

**EVALUATION OF CHINA ASTER**  
**[*Callistephus chinensis*(L.)Nees.] GENOTYPES FOR**  
**GROWTH, YIELD AND FLOWER QUALITY**

**PRABHU C. HALLIKERI**

**UHS16PGM805**

**DEPARTMENT OF FLORICULTURE AND LANDSCAPE**

**ARCHITECTURE**

**COLLEGE OF HORTICULTURE, BENGALURU**

**UNIVERSITY OF HORTICULTURAL SCIENCES**

**BAGALKOT - 587104**

**JULY, 2018**

**EVALUATION OF CHINA ASTER**  
**[*Callistephus chinensis*(L.)Nees.] GENOTYPES FOR**  
**GROWTH, YIELD AND FLOWER QUALITY**

*Thesis submitted to the*  
*University of Horticultural Sciences, Bagalkot*  
*in partial fulfilment of the requirements for the*  
*award of Degree of*

**MASTER OF SCIENCE (Horticulture)**  
**in**  
**FLORICULTURE AND LANDSCAPE ARCHITECTURE**

*By*  
**PRABHU C. HALLIKERI**  
**UHS16PGM805**

**DEPARTMENT OF FLORICULTURE AND LANDSCAPE**  
**ARCHITECTURE**

**COLLEGE OF HORTICULTURE, BENGALURU**  
**UNIVERSITY OF HORTICULTURAL SCIENCES**

**BAGALKOT - 587104**

**JULY, 2018**



*Affectionately  
Dedicated to  
My Beloved Parents,  
Sri Chinnappa &  
Smt. Hampamma*

**DEPARTMENT OF FLORICULTURE AND LANDSCAPE  
ARCHITECTURE  
COLLEGE OF HORTICULTURE, BENGALURU  
UNIVERSITY OF HORTICULTURAL SCIENCES  
BAGALKOT**

**CERTIFICATE**

This is to certify that the thesis entitled “**EVALUATION OF CHINA ASTER[*Callistephus chinensis*(L.)Nees.]GENOTYPES FOR GROWTH, YIELD AND FLOWER QUALITY**” submitted by **Mr. PRABHU C. HALLIKERI, ID. No. UHS16PGM805**, 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 Horticultural Sciences, Bagalkot, is a record of *bona-fide* research work carried out by him during the period of his study in this University of Horticultural Sciences, Bagalkot, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Bengaluru  
Date: July, 2018

**(MUNIKRISHNAPPA, P. M.)**  
Major Advisor

**Approved by:**

**Chairperson :**

\_\_\_\_\_  
**(MUNIKRISHNAPPA P.  
M.)**

**Members : 1.**

\_\_\_\_\_  
**(BALAJI S. KULKARNI)**

**2.**

\_\_\_\_\_  
**(RAJIV KUMAR)**

**3.**

\_\_\_\_\_  
**(HARSHAVARDHAN M.)**

**4.**

\_\_\_\_\_  
**(AMREEN TAJ)**

## **ACKNOWLEDGMENTS**

*The beatitude and euphoria that accompanies successful completion of any task would be incomplete without expression of appreciation of simple certitude to the people who made it possible to achieve the goal by their encouraging guidance and proper steering. It is still great at this juncture to recall all the faces and spirit in the form of teachers, friends, near and dear ones.*

*I cannot but consider myself lucky to have worked under the guidance of excellence pursuing and ever helpful personality **Dr. Munikrishanappa P. M.** Associate Professor Dept. of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, esteemed Chairman of my Advisory Committee. I am immensely grateful to him for his arduous and meticulous guidance, constant fomenting, punctilious and impeccable advice, sustained interest and above all his affectionate way of dealing with the things throughout the course of my investigation, which helped me to consummate the research work. I take this opportunity to express my heartfelt gratitude towards him.*

*I sincerely extend my profound gratitude and appreciation to the member of my Advisory Committee, **Dr. Balaji S. Kulkarni**, Professor and Head, Dept. of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, for his valuable help.*

*I deem it my privilege in expressing my fidelity to **Dr. Rajiv Kumar**, Principal Scientist, Division of Floriculture and Medicinal Crops, ICAR, IIHR, Bengaluru, member of my Advisory Committee for his munificent acquiescence and meticulous reasoning to refine this thesis and most explicitly to reckon with set standards. Ineffable in my gratitude and sincere thanks to him for this transcendent suggestions and efforts to embellish the study.*

*I am extremely thankful and sincere gratitude to **Dr. Harshavardhan M.**, Assistant Professor, Department of Floriculture and Landscape Architecture, College of Horticulture, Sirsi, and **Dr. Amreen Taj**, Assistant Professor, Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru, who rendered valuable help, suggestions and constant encouragement provided at every stage of the thesis preparation.*

*I allocate my highest respect and heartfelt regards from my inner core of heart to my ever loved parents, **Sri. Chinnappa Hallikeri** and **Smt. Hampamma**, who have given*

*me life and taught the concepts of life and their dedicated efforts to educate me to this level. With boundless affection, my brothers **Sri. Basavaraj Hallikeri, Gavisiddappa, Sharannappa and Kotresh**, my sisters **Smt. Sumangala, Mamatha, and Roopa**, for constant encouragement throughout my career and they have been a fountain of inspiration throughout my life, without whose help in every walk of life, this work would not have been possible.*

*I feel immense pleasure and joy in expressing my profound affection and gratitude to my mama **Dr. Mahesh Umachagi, Manjunath Umachagi, and Dr. Gururaj Umachagi**, for constant encouragement throughout my career and they have been a fountain of inspiration throughout my education.*

*I feel immense pleasure and joy in expressing my profound affection and gratitude to my best friend **Ms. Soujanya P.**, and her parents **Sri. Nagaraja P. and Smt. Jayamma**, and her elder brother **Mr. Santosh P.**, who gave lot of encourage and inspiration in my life, and her inspiration is also important for my future life.*

*I feel immense pleasure and joy in expressing my profound affection and gratitude to my seniors, **Rahul, Irphan, Poornima, Rashmi, and Manjula**, and to my friends **Arihanth, Raghu, Manju, Gurumurthy, Imtiyaz, Nagesh, Pragath, Devaraja, Gangadhar, Sudesh, Basvaraj, Chatrapathi, Shivakumar, Sachin, Manjunath, Ananda, Ashwini, Rosalind, Keerthi, Malli and Reddy** and to my juniors, **Sharath K. H., Sharath, Mahesh, Dileep, Santu, Vinayak, Ajaya, Sachin, Rabbani, Partha, Shivu and Shivu Hatti** and my filed workers **Devamma, Savitramma and siddappa** for their help and moral support during the course of my study and in whose cheerful company I have never felt my work as burden.*

*I express my immense and whole hearted thanks to all my dear friends for their cooperation, help during the course of study and research. Above all, whole hearted prostrations to the Almighty for sprinkling his blessings upon me.*

*Bengaluru*

*July, 2018*

*(Prabhu C. Hallikeri)*

# **EVALUATION OF CHINA ASTER [*Callistephuschinensis*(L.)Nees.] GENOTYPES FOR GROWTH, YIELD AND FLOWER QUALITY**

## **ABSTRACT**

An experiment entitled “Evaluation of China aster [*Callistephuschinensis*(L.)Nees] genotypes for growth, yield and flower quality” was carried out during 2017 - 2018 in the Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru in randomized complete block design replicated twice. Among the twenty-eight genotypes evaluated, maximum plant height (73.86 cm) was recorded in cv. Arka Violet Cushion, cv. Arka Aadyatook least number of days to first flowering and days to 50% flowering (42.90 and 49.60 days, respectively). Maximum flowering duration (35.50 days) was recorded in cv. AAC-1. Maximum flower diameter (7.33 cm) was recorded in Phule Ganesh White. Maximum stalk length (42.19 cm) was recorded in cv. AAC-1. Maximum individual flower weight (7.42 g) was recorded in cv. Phule Ganesh White. Maximum number of flowers per plant (70.80) was recorded in cv. Arka Archana. Flower yield and seed yield on weight basis was highest in cv. AAC-1 (216.40 g/plant and 19.21 g/plant, respectively). In variability studies, high GCV and PCV was recorded for all the characters studied except Shelf life. In correlation studies, the number and weight of flowers per plant was significant and positively correlated with plant spread in (North- South) flower diameter and stalk length. In path analysis, plant spread in (North- South) recorded maximum positive direct effect on weight of flowers per plant, followed by plant spread in (East- West) days to 50 per cent flowering and number of primary branches per plant.

