flower yield per hectare, seed yield per plant and seed yield per hectare in different genotypes of *Gaillardia pulchella* Foug.

Sl. No.	Genotype	Flower yield per hectare (tonnes)	Seed yield per plant (g)	Seed yield per hectare (kg)
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	22.17	11.17	669.99
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	19.20	12.91	774.59
3	T_3 - Sarpan Gaillardia Collection - 4 (SGC-4)	14.61	9.27	556.39
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	21.25	13.41	804.79
5	T_5 - Sarpan Gaillardia Collection - 3 (SGC-3)	14.32	10.02	600.99
6	T_6 - Sarpan Gaillardia Collection - 2 (SGC-2)	19.33	9.08	544.79
7	T_7 - Sarpan Gaillardia Collection - 1 (SGC-1)	16.48	17.12	1027.19
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	18.95	12.76	765.79
S. Em±		**0.48**	**0.41**	**46.71**
CD @ 5%		**1.48**	**1.26**	**141.67**

4.3.1 Number of flowers per plant

The data related to number of flowers per plant in different genotypes of gaillardia are presented in table 7.

Different genotypes showed significant differences with respect to number of flowers produced per plant. Significantly maximum number of flowers per plant was produced in the genotype DGC-1 (131.60) followed by SGC-2 (129.33) and AGC-2 (121.27) whereas the genotype SGC-4 produced least number of flowers per plant (94.87).

4.3.2 Number of flowers per plot

The data belonging to number of flowers per plot in different genotypes of gaillardia are specified in table 7.

Genotype DGC-1 recorded significantly maximum number of flowers per plot (7899.73) followed by genotypes AGC-2, SGC-2, DGC-2, SGC-3 and SGC-1 (6566.40, 6264.00, 6251.07, 6035.07 and 5426.27, respectively). Genotype AGC-1 had least (5115.60) number of flowers per plot.

4.3.3 Flower yield per plant (g)

The data on flower yield per plant of different genotypes of gaillardia are presented in the table 7.

Significant difference was observed for flower yield per plant in different genotypes of gaillardia. The maximum flower yield per plant was recorded in the genotype DGC-2 (348.94 g) and it was on par with genotypes DGC-1 (344.68 g), AGC-2 (339.11 g) and SGC-2 (334.39 g), whereas, the genotype SGC-4 recorded minimum flower yield per plant (270.61 g).

4.3.4 Flower yield per hectare (t/ha)

Data pertaining to flower yield per hectare was varied depend upon genotypes of gaillardia and are depicted in table 8.

Flower yield per hectare were significantly varied with different genotypes of gaillardia. Significantly maximum flower yield (22.17 t/ha) was recorded in genotype DGC-1 and it was on par with genotype DGC-2 (21.25 t/ha). Genotype SGC-3 registered lower (14.32 t/ha) flower yield.

4.3.5 Seed yield per plant (g/plant)

The data related to seed yield per plant in different genotypes of gaillardia are presented in table 8.

Genotype SGC-1 recorded significantly maximum seed yield per plant (17.12 g) followed by DGC-2 (13.41 g), AGC-1 (12.91 g) and AGC-2 (12.76 g) genotypes while, it was minimum in genotype SGC-2 (9.08 g/plant).

4.3.6 Seed yield per hectare (kg/ha)

Significant difference was observed with respect to seed yield per hectare and data related to it are furnished in table 8.

Genotypes exhibited significant differences with respect to seed yield per hectare. Significantly maximum yield of seed was observed in the genotype SGC-1 (1027.19 kg/ha) followed by DGC-2 (804.79 kg/ha) and AGC-1 (774.59 kg/ha). While minimum seed yield was found in the genotype SGC-2 (544.79 kg/ha).

4.4 Flower quality parameters

The data on flower quality (diameter of flower, number of whorls per flower, length of stalk, flower weight, shelf and vase life of flowers of different genotypes of gaillardia are presented in table 9 & 10.

4.4.1 Flower diameter (cm)

The data pertaining to flower diameter of different genotypes of gaillardia are presented in table 9.

Diameter of the flower recorded at the time of peak flowering from fully opened flowers and it was differed significantly among the different genotypes of gaillardia. Significantly maximum flower diameter was recorded in the genotype SGC-1 (3.73 cm) and it was statistically on par with DGC-1 (3.52 cm), whereas, minimum flower diameter was recorded in the genotype SGC-3 (2.85 cm).

4.4.2 Number of whorls per flower

The data on number of whorls per flower of different genotypes of gaillardia are given in the table 9.

Significantly maximum number of whorls per flower was noticed in genotype AGC-1 (8.00) followed by SGC-4 (7.67), SGC-1 (7.67), DGC-2 (7.00), SGC-3 (7.00) and AGC-2 (7.00) genotypes which were on par with each other whereas, it was registered minimum in the genotype SGC-2 (6.33).

4.4.3 Stalk length (cm)

The data on stalk length of different genotypes of gaillardia are depicted in table 9.

Table 9. Diameter of flower, number of whorls per flower and stalk length of different *Gaillardia pulchella* Foug. genotypes at peak flowering

Sl. No.	Genotype	Diameter of flower (cm)	Number of whorls per flower	Stalk length (cm)
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	3.52	6.67	31.09
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	3.18	8.00	25.96
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	3.18	7.67	27.43
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	3.15	7.00	25.09
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	2.85	7.00	21.81
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	2.99	6.33	29.19
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	3.73	7.67	26.89
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	3.33	7.00	26.89
S. Em±		**0.11**	**0.25**	**1.07**
CD @ 5%		**0.35**	**0.75**	**3.25**

Table 10. Individual flower weight, shelf and vase life of flowers in various genotypes of *Gaillardia pulchella* Foug.

Sl. No.	Genotypes	Individual flower weight (g)	Shelf life (hr)	Vase life (days)
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	3.27	10.27	6.27
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	3.05	11.25	6.20
3	T_3 - Sarpan Gaillardia Collection - 4 (SGC-4)	3.11	11.62	6.04
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	3.07	10.25	7.06
5	T_5 - Sarpan Gaillardia Collection - 3 (SGC-3)	2.96	13.90	6.09
6	T_6 - Sarpan Gaillardia Collection - 2 (SGC-2)	2.93	14.43	6.63
7	T_7 - Sarpan Gaillardia Collection - 1 (SGC-1)	3.60	9.90	6.39
8	T_8 - Arabhavi Gaillardia Collection - 2 (AGC-2)	3.09	10.53	6.46
S. Em±		**0.04**	**0.40**	**0.16**
CD @ 5%		**0.12**	**1.21**	**0.49**

Significant differences were obtained with respect to stalk length in different genotypes of gaillardia. Maximum stalk length was recorded in the genotype DGC-1 (31.09 cm) and it was on par with genotype SGC-2 (29.19 cm), followed by SGC-4, SGC-1 and AGC-2 (27.43 cm, 26.89 cm and 26.89 cm, respectively). However, it was recorded minimum under genotype SGC-3 (21.81 cm).

4.4.4 Flower weight (g)

Average weight of flower was recorded at peak flowering stage from a fully opened flowers and it was varied significantly among the genotypes studied (Table 10).

Significantly highest flower weight of 3.60 g was recorded in the genotype SGC-1 followed by DGC-1, SGC-4, AGC-2, DGC-2 and AGC-1 (3.27 g, 3.11 g, 3.09 g, 3.08 g and 3.05 g, respectively). Genotype SGC-2 registered least for flower weight (2.93 g).

4.4.5 Shelf life (hr)

The data pertaining to the shelf life of different genotypes of gaillardia flowers are recorded and presented in table 10.

Shelf life of flowers varied significantly among the genotypes. Genotype SGC-2 manifested highest shelf life of 14.43 hours and it was statistically on par with genotype SGC-3 (13.90 hr). The least flower shelf life was observed in the genotype SGC-1 (9.90 hr).

4.4.6 Vase life (days)

The data related to vase life of different genotypes of gaillardia are furnished in table 10.

Genotypes varied significantly with respect to vase life of flowers. The maximum vase life was recorded in the genotype DGC-2 (7.06 days) and it was statiscally on par with SGC-2 (6.63 days) whereas genotype SGC-4 had minimum vase life (6.04 days).

4.5 Biometrical parameters

4.5.1 Analysis of variance

The analysis of variance for different (vegetative, flowering, yield and quality) characters revealed significant (P=0.05) differences among genotypes for all the parameters studied except plant spread (E-W) 30 DAT, number of branches per plant (30 DAT) and stem girth (30 and 60 DAT). Values related to analysis variance of different characters for the genotypes under study are given in the table 11 and 12.

4.5.2 Genetic variability

Genetic components like genotypic variance (GV), phenotypic variance (PV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense), genetic advance (GA), genetic advance mean (GAM), correlation and path analysis studies were conducted for growth, flowering, yield and quality parameters and are presented in this chapter. The data revealed the existence of large amount of variability with respects to all characters studied as given in the tables 13, 14 and 15.

4.5.2.1 Growth parameters

4.5.2.1.1 Plant height

The plant height at 30 DAT ranged from 10.47 cm to 18.96 cm (Table 13) with grand mean of 14.83 cm. The genotypic and phenotypic variances were 10.95 and 11.65, respectively. The estimates of genotypic and phenotypic coefficient of

Table 11. Analysis of variance for vegetative character in gaillardia genotypes

	Character	Mean sum of square		
		Replication d.f = 2	Genotypes d.f = 7	Error d.f = 14
1	Plant height (cm) at 30 DAT	1.40	33.55*	0.70
2	Plant height (cm) at 60 DAT	1.54	119.06*	1.84
3	Plant height (cm) at 90 DAT	1.58	131.32*	2.66
4	Plant spread (E-W) (cm) at 30 DAT	3.61	3.05	4.07
5	Plant spread (E-W) (cm) at 60 DAT	3.38	43.58*	1.78
6	Plant spread (E-W) (cm) at 90 DAT	2.00	74.33*	1.34
7	Plant spread (N-S) (cm) at 30 DAT	0.17	10.96*	1.11
8	Plant spread (N-S) (cm) at 60 DAT	0.34	44.41*	2.49
9	Plant spread (N-S) (cm) at 90 DAT	0.42	60.89*	2.54
10	Number of branches/plant at 30 DAT	2.28	4.45	3.74
11	Number of branches/plant at 60 DAT	0.40	9.13*	0.37
12	Number of branches/plant at 90 DAT	0.21	5.10*	0.28
13	Number of leaves/plant at 30 DAT	2.33	175.45*	1.36
14	Number of leaves/plant at 60 DAT	2.94	10610.17*	37.85
15	Number of leaves/plant at 90 DAT	408.07	34576.49*	65.95
16	Leaf length at 30 DAT	0.60	7.22*	0.54
17	Leaf length at 60 DAT	1.89	8.00*	0.89
18	Leaf length at 90 DAT	0.16	3.45*	0.11
19	Stem girth (cm) at 30 DAT	0.71	0.98	0.87
20	Stem girth (cm) at 60 DAT	1.84	2.06	1.48
21	Stem girth (cm) at 90 DAT	2.33	9.01*	0.99
22	Leaf area (cm^2)	4294.78	2871816.58*	14447.16
23	Chlorophyll ‘a’(mg/g)	0.53	10.00*	0.15
24	Chlorophyll ‘b’(mg/g)	0.13	2.25*	0.13
25	Total Chlorophyll (mg/g)	10.51	24.49*	2.29
26	Dry weight of plant (g) at 30 DAT	1.84	41.88*	0.97
27	Dry weight of plant (g) at 60 DAT	0.79	23.09*	1.05
28	Dry weight of plant (g) at 90 DAT	3.85	35.60*	0.97

* Significant at 0.05 probability levels, **DAT**- Days After Transplanting, **E-W**- East to West direction, **N-S**- North to South direction.

Table 12. Analysis of variance for flowering, yield and quality character in gaillardia genotypes

	Characters	Mean sum of square		
		Replication d.f = 2	Genotypes d.f = 7	Error d.f = 14
(a)	**Flowering parameters**			
1	Days taken for appearance of first flower	11.16	40.26*	9.11
2	Days taken for 50 percent flowering (days)	71.16	88.51*	29.92
3	Duration of flowering (days)	17.54	255.78*	24.44
4	Days taken for full bloom (days)	0.16	1.11*	0.40
5	Days taken for seed setting (days)	72.04	147.88*	11.04
(b)	**Yield parameters**			
1	Number of flower/plant	1.67	610.68*	1.52
2	Number of flowers/plot	84909.92	2431121.21*	33224.53
3	Flowers yield (g/plant)	172.67	3562.90*	158.70
4	Flowers yield (t/ha)	0.98	25.64*	0.71
5	Seed yield (g/plant)	1.01	21.51*	0.51
6	Seed yield (kg/ha)	15505.61	77457.01*	6544.46
(c)	**Quality parameters**			
1	Flower diameter (cm)	0.10	0.23*	0.03
2	Number of whorls/flower	0.041	0.95*	0.18
3	Stalk length (cm)	0.06	22.76*	3.44
4	Individual flower weight(g)	0.01	0.13*	0.005
5	Shelf life (hrs)	0.16	9.00*	0.47
6	Vase life (days)	0.02	0.33*	0.07

* Significant at 0.05 probability levels

Table 13. Estimates of mean, range, components of variance, heritability, genetic advance and genetic advance mean for growth parameters in gaillardia genotypes

	Character	Mean ± S. Em	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
	(a) Growth parameters									
1	Plant height (cm) at 30 DAT	14.83±0.48	10.47-18.96	10.95	11.65	22.30	23.01	94.00	6.60	44.53
2	Plant height (cm) at 60 DAT	32.76±0.79	22.94-42.60	39.07	40.92	19.07	19.52	95.00	12.58	38.40
3	Plant height (cm) at 90 DAT	50.56±0.94	38.47-58.38	42.88	45.54	12.95	13.34	94.00	13.09	25.89
4	Plant spread (E-W) (cm) at 30 DAT	13.37±1.17	11.94-15.28	-0.34	3.73	4.36	14.45	91.00	0.36	2.72
5	Plant spread (E-W) (cm) at 60 DAT	34.68±0.77	29.56-41.38	13.93	15.72	10.76	11.43	88.00	7.24	20.87
6	Plant spread (E-W) (cm) at 90 DAT	45.98±0.67	39.47-53.28	24.33	25.67	10.72	11.01	94.00	9.89	21.51
7	Plant spread (N-S) (cm) at 30 DAT	14.38±0.61	10.53-16.02	3.28	4.40	12.60	14.58	74.00	3.22	22.42
8	Plant spread (N-S) (cm) at 60 DAT	34.29±0.91	28.64-41.96	13.97	16.46	10.89	11.83	84.00	7.09	20.67
9	Plant spread (N-S) (cm) at 90DAT	45.50±0.92	38.44-51.35	19.45	21.99	9.69	10.30	88.00	8.54	18.77
10	Number of branches/plant (30 DAT)	1.76±1.12	0.80-4.66	0.23	3.89	27.55	112.97	59.00	0.24	13.84
11	Number of branches/plant (60 DAT)	8.28±0.35	6.07-11.33	2.91	3.29	20.62	21.91	88.00	3.13	39.97
12	Number of branches/plant (90 DAT)	12.91±0.30	10.53-14.16	1.60	1.89	9.81	10.65	84.00	2.40	23.88
13	Number of leaves/plant (30 DAT)	27.58±0.68	18.00-42.86	58.02	59.39	27.61	27.94	97.00	15.51	56.23
14	Number of leaves/plant (60 DAT)	268.00±3.55	201.33-368.46	3524.10	3561.96	22.15	22.26	98.00	121.63	45.38
15	Number of leaves/plant (90 DAT)	412.60±4.68	330.23-642.40	11503.52	11569.47	25.99	26.06	99.00	220.31	53.39

Table 13. Continued…….