**(Prabhu C. Hallikeri)**

Signature of the student

**(Munikrishanappa P. M.)**

Signature of the Major Advisor

**ಚೈನಾ ಆಸ್ವರಾನ ವಿವಿಧ [ಕ್ಯಾಲಿಸ್ಟೆಫಸ್ ಚೈನೆನ್ಸಿಸ್ (ಎಲ್.) ನೀಸ್] ತಳಿಗಳ  
ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು ಹೂ ಗುಣಮಟ್ಟದ ಗುಣಗಳ ಮೌಲ್ಯಮಾಪನ  
ಸಾರಾಂಶ**

ಚೈನಾ ಆಸ್ವರಾನ ವಿವಿಧ [ಕ್ಯಾಲಿಸ್ಟೆಫಸ್ ಚೈನೆನ್ಸಿಸ್ (ಎಲ್.) ನೀಸ್] ತಳಿಗಳ ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು ಹೂ ಗುಣಮಟ್ಟವನ್ನು ತಿಳಿಯಲು ಪುಷ್ಪ ಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ವಿನ್ಯಾಸ ಶಾಸ್ತ್ರ ವಿಭಾಗ, ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರಿನಲ್ಲಿ 2017 ರಿಂದ 2018 ರವರೆಗೆ ಕ್ಷೇತ್ರ ಅಧ್ಯಯನವನ್ನು ಕೈಗೊಳ್ಳಲಾಗಿತ್ತು. ಈ ಅಧ್ಯಯನವನ್ನು 2 ಪುನರಾವರ್ತನೆಗಳ 28 ತಳಿಗಳನ್ನೊಳಗೊಂಡ ಯಾದೃಚ್ಛಿಕಗೊಳಿಸಿದ ಪೂರ್ತಿ ಪ್ರತಿ ಬಿಂದಕ ವಿನ್ಯಾಸದಲ್ಲಿ (ಆರ್.ಸಿ.ಬಿ.ಡಿ.) ಸಿದ್ಧಪಡಿಸಲಾಗಿತ್ತು. 28 ತಳಿಗಳಲ್ಲಿ ಗರಿಷ್ಠ ಸಸ್ಯದ ಎತ್ತರ (73.86 ಸೆಂ. ಮೀ.) ಅರ್ಕಾ ವೈಲೆಟ್ ಕುಶನ್ ದಾಖಲಿಸಿದೆ. ಅರ್ಕಾ ಆದ್ಯ ತಳಿಯು ಅತಿ ಕಡಿಮೆ ಸಮಯದಲ್ಲಿ ಮೊದಲು ಹೂ ಬಿಡಲು ತೆಗೆದುಕೊಳ್ಳುವ ದಿನಗಳು ಮತ್ತು ಪ್ರತಿಶತ 50 ಗಿಡಗಳು ಹೂ ಬಿಡಲು ತೆಗೆದುಕೊಳ್ಳಲು ಕನಿಷ್ಠ ದಿನಗಳನ್ನು (42.90 ಮತ್ತು 49.60 ಸೆಂ. ಮೀ. ಕ್ರಮವಾಗಿ) ದಾಖಲಾಗಿದೆ. ಎಎಸಿ-1 ನಲ್ಲಿ ಗರಿಷ್ಠ ಹೂ ಬಿಡುವ ಅವಧಿ (35.50 ದಿನಗಳು) ದಾಖಲಾಗಿದೆ. ಪುಲೆ ಗಣೇಶ್ ವೈಟ್‌ನಲ್ಲಿ ಗರಿಷ್ಠ ಹೂವಿನ ವ್ಯಾಸ (7.33 ಸೆಂ. ಮೀ.) ದಾಖಲಾಗಿದೆ. ಗರಿಷ್ಠ ಕಾಂಡದ ಉದ್ದವು 42.19 ಸೆಂ. ಮೀ, ರಷ್ಷು ಎಎಸಿ-1 ಪಡೆದಿದೆ. ಗರಿಷ್ಠ ಒಂದು ಹೂವಿನ ತೂಕ (7.42 ಗ್ರಾಂ.) ಪುಲೆ ಗಣೇಶ್ ವೈಟ್‌ನಲ್ಲಿ ದಾಖಲಾಗಿದೆ. ಅರ್ಕಾ ಅರ್ಚನ ತಳಿಯಲ್ಲಿ ಗರಿಷ್ಠ ಸಂಖ್ಯೆಯ ಹೂಗಳು ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ (70.80) ದಾಖಲಾಗಿದೆ. ತೂಕದ ಆಧಾರದ ಮೇಲೆ ಗರಿಷ್ಠ ಹೂವಿನ ಮತ್ತು ಬೀಜದ ಇಳುವರಿಯು ಎಎಸಿ-1 ನಲ್ಲಿ (216.40 ಗ್ರಾಂ./ಸಸ್ಯ, ಮತ್ತು 19.21 ಗ್ರಾಂ./ಸಸ್ಯ, ಕ್ರಮವಾಗಿ) ದಾಖಲಾಗಿದೆ. ವೈವಿಧ್ಯತೆಯ ಅಧ್ಯಯನದಿಂದ ಸಂಗ್ರಹಣಾ ದಿನಗಳನ್ನು ಹೊರತುಪಡಿಸಿ ಅಧ್ಯಯನ ಮಾಡಿದ ಉಳಿದೆಲ್ಲಾ ಸಸ್ಯಗುಣಗಳಿಗೂ ಅತಿ ಹೆಚ್ಚಿನ ಜಿಸಿವಿ ಮತ್ತು ಪಿಸಿವಿ ಗಳಿಸಿರುವುದು ಕಂಡುಬಂದಿದೆ. ಅನ್ಯೂನ್ಯತೆಯ ಅಧ್ಯಯನದಿಂದ ಪ್ರತಿ ಸಸ್ಯದ ಹೂಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ತೂಕವು ಉತ್ತರ-ದಕ್ಷಿಣ ದಿಕ್ಕಿನಲ್ಲಿ ಸಸ್ಯ ಹರಡುವಿಕೆ, ಹೂವಿನ ವ್ಯಾಸ ಮತ್ತು ಹೂಕಾಂಡದ ಉದ್ದಗಳೊಡನೆ ಅತಿ ಹೆಚ್ಚಿನ ಧನಾತ್ಮಕ ಸಂಬಂಧವನ್ನು ಹೊಂದಿರುವುದಾಗಿ ತಿಳಿದುಬಂದಿದೆ. ಸಂಖ್ಯಾಶಾಸ್ತ್ರದ ಪ್ರಕಾರ ಅಧ್ಯಯನದಿಂದ ಪ್ರತಿ ಗಿಡದ ಹೂಗಳ ತೂಕದ ಮೇಲೆ ಉತ್ತರ-ದಕ್ಷಿಣ ದಿಕ್ಕಿನಲ್ಲಿ ಸಸ್ಯ ಹರಡುವಿಕೆಯು ಅತಿ ಹೆಚ್ಚಿನ ಧನಾತ್ಮಕ ಪರಿಣಾಮವನ್ನು ಹೊಂದಿರುವುದಾಗಿ ತಿಳಿದು ಬಂದಿತು. ನಂತರದ ಸ್ಥಾನದಲ್ಲಿ ಪೂರ್ವ-ಪಶ್ಚಿಮ ದಿಕ್ಕಿನಲ್ಲಿ ಸಸ್ಯ ಹರಡುವಿಕೆ, ಪ್ರತಿಶತ 50 ಗಿಡಗಳ ಹೂ ಬಿಡಲು ತೆಗೆದುಕೊಳ್ಳುವ ದಿನಗಳು ಮತ್ತು ಪ್ರಾಥಮಿಕ ಕವಲುಗಳ ಸಂಖ್ಯೆಗಳಿರುವುದಾಗಿ ಕಂಡುಬಂದಿತು.

(ಪ್ರಭು ಸಿ. ಹಳ್ಳಿಕೇರಿ)

(ಮುನಿಕೃಷ್ಣಪ್ಪ ಪಿ.ಎಂ.)

ಮುಖ್ಯ ಸಲಹೆಗಾರರು

## CONTENTS

<b>Sl. No.</b>	<b>Particulars</b>	<b>Page No.</b>
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-26
III	MATERIAL AND METHODS	27-38
IV	EXPERIMENTAL RESULTS	39-66
V	DISCUSSION	67-81
VI	SUMMARY	82-84
VII	REFERENCES	85-97
	APPENDIX	

## LIST OF TABLES

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
1.	Silent features of China aster genotypes used in the study	28
2.	Mean performance of twenty eight genotypes of China aster for vegetative characters	40
3.	Mean performance of twenty eight genotypes of China aster for flowering and quality characters	43
4.	Mean performance of twenty eight genotypes of China aster for yield characters	47
5.	Mean, range, variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance for vegetative and flowering traits in China aster	50
6.	Mean, range, variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance for quality and yield traits in China aster	51
7.	Estimate of genotypic correlation ( $r_g$ ) among different characters in China aster	54
8.	Estimate of phenotypic correlation ( $r_p$ ) among different characters in China aster	56
9.	Direct (diagonal) and indirect effects of different traits on flower yield per plant at genotypic level	60
10.	Direct (diagonal) and indirect effects of different traits on flower yield per plant at phenotypic level	64

## LIST OF FIGURES

<b>Figure No.</b>	<b>Title</b>	<b>Between Pages</b>
1	Plant height (cm) at 30, 60 and 90 days after transplanting	40-41
2	Plant spread (cm) in East- West and North- South direction	41-42
3	Genotypic and phenotypic co-efficients of variation, heritability and genetic advance as per cent mean for different traits in China aster	51-52

## LIST OF PLATES

<b>Plate No.</b>	<b>Title</b>	<b>Between Pages</b>
1.	Experimental view of the field	27-28
2a.	China aster genotypes used for investigation	30-31
2b.	China aster genotypes used for investigation	30-31
2c.	China aster genotypes used for investigation	30-31

## LIST OF ABBREVIATIONS USED

%	- Per cent	kg	- Kilo Gram
°C	- Degree Celsius	mm	- Millimeter
CD	- Critical difference	m <sup>2</sup>	- Meter square
cm	- Centimetre	mg	- Milli Gram
cm <sup>2</sup>	- Square centimetre	MT	- Million tones
cv.	- Cultivar	S. Em±	- Standard Error of Mean
cvs.	- Cultivars	sq. m	- Square meter
<i>et al.</i>	- Et allii (and others)	t	- Tonnes
<i>etc.</i>	- And so forth	var	- Variety
FYM	- Farm Yard Manure	<i>viz.</i>	- As follows
g	- Gram		
ha	- Hectare		
<i>i.e.</i>	- That is		

# I. INTRODUCTION

China aster [*Callistephus chinensis* (L.) Nees] belongs to one of the largest families of flowering plants, 'Asteraceae'. The genus *Callistephus* has only a single species *i.e.* *Callistephus chinensis*. Its diploid (2n) chromosome number is 18 (Huziware, 1954). It is native to China and is one of the most important annual flower crops grown in most parts of the world. In India, it is grown traditionally for its loose flowers, cut flower and used in arranging vase, floral decorations, making garlands and *venis*. Among annual flowers, it ranks next to chrysanthemum and marigold.

The evolution of China aster was a history of remarkable variations. The present day asters have been developed from a single form of wild species, *Callistephus chinensis*. The name of the genus '*Callistephus*' is derived from two Greek words '*Kalistos*' meaning 'most beautiful' and '*Stephus*', 'a crown' referring to the flower head. The plant was introduced in Europe during 1731 by Jesuit missionary, R. P. d' Incarville (Bailey, 1963). According to Emsweller *et al.* (1937), the original plant had single flowers with two or four rows of blue, violet or white ray florets. The stature was medium tall, 18 to 24 inches in height.

China aster is commercially cultivated in India, France, Germany, Netherlands, U.K., Siberia, Russia, Japan, North America, Switzerland and Europe. In India, it is largely grown on commercial scale in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal. In Karnataka, it is widely grown around Bangalore, Tumkur and Kolar districts.

The genus *Callistephus* has only a single species, namely, *Callistephus chinensis*. The aster bloom contains two kinds of florets: ray florets and disc florets. The most suitable character for the classification of China aster is by the shape of ray florets. The present day varieties are available in diverse forms, types and a wide spectrum of color ranges like pink, primrose, pale blue, mauve, purple, scarlet, creamy white, pure white, violet *etc.* Due to its long vase life, China aster is a popular cut flower, bedding plant and also suitable for herbaceous borders, dwarf cultivars as potted plant suitable for edges and window boxes (Rao *et al.* 2012).

China aster [*Callistephus chinensis* (L.) Nees] is an important annual crop in India and grown throughout the world. The crop is native to China and spread to European countries and other tropical countries during 1731 AD (Desai, 1967).

Though the flower yield and quality are primarily a varietal character, it is also greatly influenced by climatic factors. The climatic factors like photoperiod, temperature, relative humidity and soil moisture influence both vegetative and reproductive phases of the plant, ultimately leading to variation in the performance of cultivars. Hence, plants have to be exposed to proper climatic factors in order to get optimum and economic flower yields. Hence, there is a need for popularization and evaluation of promising China aster cultivars under eastern dry zone of Karnataka.

Before taking crop improvement in any crop species, a thorough knowledge on the amount of genetic variability for various characters existing in the crop is essential. Information on nature and magnitude of variability in the existing plant material and association among the characters is pre-requisites for improvement in the flower yield. The genetic potentialities of yield and yield contributing any type of characteristics and their relationships should be properly assessed for crop improvement. Information on genetic variability, correlation and seed setting in this crop is meager. Studies are useful for the identification of such characters and their association for yield, which can be utilized in breeding programme.

Inheritance of a quantitative characters is often influenced by variation in other characters which may be due to pleiotropy or genetic linkage. Hence, knowledge of association among economic characters and their attributes obtainable through estimation of phenotypic and

genotypic correlations helps in determining the extent of improvement that could be brought about simultaneous selection of more than two characters.

Keeping this in view an investigation on 'Evaluation of China aster [*Callistephus chinensis* (L.) Nees] genotypes for growth, yield and flower quality' was undertaken to address the following objectives.

1. To assess the performance of China aster genotypes for growth, flowering, yield and quality.
2. To estimate the genetic variability among the China aster genotypes.
3. To know the association among the different characters influencing the flower yield.

## II. REVIEW OF LITERATURE

China aster is one of the important popular annual commercial crops grown for its attractive coloured flowers for both loose and cut flowers. The selection of suitable cultivar is an important factor for successful cultivation of China aster. In recent years, several new cultivars of China aster with wide range of colours entered the market. But their performance with respect to growth, flower yield, seed yield and seed quality has differed greatly in different regions. A variety performing well in a particular region may not perform well in other regions because of differences in agro-climatic conditions.

The genetic variability in a crop is of prime importance in its improvement. Knowledge of the existing variability in the crop enables the breeder for further crop improvement. The genetic potentialities of yield and yield contributing characteristics and their relationship should be properly assessed for crop improvement. In China aster, very meagre information is available in the area of genetic studies. Hence, investigation were carried out and earlier work done on flower crops of Asteraceae family are reviewed and presented under the following headings:

2.1 Varietal Performance

2.2 Genetic variability

2.3 Correlation and path coefficient analysis

### 2.1 Varietal performance

#### 2.1.1 China aster

Negi and Raghava (1985) carried out a large number of crosses involving many pure lines having desirable and complementary characters at IIHR, Bangalore. Selections were made in the subsequent generations. Five lines were evaluated and lines 'IIHR-26' and 'IIHR-35' performed better compared to other varieties and have been named as 'Poornima' and 'Violet Cushion'.

Negi *et al.* (1988) evaluated many selections and the line 'IIHR-35' (Violet Cushion) was found to be the best for cut flower and loose flower purpose. While another improved line 'IIHR-19' was best for individual cut flower purpose. Two violet coloured  $F_1$  hybrids from crosses 'IIHR-3' x 'IIHR-19' and 'IIHR-35' x 'IIHR-19' performed better than 'Local Violet'.

Negi and Janakiram (1990) carried out an experiment to produce  $F_1$  hybrids. Crosses were made in 21 parental combinations.  $F_1$  hybrid produced from a cross IIHR-35 x IIHR-19 was found to be promising. An improved line IIHR-19 has been identified with the longest stalk length and it was best for individual cut flower purpose.

Rao *et al.* (1996) evaluated a promising pure line selection (HHR-55) for various quantitative and qualitative traits for three years, which was derived by crossing two pure lines (AST-6 and AST-36) and was developed through pedigree method of breeding and released as variety Kamini.

Angadi (2000) studied the performance of 10 cultivars of China aster. The 'Phule Ganesh' series and the cultivar 'Violet Cushion' were vigorous in growth. The cultivars 'Giant Branching Comet' and 'Ostrich Plume Mixed' were early in flowering, the cultivar 'Phule Ganesh White' produced largest flowers and longest stalk length, maximum flower yield and seed yield with extended vase life. Cultivars 'Poornima', 'Phule Ganesh Purple' and 'Violet Cushion' produced more developed florets.

The performance of China aster cultivars Phule Ganesh Pink, Phule Ganesh White and Phule Ganesh Purple grown under an open field or under 50 per cent shading was determined in a field experiment conducted in Arabhavi, Karnataka, during the summer 2002-03. Plant height, number of primary branches and flowers per plant, flower yield and flower diameter were higher in plants under 50 per cent shading although differences in the number of primary branches and flowers per plant due to the environments were not significant. Differences in the values of the parameters measured were not significant among cultivars (Kulkarni and Reddy 2004).

Kulkarni and Reddy (2006) studied the performance of six China aster cultivars under North Karnataka conditions for four years (1999 to 2003). The cultivar 'Phule Ganesh White' recorded highest plant height (66.40 cm) while the plant spread was observed to be maximum in 'Phule Ganesh Purple' (2749.40 cm<sup>2</sup>). 'Phule Ganesh Violet' produced highest number of primary branches (23.60). The flower yield per plant was maximum in cultivar 'Phule Ganesh White' (327.90 g/plant) which was at par with 'Phule Ganesh Purple' (284.00 g/plant) and 'Phule Ganesh Pink' (249.10 g/plant).

Zosiamlina *et al.* (2012) evaluated seven China aster cultivars to identify suitable cultivars under open conditions of Hyderabad. Among the seven cultivars studied, the results showed a highly significant variation for various growth, floral and flower yield parameters among the cultivars. Cultivar Phule Ganesh Violet produced maximum plant height, number of primary and secondary branches, plant spread and number of leaves at all stages of plant growth.

## 2.1.2 Chrysanthemum

Heidemans and Stolk (1984) evaluated 15 chrysanthemum cultivars for spring culture and reported that the cultivars 'Bright Lameet', 'Impala' and 'Lucky Strike' were the best.

Rajashekaran *et al.* (1985) evaluated 33 chrysanthemum cultivars and found that cultivar MDU-1 flowered late (140 days) as compared to local cultivar (120 days). The plants of this variety was medium in height (42.60 cm) and yielded on an average 92 flowers per plant and the diameter of the flowers was 3.90 cm. It produced the highest yield (30.59 t/ha) as compared to the local check, which has the lowest yield of 26.44 t/ha.

Negi *et al.* (1988) evaluated 12 chrysanthemum varieties along with three local varieties for three years under Bangalore conditions. The varieties exhibited appreciable significant differences for all the vegetative and floral characters. The variety 'Indira' was the earliest to flower (107.97 days), followed by 'IIHR-Sel.5' (114.18 days), while 'IIHR Sel.4' was late flower (140.52 days). In red or pink coloured flower group, the variety 'Red Gold' produced the highest flower yield (419.22 g/plant), followed by 'IIHR-Sel.5' (363.63 g/plant) and were good for loose flower purpose. In white coloured flower group, 'IIHR-Sel.6' gave the highest flower yield.