	Character	Mean ± S. Em	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
	(a) Growth parameters									
16	Leaf length (cm) at 30 DAT	12.71±0.43	10.88-14.92	2.22	2.77	11.73	13.10	80.00	2.75	21.66
17	Leaf length (cm) at 60 DAT	14.32±0.55	11.90-16.68	2.37	3.26	10.75	12.61	72.00	2.70	18.88
18	Leaf length (cm) at 90 DAT	8.13±0.20	7.02-10.18	1.11	1.23	12.95	13.63	90.00	2.06	25.36
19	Stem girth (mm) at 30 DAT	9.31±0.54	8.59-10.00	0.03	0.91	2.07	10.24	41.00	0.08	0.86
20	Stem girth (mm) at 60 DAT	14.09±0.70	12.86-15.34	0.19	1.67	3.10	9.19	11.00	0.30	2.16
21	Stem girth (mm) at 90 DAT	20.74±0.58	17.74-22.85	2.67	3.66	7.87	9.22	72.00	2.87	13.85
22	Leaf area (cm^2/plant)	4512.03±69.40	3453.85-6046.68	952456.50	966903.60	21.63	21.79	98.00	1995.35	44.22
23	Chlorophyll ‘a’ (mg/g)	6.77±0.23	4.96-9.35	3.28	3.43	26.75	27.38	95.00	3.64	53.85
24	Chlorophyll ‘b’ (mg/g)	3.46±0.21	2.41-4.72	0.70	0.84	24.27	26.49	83.00	1.58	45.81
25	Total Chlorophyll (mg/g)	9.67±0.86	6.17-13.18	7.73	10.02	28.75	32.75	77.00	5.03	52.02
26	Dry weight of plant (g) (30 DAT)	14.05±0.57	9.06-19.60	13.63	14.61	26.27	27.19	93.00	7.34	52.28
27	Dry weight of plant (g) (60 DAT)	21.96±0.59	19.16-26.42	7.34	8.40	12.33	13.19	87.00	5.21	23.76
28	Dry weight of plant (g) (90 DAT)	35.82±0.57	32.02-40.64	11.54	12.51	9.48	9.87	92.00	6.72	18.76

GV-Genotypic Variance: **PV**- Phenotypic Variance: **GCV**- Genotypic Coefficient of Variation: **PCV**- Phenotypic Coefficient of Variation: **h^2**- heritability: **GA**- Genetic Advance: **GAM**- Genetic Advance Mean.

Table 14. Estimates of mean, range, components of variance, heritability, genetic advance and genetic advance mean for flowering and yield parameters in gaillardia genotypes

Sl. No	Character	Mean ± S. Em	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
(b)	**Flowering parameters (days)**									
1	Days taken for first flowering	53.08±1.74	48.00-59.00	10.38	19.50	6.07	8.319	53.00	4.84	9.12
2	Days taken for 50 percent flowering	86.71±3.16	78.00-95.33	19.53	49.45	5.09	8.11	39.00	5.72	6.59
3	Duration of flowering	132.92±2.85	119.66-146.66	77.11	101.56	6.60	7.58	75.00	15.76	15.19
4	Days taken for full bloom	5.08±0.37	4.33-6.33	0.23	0.64	9.59	15.77	37.00	0.61	12.03
5	Days taken for seed setting	61.42±1.92	52.66-71.67	45.61	56.65	10.99	12.25	80.00	12.48	20.32
(c)	**Yield parameters**									
1	Number of flowers/plant	112.63±0.71	94.86-131.60	203.05	204.58	12.65	12.69	99.00	29.24	25.96
2	Number of flowers/plot	6093.45±105.23	5115.60-7899.73	799298.90	832523.40	14.67	14.97	96.00	1804.58	29.61
3	Flower yield (g/plant)	310.65±7.26	270.60-348.94	1134.73	1293.43	10.84	11.57	87.00	64.99	20.92
4	Flower yield (t/ha)	18.28±0.48	14.21-22.16	8.30	9.02	15.76	16.42	92.00	5.69	31.15
5	Seed yield (g/plant)	11.96±0.41	9.08-17.12	7.00	7.51	22.10	22.90	93.00	5.26	43.95
6	Seed yield (kg/ha)	718.06±46.71	544.79-1027.19	23637.52	30181.98	21.41	24.19	78.00	280.28	39.03

GV-Genotypic Variance: **PV**- Phenotypic Variance: **GCV**- Genotypic Coefficient of Variation: **PCV**- Phenotypic Coefficient of Variation: **h^2**- heritability: **GA**- Genetic Advance: **GAM**- Genetic Advance Mean.

Table 15. Estimates of mean, range, components of variance, heritability, genetic advance and genetic advance mean for quality parameters in gaillardia genotypes

Sl. No	Character	Mean ± S. Em	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
	Quality parameters									
1	Flower diameter (cm)	3.24±0.11	2.85-3.72	0.06	0.10	7.93	10.02	62.00	0.41	12.93
2	Number of whorls/flower	7.16±0.25	6.33-8.00	0.25	0.44	7.05	9.26	58.00	0.79	11.08
3	Stalk length (cm)	26.79±1.07	21.80-31.09	6.44	9.88	9.47	11.73	65.00	4.22	15.74
4	Individual flower weight (g)	3.13±0.04	2.92-3.59	0.04	0.04	6.67	7.06	89.00	0.40	12.99
5	Shelf life of flowers (hours)	11.51±0.40	9.90-14.43	2.84	3.31	14.62	15.81	85.00	3.21	27.92
6	Vase life of flowers (days)	6.39±0.16	6.04-7.06	0.08	0.16	4.56	6.29	53.00	0.43	6.82

GV-Genotypic Variance: **PV**- Phenotypic Variance: **GCV**- Genotypic Coefficient of Variation: **PCV**- Phenotypic Coefficient of Variation: **h^2**- heritability: **GA**- Genetic Advance: **GAM**- Genetic Advance Mean.

variations were 22.30 per cent and 23.01 per cent, respectively. The heritability was high (94.00 %) coupled with high genetic advance as per cent of mean 44.53.

At 60 DAT plant height was ranged from 22.94 cm to 42.60 cm with grand mean of 32.76 cm. The genotypic and phenotypic variances were 39.07 and 40.92, respectively. The estimates of genotypic and phenotypic coefficient of variations were 19.07 per cent and 19.52 per cent, respectively. The high heritability (95.00 %) was observed for plant height with high genetic advance as per cent of mean estimates of 38.40.

Similarly, at 90 DAT plant height was ranged from 38.47 cm to 58.38 cm with grand mean of 50.56 cm. The estimates of genotypic and phenotypic variances were 42.88 and 45.54, respectively. The genotypic and phenotypic coefficients of variations were 12.95 per cent and 13.34 per cent, respectively. High heritability of 94.00 per cent was coupled with high genetic advance as per cent of mean of 25.89.

4.5.2.1.2 Plant spread in East-West direction

Plant spread at 60 days after transplanting were ranged from 29.56 cm to 41.38 cm with grand mean of 34.68 cm. The genotypic and phenotypic variances were 13.93 and 15.72, respectively. The genotypic and phenotypic coefficients of variation were moderate of 10.76 per cent and 11.43 per cent, respectively. The high heritability (88.00 %) was observed for plant height with high genetic advance as per cent of mean (20.87).

The plant spread at 90 DAT ranged from 39.47 cm to 53.28 cm with grand mean of 45.98 cm. The estimates of genotypic and phenotypic variances were 24.33 and 25.67, respectively. The genotypic and phenotypic coefficients of variations were moderate and of 10.72 per cent and 11.01 per cent, respectively. High heritability

(94.00 %) for plant was coupled with high genetic advance as per cent of mean (21.51).

4.5.2.1.3 Plant spread in North- South direction

The plant spread at 30 DAT varied from 10.53 cm to 16.02 cm (Table 13) with grand mean of 14.38 cm. The genotypic and phenotypic variances were 3.28 and 4.40, respectively. The genotypic and phenotypic coefficients of variation were moderate with 12.60 per cent and 14.58 per cent, respectively. The heritability was high (74.00 %) coupled with high genetic advance as per cent of mean (22.42) were observed.

The plant spread at 60 DAT ranged from 28.64 cm to 41.96 cm with grand mean of 34.29 cm. The genotypic and phenotypic variances were 13.97 and 16.46, respectively. The genotypic and phenotypic coefficients of variation were moderate with 10.89 per cent and 11.83 per cent, respectively. The high heritability (84.00 %) was observed for plant spread with high genetic advance as per cent of mean (20.67).

The plant spread at 90 DAT ranged from 38.44 cm to 51.35 cm with grand mean of 45.50 cm. The genotypic and phenotypic variances were 19.45 and 21.99, respectively. The genotypic and phenotypic coefficients of variation were 9.69 per cent and 10.30 per cent, respectively which was considered as low and moderate. High heritability of 88.00 % per cent was coupled with moderate genetic advance as per cent of mean (18.77).

4.5.2.1.4 Number of branches

Number of branches per plant at 60 DAT varied from 6.07 to 11.33 with grand mean of 8.28. The genotypic and phenotypic variances were 2.91 and 3.29, respectively. The genotypic and phenotypic coefficients of variation were (20.62 % and 21.91 %, respectively). The high heritability (88.00 %) coupled with high genetic advance as per cent of mean (39.97).

At 90 DAT, the number of branches varied from 10.53 to 14.16 with grand mean of 12.91. Estimates of genotypic and phenotypic variances were 1.60 and 1.89, respectively. The genotypic and phenotypic coefficients of variation were 9.81 per cent (low) and 10.65 per cent (moderate), respectively whereas the heritability was high with 84.00 % and genetic advance as per cent of mean were moderate (23.88).

4.5.2.1.5 Number of leaves per plant

Numbers of leaves per plant at 30 DAT ranged from 18.00 to 42.86 with grand mean of 27.58. The estimates of genotypic and phenotypic variances were 58.02 and 59.39, respectively. The genotypic and phenotypic coefficients of variation were (27.61 % and 27.94 %, respectively) high. The heritability was high (97.00 %) coupled with genetic advance as per cent of mean (56.23).

Numbers of leaves per plant at 60 days after planting varied from 201.33 to 368.46 with grand mean of 268.00. The genotypic and phenotypic variances were 3524.10 and 3561.96, respectively. The genotypic and phenotypic coefficients of variation were high, with 22.15 per cent and 22.26 per cent, respectively. Whereas, high heritability of 98.00 per cent was observed with genetic advance as per cent of mean (45.38).

At 90 days after transplanting, numbers of leaves per plant was ranged from 330.23 to 642.40 with grand mean of 412.60. Estimates of genotypic and phenotypic variances were 11503.52 and 11569.47, respectively. The genotypic and phenotypic coefficients of variation were 25.99 per cent and 26.06 per cent, respectively. The heritability was high (99.00 %) coupled with genetic advance as per cent of mean (53.39).

4.5.2.1.6 Leaf length

At 30 DAT leaf length was ranged from 10.88 cm to 14.92 cm with grand mean of 12.71cm. The genotypic and phenotypic variances were 2.22 and 2.77, respectively. The genotypic and phenotypic coefficients of variations were 11.73 per cent and 13.10 per cent, respectively. High percent of heritability was 80.00 recorded coupled with high genetic advance as per cent of mean (21.66).

At 60 DAT leaf length was ranged from 11.90 cm to 16.68 cm with grand mean of 14.32 cm. The genotypic and phenotypic variances were 2.37 and 3.26, respectively. The genotypic and phenotypic coefficients of variations were high with 10.75 per cent and 12.61 per cent, respectively. High percent of heritability was 72.00 recorded coupled with moderate genetic advance as per cent of mean (18.88).

Leaf length at 90 DAT transplanting was ranged from 7.02 cm to 10.18 cm with grand mean of 8.13 cm. The genotypic and phenotypic variances were 1.11 and 1.23, respectively. The genotypic and phenotypic coefficients of variations were 12.95 per cent and 13.63 per cent, respectively. High percent of heritability was 90.00 recorded coupled with high genetic advance as per cent of mean (25.36).

4.5.2.1.7 Stem girth

Stem girth of the plant at 90 DAT was ranged from 17.74 mm to 22.85 mm with grand mean of 20.74 mm. The genotypic and phenotypic variances were 2.67 and 3.66, respectively. The genotypic and phenotypic coefficients of variations were 7.87 per cent and 9.22 per cent, respectively. Heritability was high (72.00 %) coupled with moderate genetic advance as per cent of mean (13.85).

4.5.2.1.8 Leaf area

Leaf area of the plant at peak stage of growth was ranged from 3453.85 cm^2 to 6046.68 cm^2 with grand mean of 4512.03 cm^2. The genotypic and phenotypic variances were 952456.50 and 966903.60, respectively. The genotypic and phenotypic coefficients of variations were 21.63 per cent and 21.79 per cent, respectively. High heritability was (98.00 %) observed coupled with high genetic advance as per cent of mean (44.22).

4.5.2.1.9 Chlorophyll estimation

Chlorophyll ‘a’content (mg/g) at peak growth of plant was ranged from 4.96 to 9.35 with grand mean of 6.77 mg/g of tissue. The genotypic and phenotypic variances were 3.28 and 3.43, respectively. High estimates of GCV (26.75%) and PCV (27.38 %) coupled with high heritability (95.00 %) and high genetic advance as per cent of mean (53.85) was recorded.

Chlorophyll ‘b’ content (mg/g) in the genotypes was ranged from 2.41 to 4.72 with grand mean of 3.46 mg/g of tissue. The genotypic and phenotypic variances were 0.70 and 0.84, respectively. High estimates of GCV (24.27 %) and PCV (26.49 %) were observed coupled with high heritability (83.00 %) and genetic advance as per cent of mean (45.81).

Total chlorophyll content (mg/g) was ranged from 6.17 to 13.18. The genotypic and phenotypic variances were 7.73 and 10.02, respectively. High estimates of GCV (28.75 %) and PCV (32.75 %) were recorded coupled with high heritability (77.00 %) and genetic advance as per cent of mean (52.02).

4.5.2.1.10 Dry weight of plant

At 30 DAT dry weight of plant were ranged from 9.06 g to 19.60 g with grand mean of 14.05 g. The genotypic and phenotypic variances for this were 13.63 and 14.61, respectively. Low estimates of GCV (26.27 %) and PCV (27.19 %) were observed with high heritability (93.00 %) and genetic advance as per cent of mean (52.28).

` Dry weight of plant was ranged from 19.16 g to 26.42 g with grand mean of 21.96 g at the time of 60 DAT. The genotypic and phenotypic variances were 7.34 and 8.40, respectively. Low estimates of GCV (12.33 %) and PCV (13.19 %) were observed with high heritability (87.00%) and genetic advance as per cent of mean (23.76).

Dry weight of plant at 90 DAT was ranged from 32.02 g to 40.64 g with grand mean of 35.82 g. The genotypic and phenotypic variances for this were 11.54 and 12.51, respectively. Low estimates of GCV (9.48 %) and PCV (9.87 %) were observed with high heritability (92.00 %) and moderate genetic advance as per cent of mean (18.76).

4.5.2.2 Flowering parameters

4.5.2.2.1 Days taken for appearance first flower

Among the genotypes studied days taken for appearance of first flower were ranged from 48.00 days to 59.00 days with grand mean of 53.08 days. The genotypic and phenotypic variances were 10.38 and 19.50, respectively. Low estimates of GCV (6.07 %) and PCV (8.31 %) were coupled with medium heritability (53.00 %) and low genetic advance as per cent of mean 9.12.

4.5.2.2.2 Days taken for 50 percent flowering

It was ranged from 78.00 days to 95.33 days with grand mean of 86.71 days. Estimates of genotypic and phenotypic variances were 19.53 and 49.45, respectively. Low estimates of GCV (5.09 %) and PCV (8.11 %) were observed coupled with low heritability (39.00 %) and low genetic advance as per cent of mean of 6.59.

4.5.2.2.3 Duration of flowering

Duration of flowering in different genotypes of gaillardia ranged from 119.66 days to 146.66 days with grand mean of 132.91 days. The genotypic and phenotypic variances were 77.11 and 101.56, respectively. The estimates of GCV (6.60 %) and PCV (7.58 %) were low coupled with high heritability (75.00 %) and with moderate genetic advance as per cent of mean of (15.19).