Tewari and Umashankar (1990) evaluated 12 chrysanthemum varieties. The maximum number of flowers per plant was recorded in cv. 'Maghi' (387.50), followed by 'Jayanti' (108.50), whereas, minimum was recorded in 'Sonali Tara' (16.00). The maximum yield per plant was obtained in the cultivar 'Maghi' (691.81 g), followed by 'Jayanti' (149.00 g), 'Flirt' (131.68 g) and minimum in 'Jaya' (96.50 g). The minimum plant yield was recorded in 'Viva' (18.50 g).

Laskar and Yadav (1991) studied the performance of 14 small flowering chrysanthemum cultivars during 1986-87 at Horticulture Research Station, Mondouri, India for plant growth characters and flower yield. They found that the cvs. 'Basant', 'Jubilee' and 'Alison' produced the highest yield of 71, 63 and 60 lakh flowers per hectare, respectively. Among all the cultivars, 'Basant' was considered to be the best.

Dhiman (2003) studied the performance of eleven different cultivars of chrysanthemum (Thaichung, Fiji, Tata, Century, Ajay, Snow Ball, Sonarbangla, Pink Prince, Mountaineer, Flirt, Johnwebber), among them, Ajay, Flirt and Fiji showed higher flower yield in terms of number and

weight basis with medium size flowers and these are suitable for loose flower production. Large flowering types, namely Pink Prince, Tata Century, Thaichung and Snow Ball are suited for garden display or exhibition purposes.

Kulkarni (2003) conducted varietal evaluation of chrysanthemum, among the varieties, variety Sarval recorded maximum plant height (79.00 cm) whereas, minimum was observed in variety Kirti (36.00 cm). However, the plant spread was higher in the varieties Harvest Home (73.61 cm), Mutant No.9 (65.30 cm) and Selection-5 (65.08 cm).

Baskaran *et al.* (2004) conducted an experiment in Bangalore, University of Agriculture Sciences, GKVK Campus revealed that the tallest plant (54.03 cm) was recorded by cultivar 'Cassa'. 'Red Gold' produced the largest number of number of branches per plant and highest yield. The highest flower diameter (8.14 cm) was observed in cv. 'Ravi Kiran', whereas the lowest (2.07 cm) was recorded in button type Local.

Dilta *et al.* (2005) evaluated 55 chrysanthemum cultivars for flower yield and quality. The highest plant height was observed in cv. 'Gulmohar' (78.83 cm). The cv. 'Surf' recorded the lowest number of days to flowering (89.67) and longest flowering duration (41.87 days). The highest number of flowers per plant was recorded for cv. 'Glance' (65.67) whereas, cv. 'Diamond Jubilee' produced the largest flowers (15.33 cm). The colours of the evaluated cultivars included yellow, mauve, white, red, golden pink, purple, orange and cream.

Talukdar *et al.* (2006) assessed 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 cultivar Cavelia (128.33), whereas, under polyhouse cum rain shelter, the cultivar Stanly Gosling recorded maximum number of leaves per plant (64.67).

Rajivkumar *et al.* (2007) assessed using 24 spray type chrysanthemums for their performance. Maximum plant height (81.00 cm), plant spread (43.60 cm) and stem thickness (4.32 cm) were recorded in cultivar Purple Decorative while maximum leaves per plant (104.00) were noted in cultivar White Decorative. The cultivar Yellow Button produced maximum number of primary branches (11.43) and flowers (190.50) per plant. However, cultivar Rajkumari produced maximum number of secondary branches (51.00) per plant.

### **2.1.3 Marigold**

Nalawadi (1982) evaluated eight marigold varieties of commercial importance for different characters and yield. Among eight varieties, the high yielding varieties were 'Giant Double African Orange' followed by 'Giant Double African Yellow' and 'Cupid Orange' at all the locations and seasons.

In an evaluation study of 24 marigold cultivars for bedding, Howe and Waters (1984) indicated that cvs. 'Toreto', 'Yellow Jacket', 'Spin Wheel', 'Tiger Eyes', 'Gypsy Sunshine', 'Boy O Boy', 'Harvest Moon Improved', 'Yellow Boy' and 'Janie Flame' are the superior ones.

Janakiram and Rao (1991) found highly significant varietal differences in marigold in respect of all characters. The range of plant height in different varieties was 27.55 cm to 68.05 cm. Characters such as days to flower, plant height, flower weight and number of flowers per plant exhibited a high value of heritability.

Vijayalaxmi (1998) evaluated seven dwarf marigold varieties for their performance, early flowering and duration of flowering under northern transitional tract of Karnataka. Among the seven dwarf varieties, 'Yellow Gate' and 'Safari Queen' showed superior performance over other varieties for growth and flower characteristics. 'Disco Red' was the earliest variety to flower followed by 'Yellow Gate' and 'Safari Queen'. The high positive correlation between flowers were

yield and other characteristics like plant height, number of leaves and branches, leaf area, dry matter production, number of flowers per plant and duration of flowering.

Singh *et al.* (2004) conducted an experiment to assess the performance of marigold cultivars. Twelve cultivars each of African marigold (*Tegetes erecta*) and French marigold (*Tegetes patula*) were grown. For French marigold, plant height, number of branches and plant spread were maximum in 'French Spanish Brocade' followed by 'Naughty Marienta' and 'Orange Gate'. The duration of flowering and number of flowers per plant were highest in 'Orange Gate' (64.33 days and 59.6 respectively). For African marigold, the duration of flowering was maximum in 'Excel Mixed' (65.33 days) and minimum in 'SG mixed' (45.43 days). The maximum diameter of lowers at full open stage was 7.87 cm in 'Giant Mixed'.

Singh *et al.* (2008) evaluated 29 lines of African marigold genotypes in Uttarakhand. Among the genotypes, genotype TEG-26 recorded maximum plant height, leaf biomass per plant, flower diameter and seed yield per plant.

Narsude *et al.* (2010) carried out evaluation trail of marigold genotypes in Marathwada condition. Among the genotypes, Pakharsangavi Local significantly recorded maximum plant height, stem girth, maximum number of flowers as compared to other genotypes.

Shivakumar (2014) evaluated fifteen African marigold genotypes to identify suitable genotypes under hill zone of Karnataka. Among the fifteen genotypes studied, the results showed a highly significant variation for various growth and yield parameters among the cultivars. The genotype Nilakkotai Local Orange recorded the maximum flowering duration (86.53), number of flowers per plant (59.40) and flower yield per plant (529.33 g), whereas minimum flowering duration (38.56), number of flowers per plant (20.60) and flower yield per plant (120.93 g) was recorded in the genotype Dwarf Yellow.

## 2.1.4 Gerbera

Bhattacharjee (1981) evaluated 31 varieties of *Gerbera jamesoni* in Bangalore for their performance including plant growth and flower yield characters. Number of side shoots produced per plant were maximum in the variety 'White Perfection' (6.60), while minimum was in 'Agnihotri V. P.' (6.00) and 'Dainkiness' (6.00). Number of leaves produced per plants was maximum in 'Himadevi' (70.40), followed by 'Debendras Glory' (53.60), 'Indukumari' (52.40) and 'White Perfection' (53.60). Number of leaves were minimum in variety 'Lady Mary Herbert' (54.00). Number of flowers per plant was maximum in 'Indukumari' (13.40). The lowest numbers of flowers were recorded in variety 'Yellow Mist' (6.40).

Losser (1986) evaluated 44 gerbera cultivars of single, double and semi-double types for their yield, quality and vase life. The highest yield was recorded in cv. 'Joyce' (30 flowers/plants) and the lowest in cv. 'Suzan' (20 flowers/plant). The cv. 'Kabada' produced the highest proportional of Class-I flowers. The cv. 'M-2' recorded the longest vase life of 13 days, while cv. 'Lalazzo' had the shortest vase life with only five days.

Jawaharlal *et al.* (1998) evaluated 49 gerbera Accessions at Yercaud, wherein Accessions GJ-10, GJ-11, GJ-23, GJ-32 and GJ-39 produced flowers with a stalk length of more than 40 cm, Accessions GJ-14, GJ-23, GJ-24 and GJ-46 recorded a flower stalk girth of more than 1.5 cm, while 14 Accessions produced a flower diameter of more than 8 cm. A yield of more than 80 flowers per clump per year was observed in Accessions GJ-23, GJ-27, GJ-29, GJ-35, GJ-45 and GJ-47. Vase life ranged from 3.95 days (GJ-34) to 8.55 days (GJ-23).

Kandpal *et al.* (2003) evaluated twenty gerbera cultivars for their vegetative and floral characteristics under Tarai conditions. The average number of leaves was highest in DB-113 (48.47) and lowest in Sangria (5.94). Diablo recorded the earliest flower bearing habit. Cut flower stalk length was highest in Alasmeera (63.40 cm) and lowest in DB-232 (30.50 cm). Rosabella

and Diablo recorded the highest flower diameter (10.50 cm), whereas DB-113 recorded the lowest (7.10 cm). DB-232 and DB-113 recorded the highest number of flowers per plant. The flower of PG-2 recorded the highest shelf life (23.00 days).

Kumar and Yadav (2005) carried out an investigation in gerbera varieties where cv. Alesmera produced maximum plant height (25.75 cm), ray breadth (0.60 cm) and fresh weight stalk (4.13 g). Maximum number of leaves (52.16) and flowers (25.15) per plants was recorded in cv. Pink Star. Maximum plant spread (78.00), stalk (0.43 cm) and flower diameter (9.80 cm), number of ray florets per flower (157.60), durability of flower (7.80) and fresh weight was observed in cv. Divas Memory. However, longest stalk (44.00 cm) was observed in cv. Jameson Hybrid.

The performance of 28 genotypes of gerbera with respect to growth and yield characters was studied. The varieties were tested qualitatively with regard to flower colour, flower grade and vase life in tap water. During investigation, varieties Sonata, Esmara, Opium, Solem, Devil, Banesa, Verginia, Naome, Diana, Martinque and Maidemoselli were superior over the rest of the varieties under study in terms of flower quality and flower yield and can be recommended for commercial cultivation under naturally ventilated polyhouse conditions (Magar *et al.*, 2010).

Vasudevan and Rao (2010) reported that, out of thirteen genotypes, three genotypes *viz.*, Entourage, Red Explosion and Essence were found to give satisfactory performance based on their quantitative characters. Based on these findings, Entourage, Red Explosion and Essence genotypes of gerbera can be recommended for the commercial cultivation under mid hills of Garhwal Himalaya.

## 2.1.4 Dahlia

Mishra *et al.* (1987) evaluated the twenty-three varieties of dahlia on phenotypic performance and results revealed that the largest variations found in terms of range for plant height (72.60 to 148.40 cm), flower weight (3.60 to 49.00 g), number of flowers per plant (12.30 to 147.10), days to first flowering (102.60 to 129.70 days) and diameter of flower (4.60 to 21.80 cm). Similarly, Choudhary (1987) reported that all the characters showed a considerable range of variation. Maximum variation range was observed for plant height (72.50 to 133.63 cm), number of flowers per plant (13.36 to 51.55), diameter of flower (4.90 to 22.70 cm) and weight of tubers (191.60 to 1278.30 g).

In an evaluation study of twenty dahlia cultivars belongs to three groups *viz.*, A, B and C, comprising of decorative, cactus and pompon type dahlia were studied. Cv. Sel-CBDH-B of ball type group showed good result and was found most promising and suitable for outdoor cultivation (Joshi *et al.*, 1997).

Mishra *et al.* (2001) evaluated the eighteen dahlia genotypes indicated that cv. Monarch Sport was early to bear, had large sized flowers with longest ornamental crop duration and average number of flowers, while cv. Gloriosa Samatal produced maximum number of flowers of smallest size with average bloom life, cv. Kenya White followed by cv. Kenya Gerua had large flowers with late flowering habit.

Growth and flowering performance on twenty-five different cultivars of dahlia were studied to determine some outstanding cultivars for outdoor cultivation by Dhane and Nimbalkar (2002). The cv. Yellow Cactus was found to be the tallest (99.22 cm) and cv. Glory of India produced the highest number of secondary shoots per plant after pinching (8.44). cv. Barbara Marshall had highest number of serrations per leaf or leaflet (33.58). Yellow White Ball took the least number of days for bud appearance (57 days). cv. Purple Gem produced longest flower peduncle (17.78 cm). Flower diameter was widest in cv. Cheroky Beauty (19.11 cm). cv. Black Out had the highest number of ray florets per flower (135.83). Yellow Cactus and Grace cultivars produced the highest number of flowers per plant (10.77 flowers each). Flowers of Cheroky Beauty had the longest vase life in plain water (7.86 days). Of the twenty-five cultivars evaluated,

thirteen cultivars (Swami Madhavanand, White Kenya, Bhikkus Mother, Barbara Marshall, Cherokee Beauty, Bhikus Buddha, Bela, Yellow Ball, Dixcy, Yellow White Ball, My Love, Jyotsna and Yellow Cactus) were the most promising and suitable for outdoor cultivation

A study conducted by Syamal and Kumar (2002) revealed that the range of variation was maximum for plant height (53 to 121 cm), it was low in case of number of branches (3 to 7). The analysis of variance showed highly significant differences among the cultivars for all the characters under studied except number of tubers produced per plant.

## **2.2 Variability**

Genetic variability studies will help the plant breeder to make an efficient selection of genotypes from the available material which can be utilized for further crop improvement.

Genotypic coefficient of variation indicates the relative magnitude of genetic diversity present in the material and helps to compare the genetic variability present for different traits. Phenotype of any plant is influenced by the genotype, environmental and the interaction between the two. Further, the variation in a segregating population is attributed by both heritable and non-heritable components and the variation in a pureline is only by environmental factors (Johansen, 1909).

### **2.2.1 China aster**

An experiment on genetic variability and correlation in China aster was conducted (Rao., 1982). He found high genetic and phenotypic co-efficients of variation for laterals per plant, weight of flower per plant, height of plant and number of main branches per plant. High heritability values with high genetic advance were obtained for weight of flowers and number of ray florets per head. Number of flowers per plant exhibited positive and significant relationship with height of plants, spread of plants, length of stalk, number of main branches per plant, number of laterals per plant and days to flowering. Spread and height of plants were major factors directly influencing length of stalks. Size of flower was found to be influenced directly by length of stalks, number of ray flowers per flower head and spread of plants. Whereas, height and length of stalk of plants exhibited high total indirect effect on number of flowers per plant.

Negi *et al.*, (1983) conducted experiment on variability and correlation studies in 19 varieties of China aster. Flower weight and stalk length showed high genotypic coefficient of variation, heritability and genetic advance as percentage of mean, which may be attributed to additive gene effects. Stalk length and flower weight had positive significant correlation between themselves and with flower size, plant height and days taken to flower. Flower size was observed to have positive significant correlation with plant height and days taken to flower. Number of flowers per plant and days taken to flower showed positive significant association with number of branches per plant.

Rao and Negi (1990) studied variability and heritability on 38 genotypes of China aster with respect to 12 biometric characters. They found highly significant differences among all the genotypes for vegetative and floral characters. The range of plant height was 25.23 cm to 61.37 cm. High heritability values were observed for flower weight, flower size, days to flower, plant spread, stalk length, duration of flowering and stem girth, whereas the heritability was medium for number of flowers, number of laterals and number of main branches per plant.

Raghava and Negi (1994) study carried out on genetic analysis of various quantitative traits in China aster on 12 diverse genotypes. The results revealed that high narrow sense heritability for number of ray florets per flower followed by size of flowers and weight of flowers per plant.

Heritability studies on nine genotypes of China aster by Patil and Rane (1995) showed very high narrow sense heritability estimates for all the 12 characteristics studied. Among them, height of plants, rows of ray florets per flower were of high magnitude suggesting the role of additive genetic component in the expression of these characters. This also indicates that different genotypes can be assessed by their phenotypic expression alone, as the narrow sense heritability estimates were of high magnitude.

Srinivasulu *et al.* (2004) observed significant variations among the different cultivars of China aster. The number of flowers produced per plant was maximum in cultivars Phule Ganesh Pink, Phule Ganesh Violet and Phule Ganesh White and it was minimum in cultivar Kamini. The flower diameter was more in cultivars Phule Ganesh White and Phule Ganesh Pink, whereas less in cultivar Kamini. Stalk length was more in cultivars Phule Ganesh Pink, Phule Ganesh White and it was minimum in cultivar Kamini.

An experiment was conducted to estimate genetic variability, heritability and genetic advance in 20 genotypes of China aster. Results revealed that, high GCV and PCV were recorded for plant height, number of branches, leaves per plant, flower diameter, number of ray and disc florets/flower head, stalk length, and weight of flowers/plant. High heritability was recorded for all growth parameters and yield parameters except for flowering duration (Gayatri *et al.*, 2014).

### **2.2.2 Chrysanthemum**

Barigidad *et al.* (1992) Studies on variability in chrysanthemum results revealed that significant variation among the fifteen genotypes tested for all the characters. PCV and GCV were observed to be high only for diameter of flower disc.

Chaugule (1985) studied variability on chrysanthemum results revealed that high variability for weight of flowers per plant followed by numbers of flowers per plant. He also noticed highest genotypic co-efficient of variation (GCV) and phenotypic coefficient of variation (PCV) for number of flowers per plant.

Ponnuswami *et al.* (1985) conducted experiment on genetic variability in 27 cultivars of chrysanthemum. Genotypic variance were generally lower than phenotypic variance. High GCV and PCV were observed for earliness in flowering, number of flowers per plant and yield of flowers. High heritability was noticed for number of flowers per plant followed by spread of plants. But both had low genetic advance indicating the occurrence of non-additive effect. Earliness in flowering had high heritability with moderately high genetic advance and this traits was less influenced by the environment.

Variability studies on chrysanthemum. High heritability values along with high genetic gain were observed for leaf area, number of flowers per plant and diameter of disc indicating the occurrence of additive gene action. High heritability values with low genetic gain were observed for height of plants and earliness of flowering. (Hemalatha *et al.*, 1992).

Sirodhi and Behera (2000) conducted variability studies on 57 genotypes of chrysanthemum results revealed that higher values always for PCV than for GCV. Higher GCV and PCV values were found for number of flowers per plant followed by number of branches per plant and diameter of discs.

Baskaran (2001) conducted experiment on chrysanthemum results revealed that high GCV for diameter of floral disc followed by number of flowers per plant, length of ray florets and yield of flowers per plant.