4.5.2.2.4 Days taken for full bloom

Days taken for complete opening of flowers varied in different genotypes of gaillardia and ranged from 4.33 days to 6.33 days with grand mean of 5.08 days. The genotypic and phenotypic variances were 0.23 and 0.64, respectively. The estimates of GCV (9.59 %) and PCV (15.77 %) were low coupled with low heritability (37.00 %) and with low genetic advance as per cent of mean of (12.03).

4.5.2.2.5 Days taken for seed setting

Among the genotypes studied, it was ranged from 52.66 days to 71.67 days with grand mean of 61.41 days. The genotypic and phenotypic variances were 45.61 and 56.65, respectively. The estimates of GCV (10.99 %) and PCV (12.25 %) were coupled with high heritability (80.00 %) and with high genetic advance as per cent of mean of (20.32).

4.5.2.3 Yield parameters

4.5.2.3.1 Number of flowers per plant

Among the genotypes studied, it was ranged from 94.86 to 131.60 with general mean of 112.63 flowers per plant. The genotypic and phenotypic variances were 203.05 and 204.58, respectively. The genotypic coefficients of variations (12.65%) and phenotypic coefficients of variations (12.69 %) were moderate. Heritability was high (99.00 %) with genetic advance as per cent of mean of 25.96.

4.5.2.3.2 Number of flowers per plot

It was ranged from 5115.60 to 7899.73 with grand mean of 6093.45 flowers per plot. The genotypic and phenotypic variances were 799298.90 and 832523.40, respectively. The estimates of GCV (14.6 7%) and PCV (14.97 %) were coupled with high heritability (96.00%) and genetic advance as per cent of mean (29.61).

4.5.2.3.3 Flower yield per plant

It was ranged from 270.60 g to 348.94 g with grand mean of 310.65 g flowers per plant. The genotypic and phenotypic variances were 1134.73 and 1293.43, respectively. The estimates of GCV (10.84 %) and PCV (11.57 %) were coupled with high heritability (87.00 %) and genetic advance as per cent of mean (20.92).

4.5.2.3.4 Flower yield per hectare

It was ranged from 14.21 tons to 22.16 tons with grand mean of 18.28 tons per hectare. The genotypic and phenotypic variances were 8.30 and 9.02, respectively. The estimates of GCV (15.76 %) and PCV (16.42 %) were coupled with high heritability (92.00 %) and genetic advance as per cent of mean (31.15).

4.5.2.3.5 Seed yield per plant

It was ranged from 9.08 g to 17.12 g with grand mean of 11.96 g per plant. The genotypic and phenotypic variances were 7.00 and 7.51, respectively. The estimates of GCV (22.10 %) and PCV (22.90 %) were coupled with high heritability (93.00 %) and genetic advance as per cent of mean (43.95).

4.5.2.3.6 Seed yield per hectare

It was ranged from 544.79 kg to 1027.19 kg with grand mean of 718.06 kg per hectare. The genotypic and phenotypic variances were 23637.50 and 30181.98, respectively. The estimates of GCV (21.41 %) and PCV (24.19 %) were moderate coupled with high heritability (78.00 %) and genetic advance as per cent of mean (39.03).

4.5.2.4 Quality parameters

4.5.2.4.1 Diameter of flower

It was ranged from 2.85 cm to 3.72 cm with general mean of 3.24 cm. The genotypic and phenotypic variances were 0.06 and 0.10, respectively. The genotypic (7.93 %) and phenotypic (10.01 %) coefficients of variations were low to moderate. High heritability of 62.00 % coupled with genetic advance as per cent of mean (12.93) was observed.

4.5.2.4.2 Number of whorls per flower

It was varied from 6.33 to 8.00 with grand mean of 7.16 whorls per flower. Estimates of genotypic and phenotypic variances were 0.25 and 0.44, respectively. Low estimates of GCV (7.05 %) and PCV (9.26 %) were observed coupled with medium heritability (58.00 %) and genetic advance as per cent of mean (11.08).

4.5.2.4.3 Stalk length

Stalk length was ranged from 21.80 mm to 31.09 mm with grand mean of 26.79 mm. The genotypic and phenotypic variances were 6.44 and 9.88, respectively. The estimates of GCV (9.4%) and PCV (11.73 %) were low to moderate coupled with moderate heritability (65.00 %) and genetic advance as per cent of mean (15.74).

4.5.2.4.4 Flower weight

Average individual flower weight was varied from 2.92 g to 3.59 g with general mean of 3.13 g. Estimates of genotypic and phenotypic variances were 0.04 and 0.04, respectively. Estimates of GCV (6.67 %) and PCV (7.06 %) were low coupled with high heritability (89.00 %) and moderate genetic advance as per cent of mean (12.99).

4.5.2.4.5 Shelf life of flowers

Shelf life of flowers was ranged from 9.90 hours to 14.43 hours with general mean of 11.51 hours. The genotypic and phenotypic variances were 2.84 and 3.31, respectively. The genotypic (14.64 %) and phenotypic (15.81 %) coefficients of variations were moderate. High heritability of 85.00 was coupled with genetic advance as per cent of mean (27.92).

4.5.2.4.6 Vase life of flowers

Vase life of flowers was ranged from 6.04 days to 7.06 days with general mean of 6.39 cm. The genotypic and phenotypic variances were 0.08 and 0.16, respectively. The genotypic (4.56 %) and phenotypic (6.29 %) coefficients of variations were moderate and medium heritability (52.00 %) coupled with low genetic advance as per cent of mean (6.82) was registered.

4.5.3 Correlation studies

The genotypic and phenotypic correlation studies were carried out for various characters to know the nature of relationship existing between flower yield per plant (g/plant) and its other component characters.

4.5.3.1 Genotypic and phenotypic correlations

In general, genotypic correlation coefficients were higher than the phenotypic correlation coefficients. This indicates the presence of strong inherent association between various characters. The values of correlation co-efficient at genotypic and phenotypic level for the characters studied with respect to growth, flowering, yield and quality parameters are presented in table 16 & 17.

Plant height at 90 DAT was significantly correlated in positive direction with plant spread (E-W) at 90 DAT (0.952, 0.905), plant spread (N-S) at 90 DAT (0.927, 0.821), number of branches at 90 DAT (0.382, 0.302), number of leaves at 90 days after transplanting (0.687, 0.664), stem girth at 90 DAT (0.614, 0.508), leaf area (0.825, 0.800), diameter of flower (0.526, 0.427), duration of flowering (0.643, 0.591), flower yield per plant (0.352, 0.338), flower weight (0.362, 0.335) and flower yield per ha (0.727, 0.726), both at genotypic and phenotypic level. It had significant and positive correlation with stem girth (0.508) at phonotypic level whereas dry weight at 90 DAT had positively non significant with plant height at both genotypic and phenotypic level.

Plant spread (E-W) at 90 DAT had significant positive correlation with plant spread (N-S) at 90 DAT (1.001, 0.821), number of branches per plant at 90 DAT (0.569, 0.478), number of leaves at 90 DAT (0.699, 0.675), stem girth at 90 DAT (0.705, 0.538), dry weight at 90 DAT (0.327, 0.298), leaf area (0.842, 0.811), duration of flowering (0.638 and 0.598), plant height at 90 DAT (0.952, 0.905) and flower

Table 16. Genotypic correlation coefficient for growth, flowering and yield characters in gaillardia genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	0.952**	0.927**	0.382*	0.687**	0.614**	0.275	0.825**	0.526**	0.022	-0.002	0.352*	0.643**	0.362*	0.727**
2		1.000	1.001**	0.569**	0.699**	0.705**	0.327*	0.842**	0.461**	-0.054	-0.042	0.240	0.638**	0.312*	0.664**
3			1.000	0.612**	0.735**	0.758**	0.288	0.794**	0.397**	-0.020	-0.058	0.279	0.737**	0.288	0.646**
4				1.000	0.628**	0.659**	0.428**	0.624**	-0.291	0.522**	0.469**	0.431**	0.459**	-0.397**	0.690**
5					1.000	0.538**	0.747**	0.854**	-0.182	-0.039	-0.091	0.245	0.523**	-0.168	0.504**
6						1.000	0.045	0.517**	0.566**	0.366*	0.569**	0.643**	0.976**	0.441**	0.706**
7							1.000	0.708**	-0.455**	-0.366*	-0.299*	-0.287	-0.070	-0.405**	0.081
8								1.000	0.934**	-0.062	-0.050	0.100	0.344*	-0.021	0.623**
9									1.000	-0.116	0.197	0.196	0.582**	1.001**	0.310*
10										1.000	0.893**	0.842**	0.298*	-0.301*	0.667**
11											1.000	0.801**	0.402**	-0.007	0.641**
12												1.000	0.765**	0.002	0.825**
13													1.000	0.473**	0.647**
14														1.000	-0.012
15															1.000

* Significant at p = 0.05 probability (0.294) ** Significant at p = 0.01 probability (0.380) DAT- Days after transplanting

1 Plant height (90 DAT) (cm)
2 Pant spread (E-W) (90 DAT) (cm)
3 Pant spread (N-S) (90 DAT) (cm)
4 Number of branches (90 DAT)
5 Number of leaves (90 DAT)
6 Stem girth 90 (DAT) (mm)
7 Dry weight (90 DAT) (g)
8 Leaf area (cm^2)
9 Flower diameter (cm)
10 Number of flower/plant
11 Number of flower/plot
12 Flower yield/plant
13 Duration of flowering
14 Individual flower weight (g)
15 Flower yield/ha

Table 17. Phenotypic correlation coefficient for growth, flowering and yield characters in gaillardia genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	0.905***	0.821**	0.302*	0.664***	0.508**	0.281	0.800***	0.427**	-0.015	-0.003	0.338*	0.591**	0.335*	0.688***
2		1.000	0.942**	0.478**	0.675***	0.538**	0.298*	0.811***	0.337*	-0.047	-0.034	0.223	0.598**	0.280	0.627**
3			1.000	0.508**	0.698***	0.554**	0.253	0.748***	0.273	-0.015	-0.030	0.274	0.607**	0.232	0.560**
4				1.000	0.571**	0.517**	0.342*	0.571**	-0.197	0.481**	0.412**	0.392**	0.296*	-0.333*	0.615***
5					1.000	0.455**	0.721***	0.848***	-0.144	-0.039	-0.087	0.231	0.432*	-0.162	0.483**
6						1.000	0.083	0.423*	0.352*	0.303*	0.455**	0.450**	0.691***	0.451**	0.536**
7							1.000	0.666***	-0.328*	-0.351*	-0.287	-0.264	-0.057	-0.318*	0.084
8								1.000	0.037	-0.058	-0.048	0.114	0.277	-0.032	0.594**
9									1.000	-0.094	0.128	0.184	0.455**	0.795***	0.161
10										1.000	0.866***	0.812***	0.253	-0.287	0.634**
11											1.000	0.725***	0.355*	-0.013	0.625**
12												1.000	0.576**	-0.020	0.726**
13													1.000	0.411**	0.541**
14														1.000	-0.001
15															1.000

* Significant at p = 0.05 probability (0.294) ** Significant at p = 0.01 probability (0.380) DAT- Days after transplanting

1 Plant height (90 DAT) (cm)
2 Pant spread (E-W) (90 DAT) (cm)
3 Pant spread (N-S) (90 DAT) (cm)
4 Number of branches (90 DAT)
5 Number of leaves (90 DAT)
6 Stem girth 90 (DAT) (mm)
7 Dry weight (90 DAT) (g)
8 Leaf area (cm^2)
9 Flower diameter (cm)
10 Number of flower/plant
11 Number of flower/plot
12 Flower yield/plant
13 Duration of flowering
14 Individual flower weight (g)
15 Flower yield/ha

yield per hectare (0.727, 0.627) both at genotypic and phenotypic level, while it was positive and non significant for dry weight at 90 DAT at both level. Flower diameter exhibited significant and positive correlation with plant spread (E-W) at 90 DAT at genotypic level only. Number of flowers produced per plant and plot recorded negatively non significant for plant spread (E-W) 90 DAT at both genotypic and phenotypic level.

Plant spread (N-S) at 90 DAT had significant and positive association with plant spread (E-W) at 90 DAT (1.001 and 0.942), plant height at 90 DAT (0.927 and 0.821), number branches per plant at 90 DAT (0.612, 0.508), number of leaves per plant at 90 DAT (0.735, 0.698), stem girth at 90 DAT (0.758, 0.554), leaf area (0.794, 0.748), duration of flowering (0.737, 0.607) and flower yield per hectare (0.646, 0.541) at genotypic and phenotypic level. Flower diameter (0.397) had significant and positive association with flower yield per plant at genotypic level only.

Number of branches per plant exhibited significant and positive association with plant spread (E-W) (0.569 and 0.478), plant spread (N-S) (0.612 and 0.508), number of leaves per plant at 90 DAT (0.628, 0.571), stem girth at 90 DAT (0.659, 0.517), leaf area (0.624, 0.571), number flowers per plant (0.522, 0.481), number of flowers per plot (0.469, 0.412), flower yield per plant (0.431, 0.392) and flower yield per hectare (0.690, 0.562) at both genotypic and phenotypic level. Duration of flowering (0.459), dry weight of plant (0.428) and plant height (0.382) (90 DAT) had significant and positive value with number of branches at 90 DAT at genotypic level. Flower weight had significant (-0.397) and negative correlation with number of branches produced per plant at genotypic level.

Number of leaves produced per plant at 90 DAT showed significant positive correlation with plant height at 90 DAT (0.687 and 0.664), plant spread (E-W) at 90 DAT (0.699 and 0.675), plant spread (N-S) at 90 DAT (0.735 and 0.698), number of

branches per plant (0.628 and 0.571), stem girth at 90 DAT (0.538, 0.455), dry weight at 90 DAT (0.747, 0.721), leaf area (0.854, 0.848), duration of flowering (0.523, 0.432) and flower yield per hectare (0.504, 0.449) at both genotypic and phenotypic level. Flower yield per plant had non-significant positive correlation with number of leaves produced at 90 DAT.

Genotypic and phenotypic correlation of stem girth at 90 DAT was significantly positive correlated with leaf area (0.517, 0.423), number of flowers per plot (0.569, 0.412), flower yield per plant (0.643, 0.450), duration of flowering (0.976, 0.691), flower height (0.451, 0.44), flower yield per hectare (0.706, 0.625), plant height at 90 DAT (0.614 and 0.508), plant spread (E-W) at 90 DAT (0.705 and 0.538), plant spread (N-S) at 90 DAT (0.758 and 0.554), number of branches per plant (0.659 and 0.517), number of leaves per plant at 90 DAT (0.538 and 0.455). Flower diameter (0.566) at genotypic level had significantly positive correlation with stem girth.

The character dry weight (90 DAT) had highly significant and positive association with leaf area (0.708, 0.666), number of leaves at 90 DAT (0.747 and 0.721), plant spread (E-W) at 90 DAT (0.327, 0.298), number of branches at 90 DAT (0.428, 0.342) at both genotypic and phenotypic level. However flower diameter (-0.455, -0.328) and number of flowers per plant (-0.366, -0.351) had negatively significant with dry weight of the plant at both genotypic and phenotypic level whereas flower weight (-0.405) had genotypic level only.

Leaf area showed significant and positive correlation at both genotypic and phenotypic levels with flower yield per hectare (0.623, 0.594). It exhibited significantly positive correlation with dry weight at 90 DAT (0.708 and 0.666), stem girth at 90 DAT (0.517 and 0.423), number of leaves at 90 DAT (0.854 and 0.848), number of branches produced per plant at 90 DAT (0.624 and 0.571), plant spread (N-

S) at 90 DAT (0.794 and 0.748), plant spread (E-W) at 90 DAT (0.842 and 0.811) and plant height at 90 DAT (0.825 and 0.800) at both genotypic and phenotypic level. Flower diameter (0.934) had significantly positive association with leaf area at genotypic level only.

Flower diameter showed significant and positive correlation at both genotypic and phenotypic levels with duration of flowering (0.582 and 0.455) and flower weight (1.001 and 0.795). It also had positive correlation with stem girth at 90 DAT (0.566), plant spread (N-S) at 90 DAT (0.397), plant spread (E-W) at 90 DAT (0.461) and plant height at 90 DAT (0.526) at genotypic level and plant height at 90 DAT at phenotypic level. Negative and significant correlations were shown by dry weight of plant (-0.455) at 90 DAT at genotypic level.

Number of flowers produced per plant exhibited significant and positive correlation with number of flowers per plot (0.893 and 0.866), flower yield per plant (0.842 and 0.812) number of branches produced at 90 DAT (0.522, 0.481) and flower yield per hectare (0.667 and 0.634) at both genotypic and phenotypic levels. However it showed non-significant correlation with other characters.

Number of flowers produced per plot showed significant and positive correlation with flower yield per plant (0.801 and 0.725), flower yield per hectare (0.641 and 0.625), flowers per plant (0.893 and 0.866), stem girth at 90 DAT (0.569 and 0.455) and number of branches produced at 90 DAT (0.469 and 0.412) at both genotypic and phenotypic level.

Flower yield per plant was showing significant and positive correlation with duration of flowering (0.825 and 0.576) flower yield per hectare (0.825 and 0.726), number of flowers per plot (0.801 and 0.725), number of flowers per plant (0.842 and 0.812), stem girth at 90 DAT (0.643 and 0.450) and number of branches at 90 DAT (0.431 and 0.392) at both genotypic and phenotypic level.

Duration of flowering had significant and positive correlation with flower weight (0.473 and 0.411), flower yield per hectare (0.647 and 0.541), flower yield per plant (0.765 and 0.576), diameter of flower (0.582 and 0.455), stem girth at 90 DAT (0.976 and 0.691), number of leaves produced at 90 DAT (0.523 and 0.432), plant spread (E-W) at 90 DAT (0.643 and 0.598), plant spread (N-S) at 90 DAT (0.737 and 0.607) and plant height at 90 DAT (0.643 and 0.591) at both genotypic and phenotypic level. Number of branches produced at 90 DAT (0.459) and number of flowers per plot (0.402) had significant and positive association with duration of flowering at genotypic level.

Flower weight had significant and positive association with plant height at 90 DAT (0.362, 0.335), stem girth produced at 90 DAT (0.441 and 0.451), flower diameter (1.001 and 0.795) and duration of flowering (0.473 and 0.411) at both genotypic and phenotypic level. It had significant and negative association with number branches produced per plant at 90 DAT (-0.397, -0.333) and dry weight of plant at 90 DAT (-0.405, -0.318) at both genotypic and phenotypic level.

Flower yield per hectare was showed significant and positive correlation with plant height (90 DAT) (0.727 and 0.688), plant spread (E-W) (90 DAT) (0.664 and 0.627), plant spread (N-S) (90 DAT) (0.646 and 0.560), number of branches produced at 90 DAT (0.690 and 0.615), number of leaves produced at 90 DAT (0.504 and 0.483), stem girth at 90 DAT (0.706 and 0.536), leaf area (0.623 and 0.594), number of flower per plant (0.667 and 0.634), number of flower per plot (0.641 and 0.625), flower yield per plant (0.825 and 0.726) and duration of flowering (0.647 and 0.541) at both genotypic and phenotypic level. Flower diameter (0.310) had significantly positive association with flower yield per hectare genotypic level only.

4.5.4 Genotypic path coefficient analysis

The path analysis of flower yield per plant was done with fourteen independent characters involving growth, flowering, yield and quality parameters. The matrix of direct and indirect effects was presented in the table 18.

Plant height had maximum positive direct effect (1.069) on flower yield per plant followed by plant spread (E-W) 90 DAT (1.018), plant spread 90 DAT (N-W) (0.991), plant spread 60 DAT (E-W) (0.944), leaf area (0.883), number of branches per plant 60 DAT (0.819), duration of flowering (0.687), flower diameter (0.563), number of branches 90 DAT (0.408), flower weight (0.387) and dry weight of plant (0.294). The days taken for appearance of first flower had negatively indirect effect on flower yield per plant.

Plant spread (E-W) at 60 DAT had maximum negative direct effect (-0.594) on flower yield per plant whereas plant spread (N-S) 90 DAT (-0.602), plant spread (E-W) 60 DAT (-0.586), plant height at 90 DAT (-0.524), number of branches at 60 DAT (-0.543), leaf area (-0.513), number of branches at 90 DAT (-0.353), duration of flowering (-0.284), dry weight of plant 90 DAT (-0.226) and number of whorls per flower (-0.179) has negative indirect effect. Appearance of first flower (0.492) and number of flowers per plant (0.047) had positive indirect effect on flower yield per plant.

Plant spread (E-W) at 90 DAT had maximum negative direct effect (-0.613) on flower yield per plant whereas plant spread (N-S) 90 DAT (-0.614), plant spread (E-W) 60 DAT (-0.605), plant height 90 DAT (-0.584), number of branches at 60 DAT (-0.545), leaf area (-0.517), duration of flowering (-0.392), number of branches at 90 DAT (-0.349), flower diameter (-0.283), number of whorls per flower (-0.221), dry weight of plant 90 DAT (-0.200) and flower weight (-0.191) whereas appearance

Table 18. Genotypic path coefficient analysis of different quantitative characters on flower yield of gaillardia genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	rG
1	**1.069**	0.944	1.018	0.991	0.819	0.408	0.294	0.883	0.563	0.242	-0.024	-0.647	0.687	0.387	0.352*
2	-0.524	**-0.594**	-0.586	-0.602	-0.543	-0.353	-0.226	-0.513	-0.099	-0.179	0.047	0.492	-0.284	-0.050	0.143
3	-0.584	-0.605	**-0.613**	-0.614	-0.545	-0.349	-0.200	-0.517	-0.283	-0.221	0.033	0.409	-0.392	-0.191	0.200
4	0.432	0.473	0.467	**0.466**	0.415	0.286	0.134	0.370	0.185	0.153	-0.009	-0.361	0.344	0.134	0.279
5	0.008	0.010	0.010	0.010	**0.011**	0.009	0.007	0.010	0.002	0.002	0.009	-0.007	0.005	-0.001	0.186
6	0.062	0.097	0.093	0.100	0.139	**0.163**	0.070	0.102	-0.047	-0.050	0.085	-0.065	0.075	-0.065	0.431**
7	0.098	0.136	0.117	0.103	0.219	0.153	**0.358**	0.253	-0.163	0.152	-0.131	-0.179	-0.025	-0.145	-0.287
8	-0.520	-0.551	-0.537	-0.506	-0.590	-0.398	-0.452	**-0.638**	-0.030	-0.178	0.039	0.408	-0.219	0.013	0.100
9	0.117	0.037	0.102	0.088	0.003	-0.065	-0.101	0.010	**0.222**	0.054	-0.026	0.067	0.129	0.228	0.196
10	-0.533	-0.071	-0.084	-0.077	-0.048	0.072	-0.099	-0.065	-0.057	**-0.235**	0.244	0.045	0.042	-0.089	-0.855**
11	-0.013	-0.047	-0.032	-0.012	0.044	0.311	-0.218	-0.037	-0.069	-0.619	**0.596**	0.126	0.178	-0.179	0.842**
12	0.180	0.246	0.198	0.230	0.192	0.119	0.149	0.190	-0.090	0.057	-0.063	**-0.298**	0.087	-0.089	-0.057
13	0.092	0.068	0.092	0.106	0.067	0.066	-0.010	0.049	0.083	-0.026	0.043	-0.042	**0.144**	0.068	0.765**
14	-0.006	-0.001	-0.005	-0.005	0.002	0.007	0.007	0.001	-0.018	-0.006	0.005	-0.005	-0.008	**-0.017**	0.002

Residual Effect= 0.056 * Significant at 0.05 probability level (0.304) ** Significant at 0.01 probability level (0.393)

Bold: Direct effect Above and below diagonal: Indirect effect

1 Plant height (90 DAT) (cm)
2 Plant spread (E-W) 60 DAT (cm)
3 Plant spread (E-W) 90 DAT (cm)
4 Plant spread (N-S) 90 DAT (cm)
5 Number of branches/plant 60 DAT
6 Number of branches/plant 90 DAT
7 Dry weight of plant 90 DAT (g)
8 Leaf area (cm^2/plant)
9 Flower diameter (cm)
10 Number whorls/flower
11 Number of flowers/plant
12 Days taken for appearance of first flower
13 Duration of flowering (days)
14 Individual flower weight (g)
rG Correlation with flower yield (g/plant)

of first flower (0.409) and number of flowers per plant (0.033) had positive indirect effect on flower yield per plant.

Plant spread (N-S) 90 DAT had positive direct effect on flower yield per hectare followed by plant spread (E-W) 60 DAT (0.473), plant spread (E-W) 90 DAT (0.467), plant height (0.432), number of branches 60 DAT (0.415), leaf area (0.370), duration of flowering (0.344), number of branches 90 DAT (0.286), flower diameter (0.185) and number of whorls per flower (0.153) had positive indirect effect on flower yield per plant. While, appearance of first flower (-0.361) and number of flowers per plant (-0.009) had negative indirect effect on flower yield.

Number of branches 60 DAT had positive direct (0.011) effect on flower yield per plant whereas leaf area (0.010), plant spread (E-W) 60 DAT (0.010), plant spread (E-W) 90 DAT (0.010), plant spread (N-S) 90 DAT (0.010), number of flowers per plant (0.009), plant height 90 DAT (0.008), dry weight of plant (0.007) and duration of flowering (0.005) had positive indirect effect on it. However of time taken for appearance of first flower (-0.007) and duration of flowering has indirect negative effect (-0.001) on flower yield.

Number of branches 90 DAT had positive direct effect (0.163) on flower yield per plant followed by number of branches 60 DAT (0.139), leaf area (0.102), plant spread (N-S) 90 DAT (0.100), plant spread (E-W) 60 DAT (0.097), plant spread (E-W) 90 DAT (0.093, number of flowers per plant (0.085) and duration of flowering (0.075) had positive indirect effect. Negative and indirect effect was contributed by appearance of first flower (-0.065) and flower weight (-0.065), number of whorls per flower (-0.050) and flower diameter (-0.047) on flower yield.

Dry weight of plant had positive direct effect (0.358) on flower yield followed by leaf area (0.253), number of branches 60 DAT (0.219), number of branches 90 DAT (0.153), number of whorls per flower (0.152), plant spread (E-W) 60 DAT

(0.136) and plant spread (E-W) 90 DAT (0.117) which had a positively indirect effect on it. Traits like appearance of first flower (-0.179), flower diameter (-0.163), flower weight (-0.145) and number of flowers per plant (-0.131) had negatively indirect effect on flower yield per plant.

Leaf area had negative and direct effect (-0.638) on flower yield. Number of branches 60 DAT (-0.590), plant spread (E-W) 60 DAT (-0.551), plant spread (E-W) 90 DAT (-0.537), plant height 90 DAT (-0.520), plant spread (N-S) 90 DAT (-0.506), dry weight of plant (-0.452), number of branches 90 DAT (-0.398), duration of flowering (-0.219) and number of whorls per flower (-0.178) are has negative indirect effect on flower yield. Similarly days taken for appearance of first flower (0.408) and number of flowers per plant (0.039) had positive indirect effect on flower yield.

Flower diameter had positive and direct effect (0.222) on flower yield whereas flower weight (0.228), duration of flowering (0.129), plant height (0.117), plant spread (E-W) 90 DAT (0.102), plant spread (N-S) 90 DAT (0.088), appearance of first flower (0.067) and plant spread (E-W) 60 DAT had positively indirect effect on flower yield. Dry weight of plant (-0.011) and number of branches 90 DAT (-0.065) had negatively indirect effect on flower yield.

Number of whorls per flower had negatively direct effect (-0.235) on flower yield per plant. Similarly plant height (-0.533), dry weight of plant (-0.099), flower weight (-0.089), plant spread (E-W) 90 DAT (-0.084) and plant spread (N-S) 90 DAT (-0.077) had negative indirect effect on so. Positively indirect effects were contributed by number of flowers per plant (0.244), appearance of first flower (0.045) and flower weight (0.042) to flower yield per plant.

Number of flowers per plant had positive direct effect (0.596) on flower yield followed by number of branches 90 DAT (0.311), duration of flowering (0.178) and days taken for appearance of first flower (0.126) has positive indirect effect.

Negatively indirect effect was attributed by number of flowers per plant (-0.619), dry weight of plant (-0.218) and flower weight (-0.179).

Appearance of first flower had negative direct effect (-0.298) on flower yield per plant followed by flower diameter (-0.090), flower weight (-0.089) and flower weight (-0.087) are exhibited negative indirect effect on flower yield. Plant spread (E-W) 60 DAT (0.246), plant spread (N-S) 90 DAT (0.230), plant spread (E-W) 90 DAT (0.198), number of branches 60 DAT (0.192), leaf area (0.190), plant height (0.180) and dry weight of plant (0.149) had positively indirect effect on flower yield.

Duration of flowering had positive direct effect (0.144) on flower yield. Plant spread (N-S) 90 DAT (0.106), plant spread (E-W) 90 DAT (0.092), flower diameter (0.083), plant spread (E-W) 60 DAT (0.068), flower weight (0.068), number of branches 60 DAT (0.067), number of branches 90 DAT (0.066), leaf area (0.049) and number of whorls has a positive indirect effect on yield. While appearance of first flower (-0.042), number of whorls per flower (-0.026) and dry weight of plant (-0.010) had negative and indirect effect on flower yield per plant.

Flower weight had negative direct effect (-0.017) on flower yield. Characters like flower diameter (-0.018), duration of flowering (-0.008), plant height 90 DAT (-0.006), number of whorls per flower (-0.006), plant spread (E-W) 60 DAT (-0.005) and plant spread (N-S) 90 DAT (-0.005) had indirect effect on flower yield with negative values. Number of branches 90 DAT (0.007), dry weight of plant (0.007), number of branches 60 DAT (0.002) and number of branches 90 DAT (0.002) had positive indirect effect on flower yield per plant.

Table 19. Economics of loose flower production in different *Gaillardia pulchella* Foug. genotypes under open field condition

Sl. No.	Genotype	Total cost of production (Rs./ha)	Flower yield (t /ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
1	T_1 - Dharwad Gaillardia Collection - 1 (DGC-1)	76,943.00	22.17	3,32,550.00	2,55,607.00	3.32
2	T_2 - Arabhavi Gaillardia Collection - 1 (AGC-1)	76,943.00	19.20	2,88,000.00	2,11,057.00	2.74
3	T_3 - Sarpan Gaillardia Collection – 4 (SGC-4)	76,943.00	14.61	2,19,150.00	1,42,207.00	1.84
4	T_4 - Dharwad Gaillardia Collection - 2 (DGC-2)	76,943.00	21.25	3,18,750.00	2,41,807.00	3.14
5	T_5 - Sarpan Gaillardia Collection – 3 (SGC-3)	76,943.00	14.32	2,14,800.00	1,37,857.00	1.79
6	T_6 - Sarpan Gaillardia Collection – 2 (SGC-2)	76,943.00	19.33	2,89,950.00	2,13,007.00	2.76
7	T_7 - Sarpan Gaillardia Collection – 1 (SGC-1)	76,943.00	16.48	2,47,200.00	1,70,257.00	2.21

Note: Flowers of all the genotypes were sold at the rate of Rs. 15.00/ kg of flower

4.6 Economics

The total cost, gross returns, net returns and benefit to cost ratio (per season) of gaillardia genotypes grown under open field condition per hectare are presented in table 19 and appendix III.

Genotype DGC-1 realized maximum gross returns (Rs. 3,32,550.00) and net returns (Rs. 2,55,607.00) per hectare followed by DGC-2 and SGC-2 which realized maximum gross returns (Rs. 3,18,750.00 and Rs. 2,89,950.00) and net returns (Rs. 2,41,807.00 and 2,13,007.00, respectively) while, minimum gross returns (Rs. 2,14,800.00) and net returns (Rs. 1,37,857.00) were obtained in SGC-3. The benefit cost (B:C) ratio was highest (3.32) in DGC-1 followed by DGC-2 (3.14) and SGC-2 (2.76) which were found superior compared to other varieties. The lowest was in SGC-3 (1.79).