### **2.2.3 Marigold**

Janakiram and Rao (1991) studied variability on marigold the results observed high phenotypic and genotypic coefficient of variation in 11 varieties of African marigold for number of laterals per branches, flower size, flower weight and total flower yield per plant.

An experiment conducted on genetic viability, heritability and genetic advance on 12 cultivars of African and French marigold and recorded significant differences in all characteristics studied (Singh and Sen, 2000) High GCV values were observed for dry weight of flowers, yield of flowers per plot and weight of fresh flowers in African marigold. In French marigold, they notice high GCV for yield of flowers per plant, number of flowers per plant and spread of flowers. They notice more variability for all the traits in French marigold than in African marigold.

Nandakishore and Raghava (2001) studied on variability in African marigold the results revealed high range of variation for yields of seed per hectare, weight of flowers per plant and days to flowering. Phenotypic co-efficients of variation indicating high interaction between genotype and environment. High heritability values together with high genetic advance were observed for yield of seeds and yield of flowers per plant whereas, high heritability values with low genetic advance were noticed for days to flowering, diameter of flowers and shelf life of flowers.

A study on 31 accessions of African marigold for yield parameters (Mathad *et al.*, 2003). The phenotypic and genotypic coefficient of variations were recorded higher for the traits like flower yield per plant, flower yield per plot and per hectare, indicating existence of wide range of genetic variability in the germplasm.

Variability and heritability of 24 characters in 15 genotypes of African marigold by (Reena *et al.*, 2005). Results revealed that GCV and PCV were maximum for seed yield. Characters with high GCV and PCV include dry weight of flowers, flower yield, seed vigour and fresh weight of flowers. High heritability along with genetic advance were recorded for character such as number of buds per plant, number of flowers per plant, flower yield and seed vigour.

An experiment conducted on 11 selection of French marigold by (Singh *et al.*, 2008). The results obtained significant differences among all character observed. The French selection -1 exhibited maximum mean performance for flower yield, while minimum was observed in Cherry Red. The coefficient of variation was minimum for number of seeds per head and maximum for number of flowers per plant.

A study conducted by Kavitha and Anburani (2010) involving 30 genotypes and found that the coefficients of variation were maximum for number of flowers per plant, while minimum for dry matter production both at genotypic and phenotypic levels.

### **2.2.3 Gerbera**

Study on variability and heritability in gerbera. Kannan and Ramdas (1990). High genotypic coefficients of variation was noticed for number of suckers per plant and number of leaves per plant, while low GCV were noticed for length and girth of flower stalk. They reported high heritability for number of leaves per plant followed by number of suckers per plant. High heritability values with high genetic advance were noticed for number of leaves per plant and number of lowers per plant.

An experiment conducted on variability in ten gerbera cultivars by Mahanta *et al.* (1998a) in 14 traits. They reported high variability values were obtained for days to visibility of flower bud, days to flower opening and days for full flowering. High heritability with high genetic advance was recorded for advance to flowering. All the traits, except vase life and size of flowers exhibited high broad sense heritability.

Anuradha and Narayanagowda (1999) studied on heritability with genetic advance in gerbera. Observed heritability ranged from 29.05 per cent for number of leaves per plant to 94.39 per cent for weight of ray florets per flower. High heritability with high genetic advance was observed for weight of ray florets per head, diameter of disc, fresh weight of stalk, fresh weight of inflorescence and length of stalk.

Hedge and Gopinath, (2003) reported high heritability noticed for number of leaves per plant, height of plant and weight of flowers. However, high heritability with high genetic advance was obtained for number of leaves per plant and number of ray florets per flower indicating additive gene effects.

Nair and Shiva (2003) conducted experiment on heritability and genetic advance in gerbera. Observed heritability and genetic advance were highest for diameter of flower, number of florets, length of flower stalk and vase life.

High heritability and high genetic advance for number of leaves per plant and number of flowers per plant indicated the presence of additive gene effects in these traits and their amiability for direct selection (Kumari *et al.*, 2011).

An experiment conducted on heritability and genetic advance in 17 genotypes of gerbera for 19 quantitative traits. High heritability coupled with high genetic advance was recorded for leaf breadth and number of suckers/plant/year showed the presence of additive gene action indicated scope of improving these character through selection (Kumar *et al.*, 2012).

## **2.2.4 Dahlia**

An experiment conducted on the phenotypic performance of 23 varieties of dahlia and revealed that largest variation in terms of maximum range were plant height, flower weight, number of flower per plant, days to first flowering and diameter of flower (Mishra *et al.*, 1987).

Mishra *et al.* (2001) studied variability in 18 dahlia genotypes and found that co-efficient of variation were maximum for number of flower per plant both at genotypic and phenotypic levels. Mishra and Saini (1997) studied the genetic variability in twenty varieties of dahlia and noticed wide range of variability for all the character.

An experiment conducted on variability, heritability and genetic advance in some attributes related to yield in 25 dahlia cultivars. The highest variability was recorded for disc floret number per flower. Secondary shoots produced after pinching and flower fresh weight exhibited the highest values for genotypic and phenotypic co-efficient of variation. The GCV was highest for flower fresh weight and lowest for days to bud appearance. The PCV was highest for flower peduncle length and lowest for days to bud appearance (Dhane *et al.*, 2002).

Singh (2003) Studied on variability the results revealed that higher phenotypic and genotypic co-efficient of variation for number of flowers per plant (55.42% and 35.48%, respectively) followed by number of branches per plant (41.46% and 29.53%), fresh weight of flower (37.84% and 33.97%) and number of seeds per flower (33.57% and 24.75%). Narrow difference between phenotypic and genotypic co-efficient of variation were noticed for days to 50 per cent flowering (1.65% and 0.80%) and fresh flower weight (37.84% and 33.97%).

## **2.3 Correlation and path co-efficient analysis**

The improvement of yield is one of the main objectives of any breeding programme. But yield being a complex character which is controlled by large number of character. Hence, it becomes necessary to investigate how these character contribute to yield, *i.e.* to find out how

they are related, the magnitude and direction of association. Such knowledge of correlation will help the plant breeder in planting more efficient breeding programme.

The theory of correlation was presented by Galton (1889) and later elaborated by Fisher (1918) and Wright (1921). The direct observation of phenotypic correlation does not indicate the magnitude or direction of genetic correlation, which presents a true genetic picture of relationship between the genes controlling the character.

The correlation of characters may be due to either genetic linkage or pleiotropy (Harland, 1939). Probably the main cause of genetic correlation is due to pleiotropic effects of genes, *i.e.* some of genes which affect one trait also affect the other. If the correlation is high, then probably pleiotropy is important and if the correlation is low then we might say that the two traits are inherited independently as they are under the control of different sets of genes (Jain, 1982).

The techniques of path coefficient analysis was developed by Wright (1921), as a means of separating direct and indirect contribution of various factors, path coefficient analysis is a standardized partial regression coefficient analysis and as such measures the direct influence into components of direct and indirect effects. Use of this technique requires a cause and effect situation among the variables.

### **2.3.1 China aster**

Rao (1982) reported number of flower per plant exhibited positive and significant relationships with height of plants, spreads of plants, length of stalk, number of main branches per plant, number of laterals per plant and days to flowering in China aster.

In a study conducted with 19 varieties indicated that days taken to flower had positive significant correlation with number of branches per plant, flower size, stalk length and flower weight. Number of flowers per plant had highly significant association with number of branches per plant. Highly significant and positive correlation was also observed between stalk length and flower weight (Negi *et al*, 1983).

Ashwath and Parthasathy (1993) reported number of flowers per plant recorded significant positive correlation with weight of plants, number of laterals per plant and weight of flowers, whereas plant spreads was negatively correlated with plant height.

The study conducted on correlation the results revealed that flower yield had significant positive correlation with diameter of flower and number of flowers per plant. The correlation between weight and number of flowers was positively significant. Both the characters were positively correlated with plant height, days to flowering, days to harvest, plant spread and stalk length at genotypic and phenotypic levels (Ravikumar and Patil, 2003).

The results revealed that number of flowers per plant was positive and significantly correlated 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 positive and significantly associated with dry weight of plant (Srinivasulu *et al.*, 2007).

### **2.3.2 Chrysanthemum**

Chaugule (1985) Conducted experiment on correlation studies the results revealed that weight of flowers per plant had significant positive correlation with plant height, duration of flowering, plant spread, number of branches per plant and shelf life of flowers.

Worked out correlation studies in *Chrysanthemum cinerariifolium* indicated high significant positive correlation between number of flowers per plant and yield per plant. Weight of flowers was negatively correlated with the pyrethrin content (Pandita and Bhan, 1989).

Plant height had positive significant correlation with flowers per plant, flower size and yield of flowers per plant, while size of flower was negatively associated with yield of flowers per plant (Raghava *et al.*, 1992).

Studied correlation and path analysis on 57 genotypes of chrysanthemum by Sirohi and Behera (1999). And reported significant positive correlation between yield of flowers with number of flowers per plant, spread of plants and number of branches per plant. Whereas, diameter of flower was significantly negatively correlated with number of flowers per plant and positively correlated with number of petals per flower. High heritability values with high genetic advance were observed for number of branches per plant, diameter of discs, number of petals per flower and yield of flower per plant. Number of flowers per plant had very high direct effect on the yield of flowers and it also influenced the yield in an indirect way through many traits such as spread of plants, number of branches per plant and diameter of discs while, flower diameter had direct negative effect on flower yield.