DISCUSSION

V. DISCUSSION

Gaillardia is a popular plant in our country owing to its wider adaptability and suitability to grow throughout the year. Nowadays, its gaining importance for loose flower production especially in south India and western India. Due to the wide range of diversity available in the flower size, shape, form and colour it is widely grown. However, its commercial value is yet to be exploited to a maximum extent for different purposes. Hence, it is necessary to assess the suitability of different genotypes for successful cultivation.

Similarly, success of crop improvement programme depends on the extent of genetic variability existing in the population or germplasm for the traits. The information on genetic architecture of various quantitative characters particularly of those which contribute to economic characters would be very useful in planning breeding programme. Such studies on genetic diversity in a crop plant will not only give information regarding the amount of variation existing in the crop for various characters, but also helps in estimating the ability of the plant to transfer the characters to next generation and amount of improvement that can be achieved over the base population.

Further, correlation studies will provide information regarding the amount and direction of association between two characters at a time, while the path coefficient analysis will help in determining the direct and indirect effects of various characters on the economic traits. With the help of these results, a selection index can be framed that would enable the breeder to select accessions for further crop improvement.

The present experiment was carried out during the year 2014 -15 at experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The investigations were made as an attempt to

assess the performance of different *Gaillardia pulchella* Foug. genotypes for growth, flowering, yield, quality and biometrical parameters under hill zone of Karnataka. The results of the experiment are discussed in this chapter with the supporting data and available literature.

5.1 Vegetative parameters

Vegetative characters such as plant height, number of branches per plant, plant spread, number of leaves per plant, leaf length, leaf area, stem girth, chlorophyll content and dry weight were recorded at different stages of crop growth. In general, growth rate of all the genotypes with respect to vegetative parameters increased as the days advanced except for leaf length which exhibited a declining. At initial stage, crop recorded slow growth rate.

Plant height varied significantly among the genotypes at various stages of growth. Genotype DGC-2 was found to be vigorous in its growth habit at 90 DAT with respect to plant height followed by AGC-1 and SGC-1 whereas it was minimum in SGC-3 (Fig. 2). Variations in plant height were mainly due to genetic factor of the respective genotype. Similar trend of variation in plant height was observed by Vikas *et al.* (2011) and Mahawer *et al*. (2010) in dahlia; Panwar *et al*. (2013) and Anuja and Jahnavi (2012) in marigold; Munikrishnappa *et al.,* (2013) in China aster and Parul *et al.* (2011) in chrysanthemum.

Significant differences were observed among the genotypes studied with respect to number of branches per plant. The genotype DGC-2 exhibited maximum number of branches per plant whereas genotype SGC-4 recorded minimum number of branches per plant at peak growth stage. Variation for this character may be due to genetic behaviour of the genotype. Similar observations were noticed in marigold by Choudhary *et al.* (2014) and Bharathi and Jawaharlal (2014); Parul *et al.* (2011) in chrysanthemum and Ajeetkumar *et al.* (2015) in dahlia.

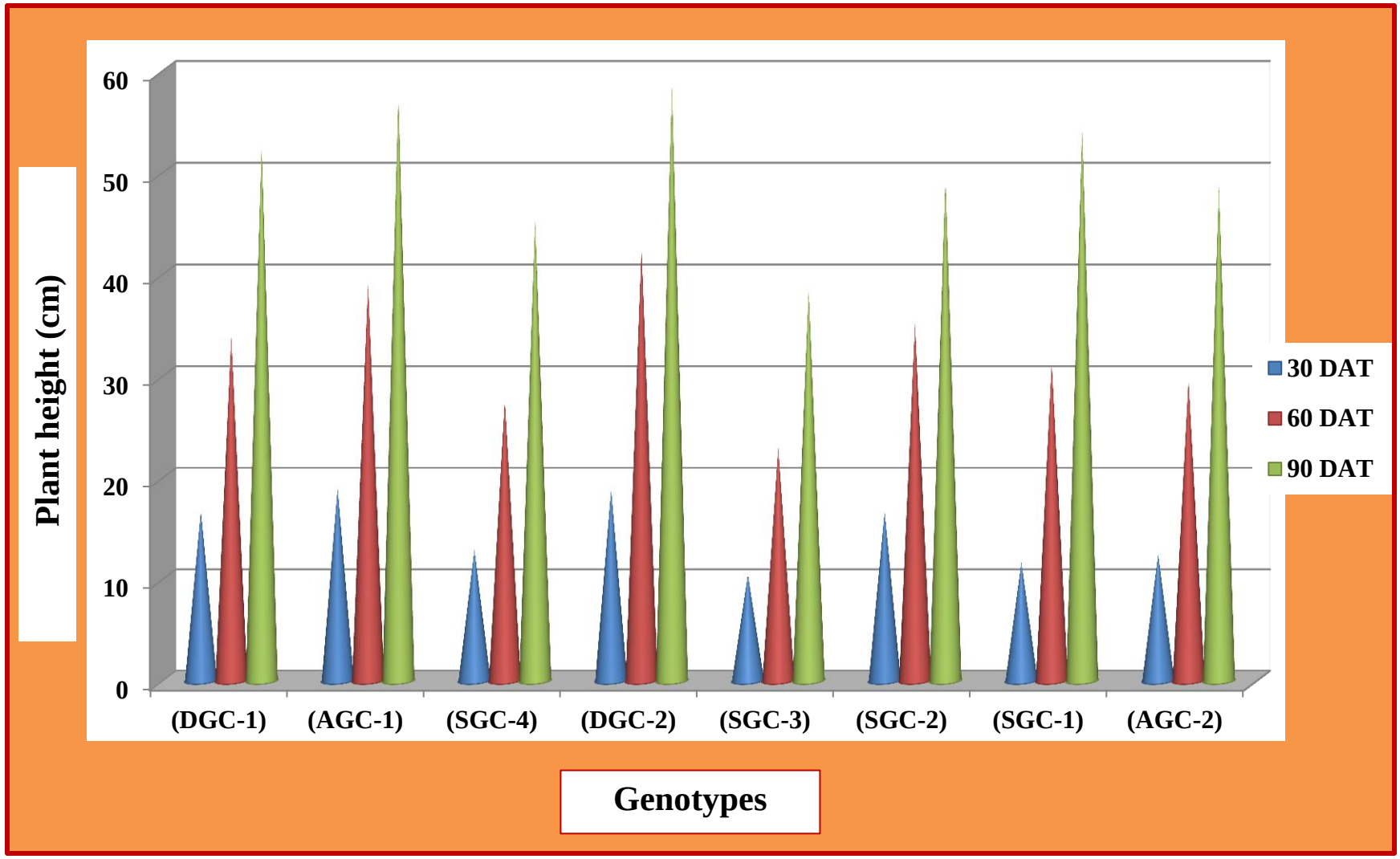


Fig. 2. Plant height (cm) of different *Gaillardia pulchella* Foug. genotypes at various stages of growth

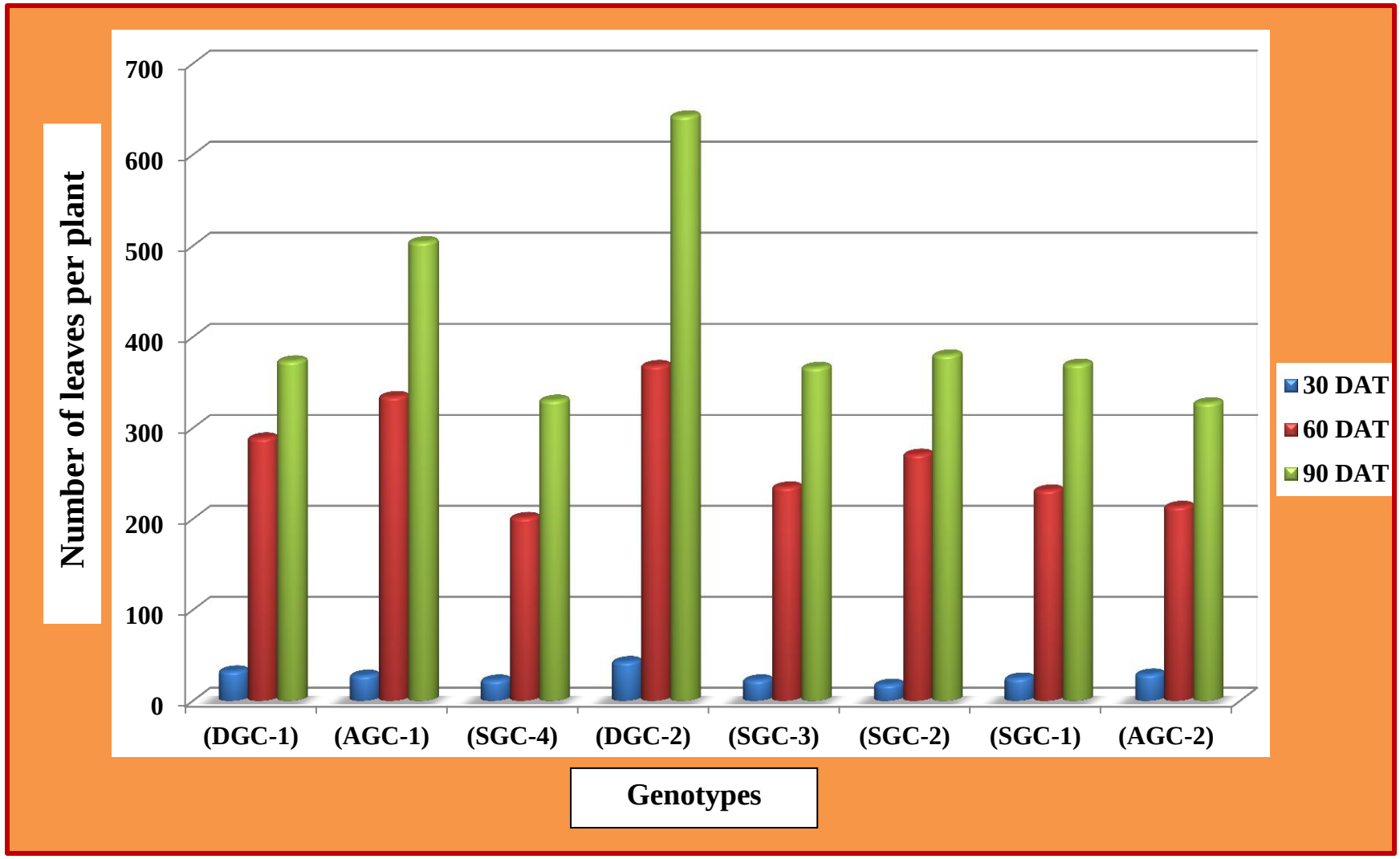


Fig. 3. Number of leaves per plant of *Gaillardia pulchella* Foug. genotypes at various stages of growth

Maximum and minimum plant spread (both in E-W and N-S directions) was observed in genotype AGC-1 and SGC-4, at 90 days after transplanting. The better performance of the genotype AGC-1 for plant spread in both directions may be due to its genetic makeup and its wide adaptability to the prevailing environmental conditions. Similar trend of result was observed earlier by Raghuvanshi and Sharma (2011), Choudhary *et al.* (2014) and Sapna *et al.* (2013) in different genotypes of marigold, Peddi *et al.* (2008) and Simrat *et al.*, (2012) in chrysanthemum, Ajeetkumar *et al.* (2015) in dahlia.

At 90 DAT maximum number of leaves per plant was recorded in the genotype DGC-2, whereas, it was least in AGC-2 (Fig. 3). The production of more number of leaves was due to the increased plant height and production of more number of branches per plant. These results are confirmation with that of Singh and Misra, (2008) and Singh and Singh (2005 a) in marigold and Poornima *et al.* (2006) and Zosiamliana *et al.* (2013) in China aster.

Significantly maximum leaf length at 90 DAT was recorded in genotype SGC-4 followed by SGC-3 and AGC-1 and it was registered minimum in AGC-2. This may be due to genetic makeup of the respective genotypes. Similar kind of result was observed by Kumar (2013) and Kumar and Yadav (2013) in gerbera.

Girth of the stem also varied significantly within the genotypes of gaillardia at various stages of growth. Genotype DGC-2 recorded the maximum stem girth followed by DGC-1 and SGC-1. The genotype SGC-4 had minimum stem girth. The variation in stem diameter among the genotypes may be due to the variation in genetic makeup of the genotypes. Similar variations in stem diameter among the genotypes were observed by Singh and Singh (2006) and Narsude *et al*. (2010) in marigold and in dahlia by Vikas *et al.* (2011).

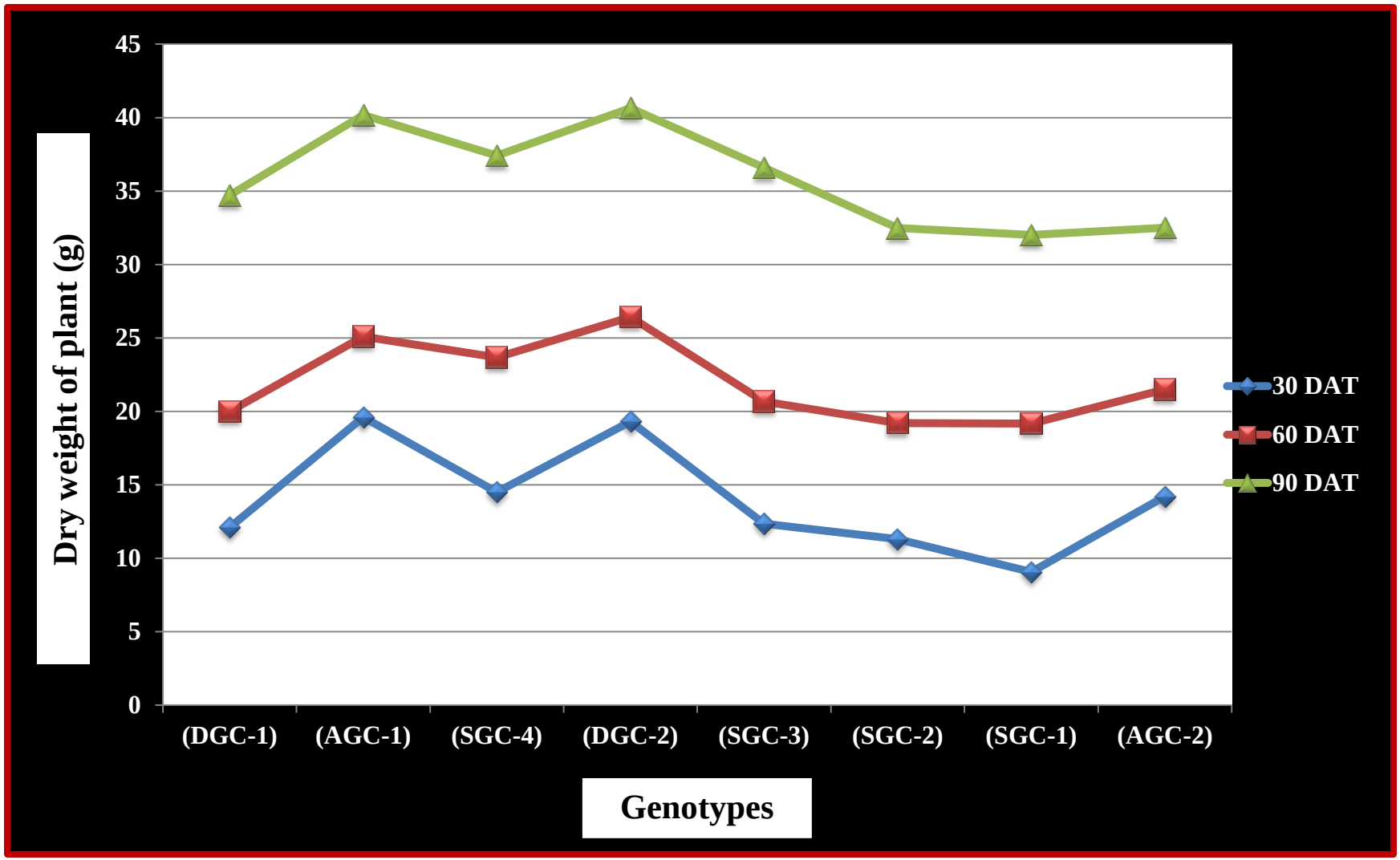


Fig. 4. Dry weight (g) of *Gaillardia pulchella* Foug. genotypes at various stages of plant growth

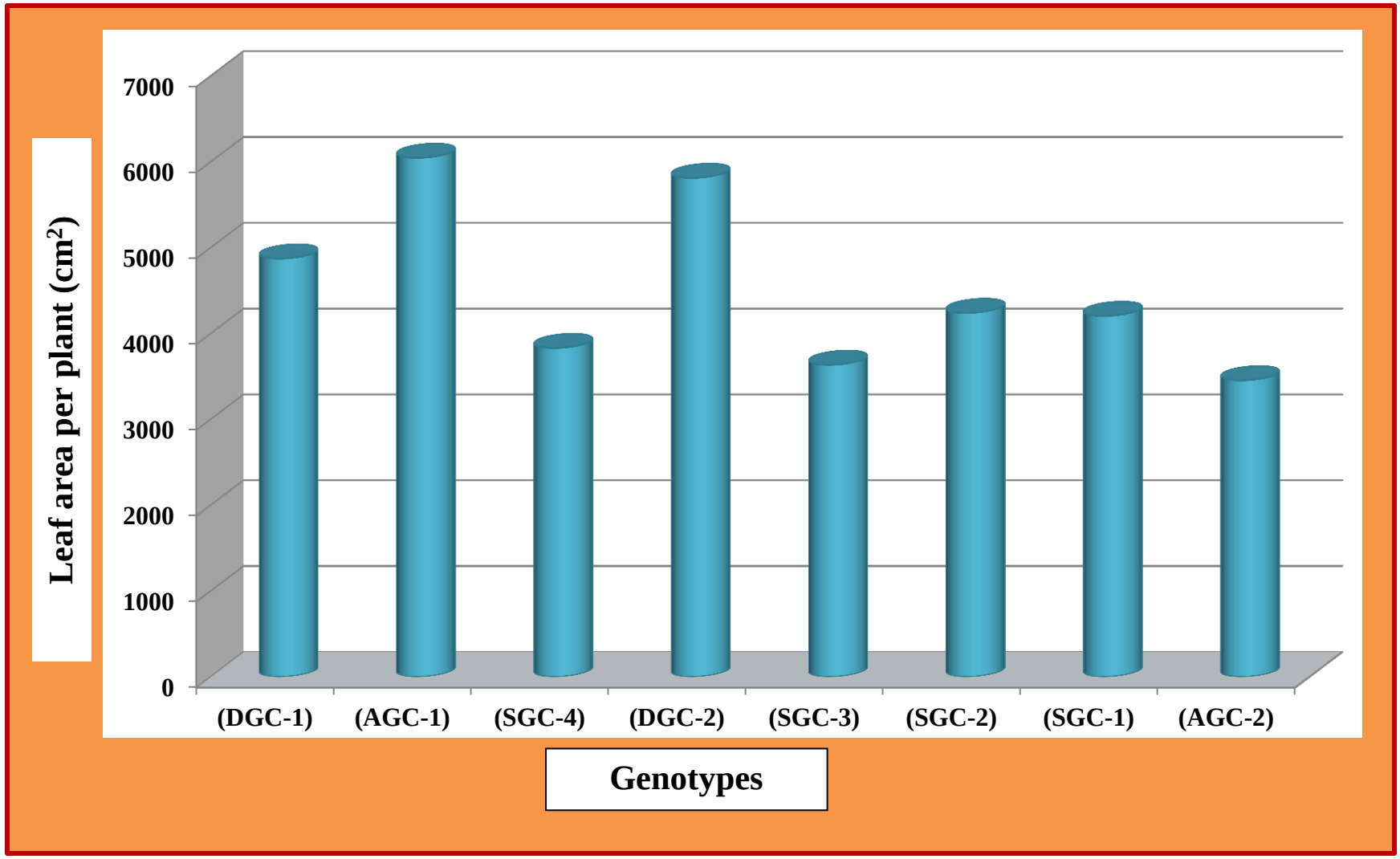


Fig. 5. Leaf area (cm^2/plant) of different *Gaillardia pulchella* Foug. genotypes at peak growth stage

Dry weight of the plant was significantly maximum in genotype DGC-2 and minimum in SGC-1 (Fig. 4). This was mainly attributed by increased growth characters such as plant height, plant spread and production of higher number of branches and leaves. Similar variation has been reported in marigold by Panwar *et al.* (2013).

The chlorophyll content in gaillardia genotypes varied significantly. Chlorophyll 'a' content was maximum in genotype SGC-1 and minimum in genotype SGC-4. Chlorophyll 'b' content was maximum in genotype SGC-1, whereas it was minimum SGC-4. Total chlorophyll content was more in genotype SGC-1 and recorded less in SGC-4. The leaf chlorophyll content is a varietal character that differs according to genotype. Similar results were previously reported by Deepa and Chezhiyan, (2002) in chrysanthemum.

Genotype AGC-1 had significantly maximum leaf area at peak stage of growth followed by DGC-2 and DGC-1 whereas, it was found minimum in genotype AGC-2 (Fig. 5). This variation might be due to tendency of genotype to produce number of branches and leaves per plant that indirectly increase the leaf area of the plant. Vikas *et al*. (2011) and Dhane and Nimbalkar (2002) reported similar result in dahlia.

5.2 Flowering parameters

The days taken for appearance of first flower were minimum and maximum in genotype DGC-2 and DGC-1, respectively and can be classify it as early and late flowering type. This variation was mainly governed by genetic makeup of the genotypes. Similar, variations were also reported by Singh *et al.* (2014) and Chandrashekara *et al*. (2005) in marigold; Parul *et al.* (2011) in chrysanthemum.

The genotype DGC-2 took minimum days to reach 50 per cent flowering, whereas genotype SGC-4 took maximum days for 50 percent flowering which could

be attributed to genetic behaviour of genotypes. These results are in conformity with the reports of Zosiamliana *et al.* (2013) in China aster and Suma and Patil (2006) in daisy.

As far as flowering duration is concerned, the genotype DGC-2 flowered for maximum duration followed by SGC-1 and AGC-2 whereas minimum in SGC-4. The duration of flowering in all the genotypes were clearly related to the number of days taken for appearance of the first flower and days taken for 50 per cent flowering. Similar results were reported in marigold by Khanvilkar *et al*., 2003, Singh *et al.* (2003), in dahlia by Mahawer *et al.* (2010) and Vikas *et al.* (2011); in chrysanthemum by Kishan *et al.* (2008(b)).

Genotype SGC-2 recorded minimum number of days for full bloom whereas it was found maximum in genotype SGC-1. This variation was dependent upon the presence of number of ray and disc florets. Higher number of ray florets in flower led to maximum number of days for full bloom. These findings confirm the earlier reports of Baskaran *et al.* (2010) in chrysanthemum.

Days taken for seed set were significantly minimum in genotype SGC-2 and maximum in SGC-1. Variation for time taken for seed set might be attributed to size of flower head and number of ray florets. Higher the number of ray florets, longer the time taken for seed set.

5.3 Yield parameters

Significant differences were observed among the genotypes with respect to number of flowers per plant (Fig. 6). Maximum number of flowers per plant was produced in the genotype DGC-1, followed by SGC-2 and AGC-2 while least was in SGC-4. It may be directly related to the number of branches per plant. Similar results

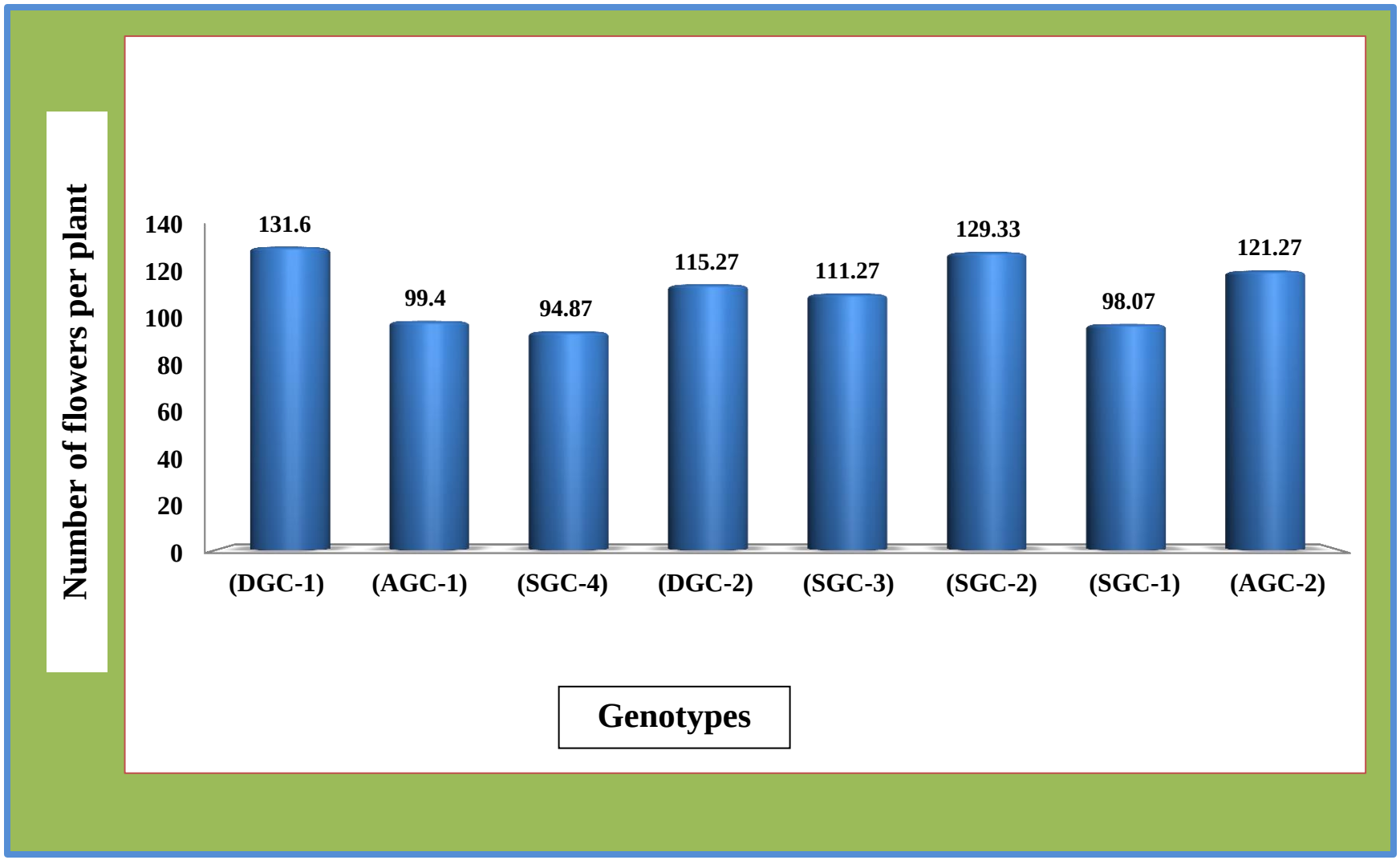


Fig. 6. Number of flowers per plant in different *Gaillardia pulchella* Foug. genotypes

were reported in marigold by Patil *et al.* (2011) and Naik *et al.* (2005), in China aster by Zosiamliana *et al.* (2013) and Munikrishnappa *et al.* (2013).

Significant variation was observed amongst the genotypes for number of flowers produced per plot. Genotype DGC-1 produced maximum number of flowers per plot whereas minimum was recorded AGC-1. This increase in flower number per plot can be attributed to greater plant spread which would have resulted in production and accumulation of more photosynthates, thereby leading to the production of more number of flowers. Similar observations were also made by Deepa and Chezhiyan (2002) in chrysanthemum and in gerbera by Ahlawat *et al*. (2012).

The highest flower yield per plant was recorded in the genotype DGC-2, followed by DGC-1 and AGC-2 whereas, the genotype SGC-4 recorded lowest flower yield. It is clearly visible that existence of relationship between number of flower production per plant and number of branches per plant increase the flower yield per plant. These results are in conformity with the results reported earlier by Karuppaiah and Kumar, (2010), Raghuvanshi and Sharma, (2011) in marigold and by Ajeetkumar *et al.* (2015) in dahlia.

There was significant difference among the genotypes with respect to flower yield per hectare (Fig. 7). Maximum flower yield per hectare was recorded in the genotype DGC-1, while minimum flower yield was in the genotype SGC-3. Number of primary and secondary branches produced per plant is directly related to flower yield per hectare. These results were supported by findings of Narsude *et al.,* 2010, Naik *et al.,* 2005 in marigold and by Zosiamliana *et al.* (2013) and Kulkarni and Reddy (2006) in China aster.

Seed yield obtained per plant and per hectare was significantly maximum in genotype SGC-1 and minimum in SGC-2. The increase in seed yield may be due to

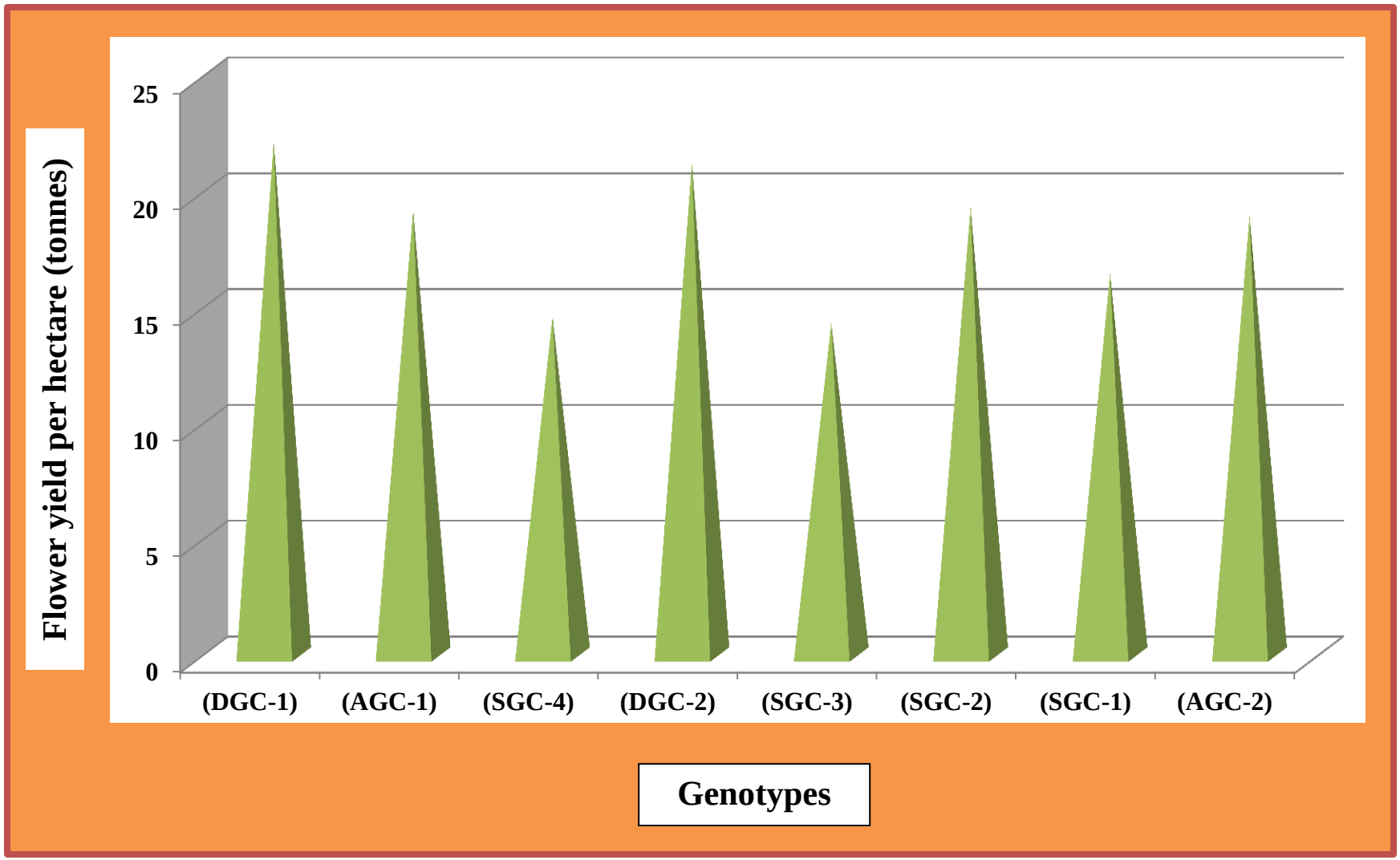


Fig. 7. Flower yield per hectare (tones) in different *Gaillardia pulchella* Foug. genotypes

presence of large number of secondary branches and increased size of achenes in flower head. This is in line with the findings of Tamut (2013) in gaillardia.