Baskaran *et al.* (2004) conducted an experiment in Bangalore, University of Agriculture Sciences; GKVK Campus revealed number of suckers per plant showed positive and significant correlation with number of flowers both at genotypic and phenotypic levels. Plant spread showed negative significant correlation with disc diameter at the genotypic level. Number of flower per plant showed positive non-significant association with number of ray florets.

### **2.3.3 Marigold**

Bhanupratap *et al.* (1999) reported plant spread had significant positive correlation with size and yield of flowers per plant. Whereas, in French marigold, height of plants showed significant positive correlation with number of lateral branches, days to visibility of bud and duration of flowering. Spread of plants had positive correlation with number of flowers per plant.

Naik *et al.* (2004) studied correlation and path analysis in marigold and revealed that genotypic and phenotypic correlation of xanthophyll yield per hectare was found to be positively significant with petals meal yield per hectare, number of flower per plant, flower yield per plant, number of secondary branches, total dry matter production, leaf area, flower size and flower yield per hectare.

Karuppaiah *et al.* (2004) reported yield and its components were generally positive and highly significant correlation with the number of branches per plant, flower head size, flower head weight, number of flower per plant and xanthophyll content.

Number of 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 flower per plant and flower yield showed highest positive direct effect (Mathew *et al.*, 2005).

Singh and Singh (2005) studied correlation and path analysis in marigold and revealed that number of flowers per plant had highly positive significant correlation with number of primary branches per plant and significant negative correlation with days to flowering. Average fresh weight of flower recorded maximum positive direct effect towards number of flowers per plant, whereas number of primary branches per plant showed maximum indirect positive effect.

Reena *et al.* (2005) reported that character such as seed yield per plant, buds per plant and number of flowers per plant showed highly significant correlation with flower yield, while the number of flowers, number of buds and flower yield per plant showed highly significant correlation to seed yield.

Singh and Kumar (2008) studied correlation and path analysis in forty four genotypes of marigold. Significant positive correlation was recorded between number of primary branches per plant, plant spread and number of flowers per plant, days taken to bud initiation and flower diameter, days taken to flowering and weight of seeds per peduncle. Significant but negative correlation was observed between number of primary branches per plant and plant height, plant spread and days taken to flowering, flower duration and number of flower per plant and between flowering duration and flower diameter.

Studied correlation and path analysis indicated that the flower yield per plant was found to be significant and positively correlated with number of branches per plant, flower weight, flower size, number of flowers per plant and xanthophyll content. Days to first flowering showed a negative association with flower yield per plant. Path analysis had shown that number of flowers per plant and xanthophyll content had high positive direct effects. The study indicated that flower diameter, number of flowers per plant and xanthophyll content are important characters in deciding the flower yield per plant. Hence, these characters may be considered as selection indices in marigold breeding programme (Karuppaiah and Kumar, 2010).

### **2.3.4 Gerbera**

Mahanta *et al.* (1998b) studied on correlation and path analysis in 10 genotypes of gerbera and observed highly significant positive association between number of flowers per clump and leaf area. Characteristics like leaf area, girth of stalk and days to flower bud opening could effectively be used in selection programme.

Path analysis studies on gerbera by Anuradha and Narayanagowda (1999) revealed that heritability ranged from 29.05 per cent for number of leaves per plant to 94.39 per cent for weight of ray florets per flower. High heritability with high genetic advance was observed for weight of ray florets per head, diameter of disc, fresh weight of stalk, fresh weight of inflorescence and length of stalk.

Nair and Shiva (2003) studies on correlation and path analysis in gerbera, reported leaf area and diameter of flower head have significant positive correlation with yield of flowers at genotypic level. Plant spread in turn was found to have positive significant correlation with number of leaves per plant, leaf area and diameter of flower head. Number of leaves per plant and leaf area showed positive significant correlation with diameter of flower head at both phenotypic and genotypic levels. This reveals that indirect selection of any one these characters shall lead to concomitant increase in cut flower yield.

Magar *et al.* (2010) reported the number of flowers per plant showed significant positive correlation with number of leaves per plant, leaf area, plant spread and number of suckers per plant at genotypic level. Path coefficient analysis showed that the leaf area had highest direct effect on number of flowers per plant, followed by plant spread and number of leaves per plant and direct selection could be made for these characters for improving yield.

Studies on correlation in 17 genotypes of gerbera for 19 quantitative traits and found that flower diameter showed significant and positive correlation with disc diameter, fresh weight of flower head, stalk length, durability of single flower, ray floret length both at genotypic and phenotypic levels (Kumar *et al.*, 2012).

### **2.3.5 Dahlia**

Thirty-one cultivars and strains of dahlia were studied for correlation. Reported that the number of flowers per plant showed significant genotypic and phenotypic correlation with all the traits except flower longevity at the phenotypic level. Plant height and number of leaves exerted a slight positive effect on the number of flower (Suman *et al.*, 1980).

Studied correlation coefficient and path analysis for different characters in dahlia. Genotypic correlation were of larger magnitude than of phenotypic and environmental levels. Number of flower per plant had positive correlation with flower weight per plant indicated that increase of flower number leads to increased in weight of flowers per plant. The phenotypic correlation observed with plant spread were positively significant with number of flower per plant (Mishra *et al.*, 1987).

Choudhary (1987) reported that the number of tubers per plant was positively and significantly correlated with number of branches per plant and days to first flowering at genotypic level. Plant height, days to first flowering, number of branches per plant and weight of the tubers had positive direct effect on number of tubers per plant. The indirect effect of plant height via diameter of flower was positive and highest in magnitude.

Studied correlation and path analysis in dahlia and reported a highly significant positive association between days to internode length and span of flowering. And highly significant negative association between days to first flowering and total number flowers per plant. Positive correlation of plant height and branches per plant and similarly a non-significant negative association of stem diameter, leaf area, diameter of first flower with total flower per plant was recorded (Beura *et al.*, 1995).

Nimbalkar *et al.* (2004) reported that the number of flowers per plant had highly significant negative correlation with fresh flower weight followed by days to flowering, indicating the dependence of yield on these characters.

### III. MATERIAL AND METHODS

The present investigation on 'Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] genotypes for growth, quality and yield' was carried out in the experimental field of Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru during the period from November 2017 to March 2018. The details of the material, techniques and methodology adopted during the course of experimentation are presented below.

#### 3.1 Geographical location of the experimental site

The experiment was conducted at College of Horticulture, Bengaluru, which is geographically situated at 13<sup>o</sup> 05' Latitude and 77<sup>o</sup> 33' East Longitude.

#### 3.2 Climatic conditions of the experimental site

Bengaluru lies in eastern zone of agro climatic zones of Karnataka. The center is at an altitude of 924 meters above mean sea level. The details of the meteorological data on weather condition that prevailed during the experimentation period are presented in Appendix-I.

#### 3.3 Experimental details

##### 3.3.1 Selection of genotypes

Twenty-eight genotypes of China aster were used for the present investigation. The brief details of the genotypes used are given in Table 1.

##### 3.3.2 Design and experimental layout

(i) Experimental Design	: Randomized Complete Block Design
(ii) Number of replication	: Two
(iii) Number of genotypes	: Twenty-eight
(iv) Number of plant per plot	: 30
(v) Spacing	: 30 cm x 30 cm



**Plate 1. Experimental view of the field**

**Table 1. Salient features of China aster genotypes used in the study.**

<b>Sl. No.</b>	<b>Genotype</b>	<b>Growth habit</b>	<b>Flower colour</b>	<b>Flower form</b>
1	AAC- 1	Erect	Pink	Semi - Double
2	Arka Aadya	Spreading	Pink	Semi – Double
3	Arka Archana	Spreading	White	Semi – Double
4	Arka Kamini	Erect	Pink	Semi – Double
5	Arka Poornima	Semi-erect	White	Powderpuff
6	Arka Shashank	Erect	White	Pompon
7	Arka Violet Cushion	Erect	Violet	Pompon
8	Hulk	Erect	Green White	Semi – Double
9	Local Pink	Erect	Pink	Semi – Double
10	Local Violet	Erect	Violet	Semi – Double
11	Local White	Erect	White	Semi – Double
12	Matsumoto Apricot	Erect	Apricot	Semi – Double
13	Matsumoto Blue	Erect	Blue	Semi – Double
14	Matsumoto Pink	Erect	Pink	Semi – Double
15	Matsumoto Rose	Erect	Deep Red	Semi – Double
16	Matsumoto Scarlet	Erect	Scarlet	Semi – Double
17	Matsumoto White	Erect	White	Semi – Double
18	Namdhari White	Erect	White	Semi – Double
19	PG Pink	Semi-erect	Pink	Semi – Double
20	PG Purple	Semi-erect	Purple	Semi – Double
21	PG Violet	Semi-erect	Violet	Semi – Double
22	PG White	Erect	White	Semi – Double
23	SAT- 1	Erect	Pink	Semi – Double
24	SAT- 2	Erect	Pink	Semi – Double
25	SAT- 3	Erect	Pink	Semi – Double
26	SAT- 4	Erect	Pink	Semi – Double
27	SAT- 5	Spreading	Pink	Pompon
28	SAT- 6	Spreading	Pink	Semi – Double

## **3.4 Cultural Practices**

### **3.4.1 Nursery**

A raised nursery bed of 120 cm x 60 cm with 10 cm in height was prepared. The nursery bed was prepared with fine mixture of sand, red soil and farmyard manure and the beds were first drenched with Captan at 2.5 g/litre of water before sowing the seeds to avoid fungal disease like damping off and seeds were sown in lines at spacing of 10 cm between lines maintaining shallow depth of sowing at 0.5 cm. The plants in nursery bed were watered daily twice for the first 10 days and daily once for the remaining period.