5.4 Quality parameters

Significant difference was observed among different genotypes of gaillardia with respect to flower diameter. Maximum flower diameter was recorded in the genotype SGC-1, whereas minimum was in genotype SGC-3. The variation in flower diameter may be due to the genotypic character or genotypic expression of the genotypes. Such variation in flower diameter was earlier reported by Raghuvanshi and Sharma (2011), Singh and Singh (2010) and Patil *et al*. (2011) in marigold; Baskaran *et al.* (2010) and Kishan *et al.* (2008(a)) in chrysanthemum.

The number of whorls per flower was maximum in genotype AGC-1 and minimum in SGC-2. Variation was due to varietal characters, which attributed to their genetical make up. A similar variation has been reported previously in dahlia by Vikas *et al.* (2011) and Dhane and Nimbalkar (2002) and in chrysanthemum by Baskaran *et al.* (2010).

Stalk length is also a desirable character in gaillardia. In present investigation, longest stalk length was recorded in the genotype DGC-1 and genotype SGC-3 registered shortest stalk length. This might be due to proper vegetative development and healthy root development under favorable conditions. Similar results were supported by the Zosiamliana *et al.* (2013) and Balaji *et al.* (2004) in China aster.

Weight of average individual flower was highest in genotype SGC-1 whereas, lowest flower weight was recorded by genotype SGC-2. The variation among the genotypes was mainly because of increased flower size. Narsude *et al.* (2010), Raghuvanshi and Sharma (2011) reported similar results in marigold and in chrysanthemum by Kishan *et al.* (2008 a).

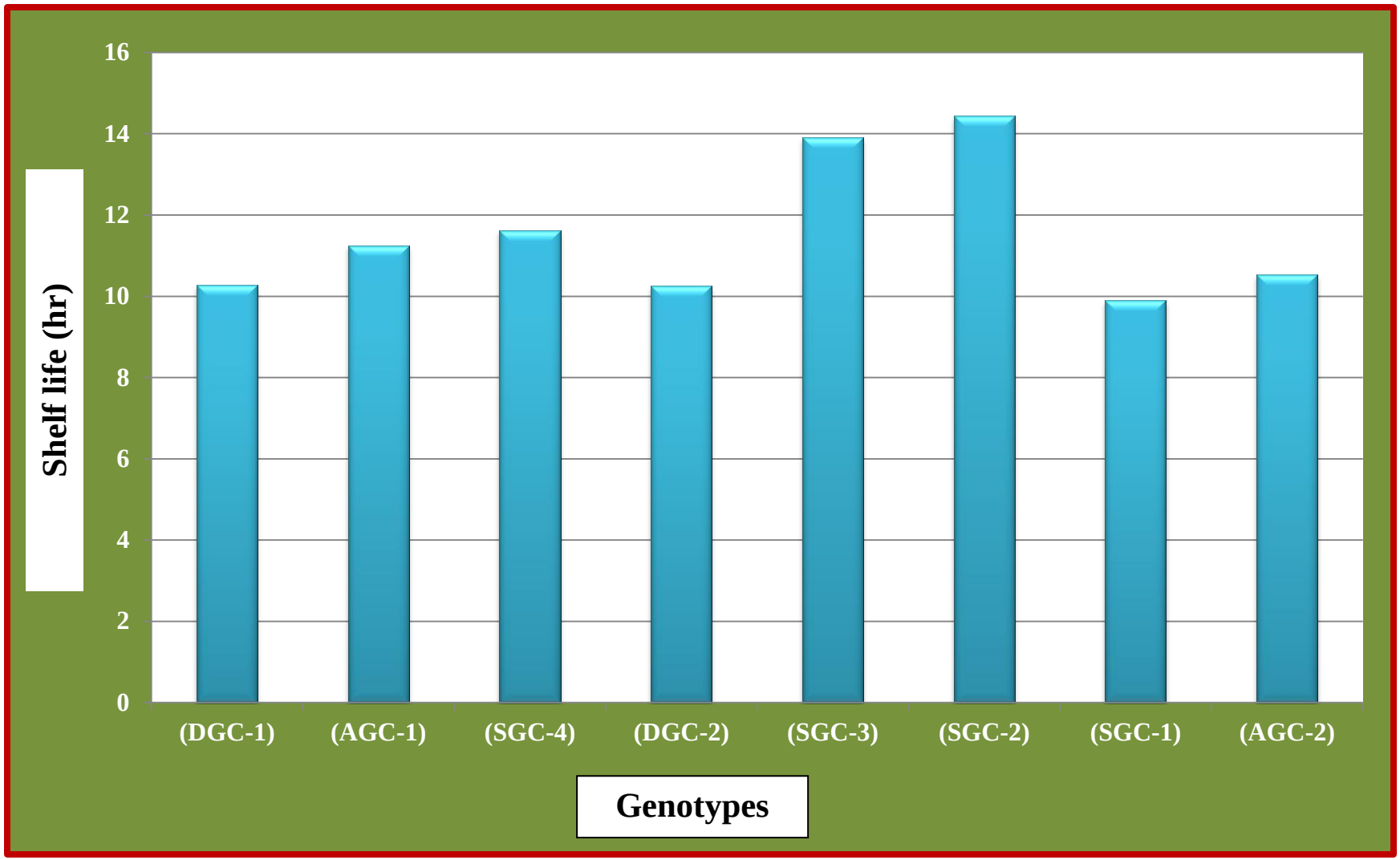


Fig. 8. Shelf life (hr) of different *Gaillardia pulchella* Foug. genotypes

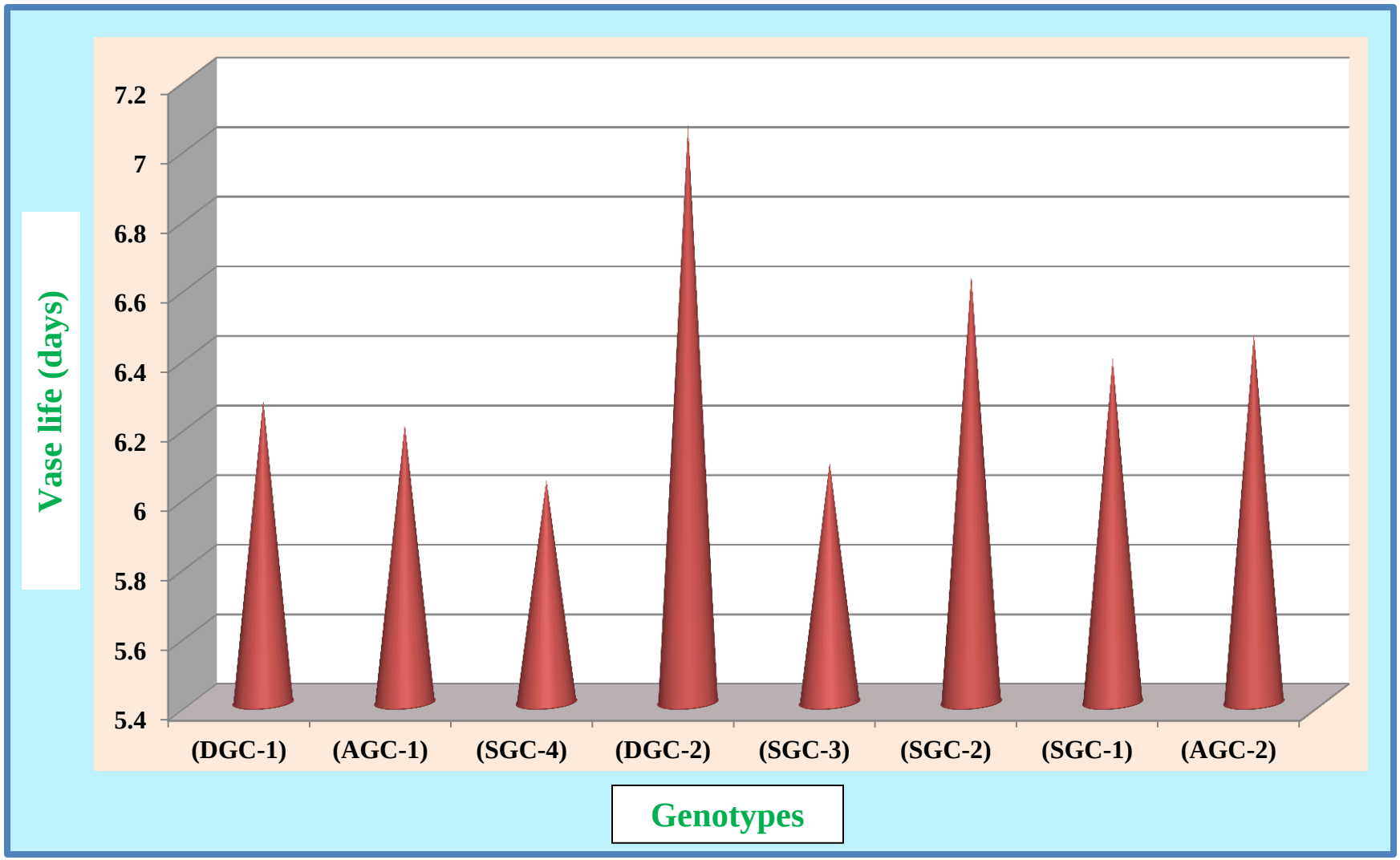


Fig. 9. Vase life of (days) different *Gaillardia pulchella* Foug. genotypes

Genotype SGC-2 had maximum shelf life whereas minimum shelf life was observed in genotype SGC-1 (Fig. 8). This variation may be due to different genetic makeup of genotypes, influenced by prevailing environmental conditions which affect the physiological processes of flower like cell turgidity, water loss through evapotranspiration and break down of the reserve food which governs the shelf life of the flower. Similar results were noted by Mishra *et al*. (2001) and Mahawer *et al*. (2010) in dahlia and in marigold by Patil *et al*. (2011).

The maximum vase life period was observed in genotype DGC-2 and it was minimum in genotype SGC-4 (Fig. 9). It is mainly due to factors like stem girth and dry matter that influence the water absorption rate of stem thereby increase the vase life. Vikas *et al.* (2011) and Dhane and Nimbalkar (2002) observed similar results in dahlia.

5.5 Variability, heritability and genetic advance as per cent of mean

Genetic variability in a group of germplasm is a pre-requisite for a successful breeding programme. Since, most of the characters influencing yield are polygenic, it is essential for plant breeders to estimate the type of variation available in germplasm. Therefore, the present investigations were under taken to estimate the magnitude and nature of variations in collected genotypes of gaillardia with respect to different growth, flowering, yield and quality traits which can be used in the improvement programme.

Analysis of variance of all the eight genotypes revealed highly significant variation among the genotypes for most of the characters studied (Table 11 & 12). This suggested the presence of wide range of variability for different characters among the genotypes which can be exploited through selection.

Maximum plant height (90 DAT), number of branches and leaves per plant (90 DAT), stem girth (90 DAT) and dry weight of plant (90 DAT) were recorded in genotype DGC-2. Genotype, AGC-1 performed better in terms of plant spread (E-W and N-S), total chlorophyll content and leaf area whereas maximum leaf length at 90 DAT was recorded in genotype SGC-4. Similar trend was also made by Panwar *et al*. (2013) in marigold.

Among the flowering characters, DGC-2 was superior for days taken for first flowering, days taken for 50 percent flowering and duration of flowering. Minimum days taken for full bloom and seed setting were recorded in genotype SGC-2. With respect to yield and quality parameter, genotype DGC-1 performed better in terms of flower yield per plant and plot, diameter of flower, length of stalk and flower weight. Similarly genotype DGC-2 showed maximum flower yield per plant and hectare, and vase life. Maximum seed yield both per plant and per hectare were higher in genotype SGC-1. Genotype SGC-4 and SGC-2 exhibited maximum whorls per flower and shelf life, respectively. Similar results were obtained by Sreekala *et al.* (2002), Singh and Singh (2010) and in Singh *et al*. (2003) marigold and in dahlia by Vikas *et al.* (2011).

Range of variations was observed for all the traits in the present study indicating the presence of sufficient amount of variation among the genotypes (Panwar *et al*., 2013). The range in the values reflect the amount of phenotypic variability, which is not very reliable since it includes genotypic, environmental and genotype × environmental interaction components and does not reveal the character showing higher degree of variability. Further, the phenotype of the crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistatis (non-allelic interaction). Hence, it becomes necessary to split the observed variability into phenotypic coefficients of variability (PCV) and genotypic coefficients of variability (GCV), which ultimately indicates the extent of variability existing for various traits.

However, even this does not give a true picture about the extent of inheritance of the character.

The effectiveness of selection for any character does not depend on the amount of variability alone but also with estimates of heritability. Therefore, the heritability (h^2) of a character can be relied upon, as it enables them to decide the extent of selection pressure to be applied under particular environment, which separates out the environmental influence from the total variability.

Estimates of phenotypic variance (PV) were higher compared to genotypic variance (GV) for all the characters, indicating the role of environmental factors for the expression of these characters. Less difference was observed for genotypic and phenotypic variance for most of the characters studied, which indicates the fact that these characters are not much influenced by environmental factors. This also suggests the presence of sufficient variability, which can be exploited by practicing selection based on phenotype for growth parameters.

Phenotypic coefficient of variation (PCV) was higher than those of genotypic coefficient of variation (GCV) for the characters under study and is in agreement with the result of Singh and Singh (2010), Namita *et al.*, (2008) and Pal and Kumar (2010) in marigold and in dahlia by Vikas *et al*. (2011). In this study, phenotypic and genotypic coefficient of variations was high for total chlorophyll content followed by number leaves. It was least for vase life. Similar were obtained by Anuja and Jahnavi (2012), Singh and Singh (2010) and Panwar *et al*. (2013) in marigold and in chrysanthemum by Baskaran *et al.*, (2010).

The genotypic coefficient of variation alone does not provide reliable information about the assessment of variation that is heritable and therefore, estimation of heritability becomes imperative. Heritability (broad sense) estimates ranged from 11.00 % for stem girth at 90 days after transplanting to 99.00 % for

number of leaves (90 DAT) and flowers produced per plant. The high value of heritability (>70%) was observed for most of traits studied except plant spread (30 DAT), number of branches per plant (30 DAT), stem girth (30 and 90 DAT), days taken for first and 50 percent flowering and time taken for full bloom which revealed that these traits were most influenced by environmental changes suggesting that the selection based on phenotype would not be effective for these traits. Similar findings were reported in marigold by Panwar *et al*. (2013) and Mathew *et al.* (2005) and in dahlia by Vikas *et al*. (2011).

In present study, estimates of high heritability with high genetic advance over per cent mean (GAM) for growth characters were observed for plant height, number of branches per plant, number of leaves per plant, leaf area and chlorophyll content. And for flowering traits, it was recorded in duration of flowering, days taken for seed setting, indicating the possible role of additive gene action. Similarly, for yield and quality parameters high genetic advance over per cent mean (GAM) was observed for number of flowers per plant and plot, flower and seed yield both per plant and hectare, stalk length and shelf life of flowers. The results are in conformity to those observed for number flowers per plant by Anop *et al.*, *(*2011) in gerbera and Talukdar *et al*. (2003), in chrysanthemum, for flower yield in marigold by Mathew *et al.* (2005) and Misra *et al*. (2013) for average flower weight in chrysanthemum.

5.6 Correlation

Character association on correlation is a measure of the degree of association between two characters. The phenotypic correlation indicates the extent of the observed relationship between two characters. This does not give true genetic picture of the relationship because it includes both heritable and non heritable association. Genotypic correlation provides an estimate of inherent association between genes controlling any two characters. Improving genetic correlation was mainly due to

pleiotrophy and linkage (Harland, 1939). Hence, it is of great significance and could be effectively utilized in formulating an effective selection scheme. Simultaneous improvement of traits becomes difficult if there is high correlation among them.

In the present study, it was observed that the genotypic correlation was more than the phenotypic correlation, indicating the presence of inherent association between various characters. Similar trend has been observed by Raghava *et al*. (1992) in chrysanthemum and Magar *et al*. (2010) in gerbera.

Plant height produced at 90 DAT significantly correlated in positive direction with plant spread (E-W) at 90 DAT, plant spread (N-S) at 90 DAT, number of leaves at 90 days after transplanting, stem girth at 90 DAT, leaf area, diameter of flower, duration of flowering and flower yield per hectare both at genotypic and phenotypic level. Similar results were observed by Raghava *et al*. (1992) in chrysanthemum and Mathad *et al*. (2005) and Kumar (2011) in marigold and Vikas *et al*. (2011) in dahlia. However it showed non-significant correlation with other characters.

Plant spread (E-W) at 90 DAT had significant positive correlation with plant spread, number of branches per plant, number of leaves, stem girth, leaf area and flower yield per hectare, while it was positive and non significant for dry weight at 90 DAT.

Number of branches produced per plant exhibited significant and positive association with number of leaves per plant, stem girth, leaf area, number flowers per plant, number of flowers per plot, flower yield per plant and flower yield per hectare. Flower weight had significant (-0.397) and negative correlation with number of branches produced per plant at genotypic level. This trend was confirmed by Mishra *et al.* (2001) in dahlia and Misra *et al.,* (2013) in chrysanthemum.

Number of leaves produced per plant showed significant positive correlation with stem girth, dry weight, leaf area, duration of flowering and flower yield per hectare. Similar findings were reported by Vikas *et al*. (2011) in dahlia.

Genotypic and phenotypic correlation of stem girth at 90 DAT was significantly positive correlated with leaf area, number of flowers per plot, flower yield per plant, duration of flowering, flower weight, and flower yield per hectare. Similar findings were reported by Vikas *et al*. (2011) in dahlia.

The character dry weight had highly significant and positive association with number of leaves produced per plant and number of branches produced per plant at genotypic level. It was significantly negative association with diameter of flower and flower weight at genotypic level. Similar observations have been reported by Kumar (2011) and Gourishankarayya *et al*. (2005) in marigold.

Leaf area showed significant and positive correlation with flower yield per hectare, dry weight, stem girth, number of leaves, number of branches produced per plant, plant spread and plant height. This is in line with the findings of Namita *et al*. (2008) and Singh and Singh (2010) in marigold and in chrysanthemum by Punetha *et al*. (2012).

Flower diameter exhibited significant and positive correlation with duration of flowering and flower weight, stem girth, plant spread and plant height. Similar results were reported by Vikas *et al.* (2011) in dahlia and in chrysanthemum by Punetha *et al*. (2012). Negative and significant correlations were shown by dry weight of plant.

Number of flowers produced per plant exhibited significant and positive correlation with stem girth, number of flowers per plot, number of flowers produced per plant, number of branches and flower yield per hectare at both genotypic and phenotypic levels. Similar results were reported by Sreenivasulu *et al*. (2007) in China

aster and Karuppaiah and Kumar (2010), Singh and Singh (2005(b)) and Karuppaiah *et al*. (2004) in marigold. However it showed non-significant correlation with other characters.

Number of flowers produced per plot showed significant and positive correlation with flower yield per plant and flower yield per hectare at both genotypic and phenotypic level. It had significant and positive correlation with number flowers per plant, duration of flowering and number of genotypic level. At phenotypic level number of flowers produced per plot had significant and positive correlation with number of flowers per plant, stem girth and number of branches per plant.

Flower yield per plant showed significant and positive correlation with duration of flowering, flower yield per hectare, number of flowers per plot, number of flowers per plant, stem girth and number of branches at both genotypic and phenotypic level. Similar findings were reported by Reene *et al.* (2005) and Anuja and Jahnavi (2012) in marigold.

5.7 Path analysis

In the present study, path coefficient analysis between the components of flower yield per plant was worked out and the results are discussed at genotypic level only as the genotypic associations are inherent. The residual effect of the genotypic path analysis was low (0.056), indicating that, the characters considered for the path analysis were appropriate for the study. Flower yield per plant is taken was the dependent variable.

Plant height had maximum positive direct effect on flower yield per plant followed by plant spread, number of branches per plant, duration of flowering, flower diameter, number of branches, flower weight and dry weight of plant. Days taken for

appearance of first flower exhibited negative indirect effect on flower yield per plant. The results are in line with the findings of Singh and Singh (2005(b)) in marigold.

Plant spread had maximum negative direct effect on flower yield per plant whereas plant spread, number of branches, leaf area, duration of flowering, dry weight of plant and number of whorls per flower have negative indirect effect. Appearance of first flower had positive indirect effect on flower yield per plant. Similar results were also reported by Kumar (2011) and Anuja and Jahnavi (2012) in marigold.

Number of branches at 60 DAT had positive direct effect on flower yield per plant whereas leaf area has positive indirect effect on it. Number of branches at 90DAT also had positive direct effect on flower yield per plant followed by number of branches, leaf area, plant spread has positive indirect effect. Negative and indirect effect was contributed by appearance of first flower and flower weight on flower yield. Similar results were obtained by Karuppaiah and Kumar (2010) and Mathew *et al.* (2005) in marigold and in chrysanthemum by Misra *et al.* 2013.

Dry weight of plant had positive direct effect on flower yield followed by leaf area and number of branches whereas plant spread had a positively indirect effect on it. The traits like appearance of first flower, flower diameter, flower weight and number of flowers per plant had negatively indirect effect on flower yield per plant.

Leaf area had negative and direct effect on flower yield. Plant height, plant spread, dry weight of plant, number of branches, duration of flowering and number of whorls per flower had negative indirect effect on flower yield. Similarly days taken for appearance of first flower had positive indirect effect on flower yield.

Flower diameter had positive and direct effect on flower yield, followed by plant height, plant spread, flower weight, duration of flowering all of which had positively indirect effect on flower yield. Dry weight of plant had negatively indirect

effect on flower yield. Punetha *et al*. (2012) also observed similar results in chrysanthemum.

Number of whorls per flower had negatively direct effect on flower yield per plant and plant height and dry weight of plant had negative indirect effect. Positively indirect effects were contributed by number of flowers per plant to flower yield per plant.

Number of flowers per plant had positive direct effect on flower yield followed by number of branches, duration of flowering and days taken for appearance of first flower which has positive indirect effect. Negatively indirect effect was attributed by number of flowers per plant dry weight of plant and flower weight. Punetha *et al*. (2012) also observed similar results in chrysanthemum and Anuja and Jahnavi (2012) in marigold

Appearance of first flower had negative direct effect on flower yield per plant whereas flower diameter and flower weight had negative indirect effect on flower yield. Plant spread, number of branches, leaf area and dry weight of plant had positively indirect effect on flower yield. Kumar (2011) recorded similar results in marigold.

Duration of flowering had positive direct effect on flower yield. Plant spread has a positive indirect effect on yield. Punetha *et al*. (2012) also observed similar results in chrysanthemum.

Average individual flower weight had negative direct effect on flower yield followed by flower diameter, duration of flowering, plant height and number of whorls per flower, which had indirect effects on flower yield with negative values. In marigold similar findings were recorded by Anuja and Jahnavi (2012).

5.8 Economics of gaillardia production

The maximum benefit to cost ratio was recorded in the genotype ‘DGC-1’ whereas, the lowest was recorded in the genotype ‘SGC-3’. It is clear that higher the yields, higher would be the returns. In addition, the total cost of cultivation and the market price for the produce plays a vital role on the net returns.

Future line of work

With the results obtained from the present study, the following future line of works could be taken up.

1. Evaluation of the performance and suitability of available high yielding gaillardia genotypes under different conditions to identify stable genotypes.

2. Studies on standardisation of nutritional requirement of gaillardia can be taken up to get high yield and better quality flowers.

3. Breeding programme can be initiated for developing high fragrance and multiple shoots genotypes in gaillardia.

4. Developing varieties suited to both abiotic and biotic stress condition.

SUMMARY

VI. SUMMARY

Gaillardia is an emerging loose flower and is being grown on a commercial scale in open condition. The present investigation on "Evaluation of *Gaillardia pulchella* Foug. genotypes under hill zone of Karnataka" was carried out during the year 2014-15 at the experimental block of Department of Floriculture & Landscape Architecture, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga. The main objectives of the study were to evaluate different genotypes for their growth, flowering, yield and quality parameters and also to know the presence of variability and to the workout the economics. The salient findings of the investigation are summarized in this chapter.

Growth performance of eight genotypes of gaillardia indicated significant variations at all stages of crop growth. Genotypes DGC-2, AGC-1 and SGC-1 are better in terms of plant height at peak growth (90 DAT) stage. Plant spread on both direction (E-W and N-S) was significantly maximum in genotype AGC-1 followed by DGC-2 at 90 DAT.

Number of branches and leaves produced by plant contributes major share to flower production. Genotypes AGC-2 and DGC-2 exhibited maximum number of branches and leaves per plant at 90 DAT. Significantly maximum leaf length at 90 DAT was recorded in genotype SGC-4 followed by SGC-3 and AGC-1, and it was registered minimum in AGC-2.

Genotype DGC-2 recorded the maximum stem girth at 90 DAT. Similarly leaf area was maximum in AGC-1. The chlorophyll content in gaillardia genotypes varied significantly. Total chlorophyll content and dry weight of plants was maximum in genotype SGC-1 and DGC-2, respectively. Overall growth character was good in genotypes DGC-2, AGC-1 and DGC-1.

The days taken for appearance of first flower were minimum and maximum in the genotypes DGC-2 and DGC-1, respectively. As far as flowering is concerned, the genotype DGC-2 flowered for maximum duration followed by SGC-1 and DGC-1.

On the other hand, the days taken for first flower appearance, days taken 50 percent flowering and duration of flowering was superior in genotype DGC-2. Similarly genotype SGC-2 took minimum number of days for full bloom as well as seed setting.

Significant differences were observed in genotypes with respect to yield attributes. Maximum number of flowers per plant and per plot and flower yield per hectare was produced in the genotype DGC-1, followed by DGC-2, AGC-2 and SGC-2. Genotype SGC-1 exhibited maximum seed yield per plant as well as per hectare.

Maximum flower diameter was recorded in the genotype SGC-1, whereas minimum was in genotype SGC-3. Maximum stalk length and shelf life was observed in the genotypes DGC-1 and SGC-2, respectively. The maximum vase life period was registered in genotype DGC-2.

The analysis of variance revealed that highly significant differences among genotypes for all the characters studied were observed. The phenotypic coefficient of variation was more than genotypic coefficient of variation for all the studied characters.

Estimates of phenotypic variance (PV) were higher compared to genotypic variance (GV) for all the characters, indicating the role of environmental factors for the expression of these characters. Less difference was observed for genotypic and

phenotypic variance for most of the characters studied, which also indicates the fact that these characters are not much influenced by environmental factors.

The high value of heritability was observed for most of traits studied except plant spread (30 DAT), number of branches per plant (30 DAT), stem girth (30 and 90 DAT), days taken for first and 50 percent flowering and time taken for full bloom which revealed that these traits were most influenced by environmental changes suggesting that the selection based on phenotype would be not effective to these traits.

Correlation studies revealed that highly significant and positive association of flower yield per plant with days taken for first flowering, duration of flowering, flower diameter, number of florets per plant, number of whorls of petals per flower and single flower weight. Also plant height, plant spread, number of branches, number of leaves and leaf area also showed significant and positive correlation with flower yield, indicating the possibility of simultaneous selection for these traits to improve the yield.

Path analysis for flower yield per plant revealed that flower diameter, number of whorls of petals per flower, number of flowers per plant, duration of flowering and in flower weight had positive direct effect on flower yield which indicated the possibility of increasing flower yield by selecting the genotypes for these characters directly.

Performance of the genotype DGC-1 were better in terms of characters like days taken for appearance of first flower, number of flowers per plant and per plot, flower yield per hectare, shelf life and vase life of flowers. So, the genotype DGC-1 was recommended for cultivation under hill zones of Karnataka.

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* - *Originals not seen*

APPENDICES

APPENDIX-I

Monthly mean meteorological data for the experimental year (2014-15) recorded at the ZAHRS, Mudigere

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)		Sun shine (hrs)
		Max.	Min.	Max.	Min.	
August	542.6	26.29	17.33	88.22	76.90	0.16
September	365.4	27.41	18.75	90.63	80.70	0.1
October	88.0	26.46	18.01	90.38	81.70	2.16
November	12.0	26.96	17.41	84.03	73.46	6.98
December	19.0	26.80	14.91	84.70	74.29	7.87
January	Nil	27.14	14.58	74.25	63.58	7.91
February	Nil	28.28	15.21	73.28	60.46	9.19
March	34.6	32.30	18.37	74.83	53.12	10.35
April	262.8	31.55	18.31	86.66	74.00	-
Total	**2553.1**	-	-	-	-	-

APPENDIX-II

Chemical properties and fertility status of the experimental site

Soil (chemical) properties	Characterization
pH	3.88
Electrical Conductivity (dSm^{-1})	0.037
Available Nitrogen (kg/ha)	225.78
Available Phosphorous P_2O_5 (kg/ha)	19.4
Available potassium K_2O (kg/ha)	328.1

APPENDIX-III

Cost of cultivation of gaillardia per hectare under open field condition

Particulars	Quantity	Rate unit (Rs.)	Total cost (Rs.)
I Inputs			
1. Seeds	2.50 kg	5000.00/kg	12500.00
2. Fertilizers (RDF- 75:60:80 kg NPK/ha, FYM- 15 t/ha)			
a. Urea	163.00 kg	5.00/kg	815.00
b. Rock phosphate	200.00 kg	5.00/kg	1000.00
c. Murate of potash	133.00 kg	16.00/kg	2128.00
d. FYM	15.00t/ha	800.00/t	12000.00
3. Plant production chemicals			
a. Metalaxyl (Ridomil gold)	2.00 kg	1600.00/kg	3200.00
b. Dimethoate (Rogar)	1.00 liter	450.00/lit	450.00
c. Others			1000.00
II Labour charges			
a. Ploughing, land preparation, transplanting and gap filling		190.00/man day	15000.00
b. Weeding		190.00/man day	2850.00
c. Irrigation			3000.00
d. Harvest and miscellaneous charge			19000.00
e. Transportation and marketing			4000.00
Total			**76943.00**

APPENDIX IV

List of symbols and abbreviations

Symbols	Abbreviations
%	Per cent
@	At
Anon.	Anonymous
$^{\circ}$C	Degree centigrade
C.D	Critical difference
cm	Centimetre
cm^2	Centimetre square
cv.	Cultivar
DAT	Days after transplanting
DMSO	Di methyl sulphoxide
et al.	Et allii (and other)
FYM	Farm yard manure
g	Gram
hr	Hour
ha	Hectare
i.e.	That is
kg	Kilogram
m^2	Meter square
mg	Milligram
ml	Milliliter
mm	Millimeter
NPK	Nitrogen: Phosphorous: Potassium
S.Em.	Standard Error of Mean
S.D	Standard deviation
t	Tonne
viz.	As follows