### **3.4.2 Preparation of experimental Site**

The land was brought to a fine tilth by repeated ploughing and harrowing. Entire recommended dose (15 tonnes/ha) of well decomposed farm yard manure was mixed in to the soil at the time of land preparation. A spacing of 0.60 m between replications and 0.30 m between two plots were provided for laying out of bunds, respectively. The entire experimental land was divided into plots measuring 1.2 m x 2.4 m these were totally 30 plants.

### **3.4.3 Transplanting**

Thirty days old healthy and uniformly grown seedlings were transplanted on 13<sup>th</sup> November, 2017 with a spacing of 30 cm x 30 cm, at the rate of one seedling per hill. It was done during evening hours to avoid bright sunlight.

### **3.4.4 Application of manures and fertilizers**

Application of manures and fertilizers in required quantities is important for proper growth, yield and quality of flowers. Well decomposed FYM @ 25 tonnes per hectare was applied at the time of land preparation. A fertilizers dose of nitrogen @ 90 kg, phosphorus @ 60 kg and potash 60 kg per hectare was applied during field preparation and dressing of nitrogen @ 90 kg/ha after 40 days of transplanting (Rao *et al.* 2012).

### **3.4.5 Intercultural operations**

Gap filling was done a week after transplanting. The plots were kept free from weeds by periodic hand weeding. Irrigation were given through drip irrigation at an interval of 3-4 days throughout the period of experimentation, depending on the soil moisture status and climatic condition.

### **3.4.6 Pinching**

Pinching is an important cultural operation for successful production of quality China aster flowers. Pinching was done by removing the growing tip of the crop, 30 days after transplanting. Pinching was done on 13<sup>th</sup> December, 2018 to induce lateral shoots.

### **3.4.6 Earthing up**

Earthing up was done two times *i.e.* at the time of basal and top dressing of fertilizer.

### **3.4.7 Plant protection measures**

Timely and suitable plant protection measures were adopted to protect the experimental plants from the attack of insect pests and diseases. In this crop there was no serious pest and disease observed in the experimental plot except caterpillars which were controlled by spraying dimethoate @ 1.0 ml/litre of water.

### **3.5 Biometrical observation**

The observations were recorded on various parameters of vegetative growth and flower characters. Five randomly tagged plants, leaving the border plants in each plot were used for recording various observations.

#### **3.5.1 Vegetative characters**

Vegetative parameters were recorded at pre-blooming stage.



**AAC-1**



**ARKA AADYA**



**ARKA ARCHANA**



**ARKA KAMINI**



**ARKA SHASHANK**



**ARKA VIOLET CUSHION**



**ARKA POORNIMA**



**HULK**



**LOCAL PINK**



**LOCAL VIOLET**



**LOCAL WHITE**



**MATSUMOTO APRICOT**

**Plate 2a. China aster genotypes used for investigation**



**MATSUMOTO BLUE**



**MATSUMOTO PINK**



**MATSUMOTO ROSE**



**MATSUMOTO SCARLET**



**MATSUMOTO WHITE**



**NAMDHARI WHITE**



**PG PINK**



**PG PURPLE**



**PG VIOLET**



**PG WHITE**



**SAT-1**



**SAT-2**

**Plate 2b. China aster genotypes used for investigation**



**SAT- 3**



**SAT- 4**



**SAT- 5**



**SAT- 6**

**Plate 2c. China aster genotypes used for investigation**

### **3.5.1.1 Plant height (cm)**

The plant height of every tagged plant as measured from the ground level to the tip of the top most flower recorded and recorded in centimetres and average was worked out. This was done at 30, 60, and 90 days after transplanting.

### **3.5.1.2 Plant spread (cm<sup>2</sup>)**

The plant spread was measured by recording spread of plant at full flowering stage from tagged plants from East - West and North – South direction at 30, 60, and 90 and days and the averages were worked out and expressed in cm<sup>2</sup>.

### **3.5.1.3 Number of primary and secondary branches per plant**

The number of main branches arising from the main stem of the tagged plants was counted and recorded as the primary branches and the branches arising from the primaries were counted and recorded as secondary branches. This was done at 30 days, 60 days and 90 days after transplanting to the main field and the average was worked out.

### **3.5.1.4 Plant type**

Visual assessment by a single observation of a group of plants or parts of plants was taken on the basis of DUS guidelines

## **3.5.2 Flowering characters**

### **3.5.2.1 Days to first flowering**

Days taken for the first flower opening was recorded from each plot by counting the days from the date of transplanting to the opening of first flower.

### **3.5.2.1 Days to 50 per cent flowering**

The number of days taken for 50 per cent flowering was recorded from each plot by counting the days from the date of transplanting to the 50 per cent flowers opened.

### **3.5.2.1 Duration of flowering**

Number of days taken from the first flowering to the last flowering was recorded as the total duration of flowering in each plot.

## **3.5.3 Quality characters**

### **3.5.3.1 Flower diameter (cm)**

Diameter of the flower was measured from the distance between one margins of the other across the centre, was recorded at full flowering stage and expressed in centimetres.

### **3.5.3.2 Stalk length (cm)**

The length of the flower stalk was measured from the base of the stalk to top most flower head on the stalk at full flowering stage and was expressed in centimeters.

### **3.5.3.3 Shelf life (days)**

Fully opened flowers were harvested from each plot and kept in paper plates in laboratory condition. Number of days was counted until the flowers lost their marketable quality.

### **3.5.3.4 Vase life (days)**

Fully opened flowers along with stalk were harvested from plot and kept in a conical flask with normal water in a laboratory condition. Total number of days was counted until the cut flowers started wilting in vase.

### **3.5.3.5 Individual flower weight**

After recording the number of flowers per plant, the weight of flowers per plant was recorded in grams using physical balance from tagged plants at full flowering stage and averages were worked out.

## **3.5.4 Yield parameters**

### **3.5.4.1 Number of flowers per plant**

The number of flowers per plant was counted from the five tagged plants from each replication and average was worked out.

### **3.5.4.2 Flower yield per plant**

After recording the number of flowers per plant, all the flowers were weighed separately at every harvest from each plant till the final harvest and the average flower yield per plant was calculated and expressed in grams per plant.

### **3.5.4.3 Flower yield per square meter**

Flower yield per square meter was worked out by totalling the weight of flowers recorded at each plant per square meter of the plot and expressed in kilograms.

### **3.5.4.4 Flower yield per hectare**

Flower yield per hectare was calculated by summing up the flower yield obtained per plot during each harvest and expressed in terms of tonnes.

### **3.5.4.5 Seed yield per plant**

Flowers were harvested from the tagged plants after complete drying. The seeds obtained from these plants were weighed and average weight per plant was worked out and expressed in grams.

### 3.5.4.6 Seed yield per square meter

Seed yield per square meter was calculated by totalling the weight of seeds recorded at each plant per square meter of the plot and expressed in grams.

### 3.5.4.7 Seed yield per hectare

Seed yield per hectare was calculated on the basis of seed weight obtained from each net plot and expressed in kilograms.

## 3.6 Statistical analysis

The data on various biometrical parameters recorded during the period of investigation was subjected to statistical analysis as per the procedure given by Panse and Sukhatme (2002). The results have been presented and discussed at the five per cent probability level.

### 3.6.1 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 source and also provides the basis for test significant (Singh and Choudhary, 1979).

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (2002) using the mean values of random plant in each replication from all treatments to find out the significance of treatment effect.

The model of analysis of variance is given as below.

Source	D.F	SS	MSS	F-cal
Treatments	t-1	Tr.SS	Tr.MS	F = Tr.MS/EMS
Replications	r-1	RSS	RMS	
Error	(r-1) (t-1)	ESS	EMS	
Total	(rt-1)	TSS		

Where,

t = number of treatments (genotypes)

r = number of replications

SS = Sum of square

MSS = Mean sum of square

DF = Degrees of freedom

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

### 3.6.2 Estimation of genetic parameters

#### 3.6.2.1 Genotypic and phenotypic variances

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

$$\text{Phenotypic variance } (\sigma^2_p) = \sigma^2_g + \sigma^2_e$$

### 3.6.2.2 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 coefficient of variation were estimated according to Burton, (1953) based on estimate of genotypic and phenotypic variance

$$\text{Genotypic Co-efficient of Variability (GCV\%)} = \frac{\sqrt{\text{Genotypic variance}}}{\text{Grand mean}} \times 100$$

$$\text{Phenotypic Co-efficient of Variability (PCV\%)} = \frac{\sqrt{\text{Phenotypic variance}}}{\text{Grand mean}} \times 100$$

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

0 – 10%	- Low
10 – 20	- Moderate
20% and above	- High

### 3.6.2.3 Heritability ( $h^2$ ) (%)

Heritability in broad sense for all the characters was computed by the formula suggested by Webber and Moorthy (1952).

$$h^2 = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$$

Heritability was classified as suggested by Robinson *et al.* (1966) as follows.

0 – 30%	- Low
30 – 60	- Moderate
60% and above	- High

### 3.6.2.4 Genetic Advance (GA)

The predicted genetic advance was estimated according to the formula given by Johnson *et al.* (1955).

$$GA = h^2 \times K \times \sigma_p$$

Where,

$h^2$	: Heritability
K	: Standard selection differential (2.06 at 0.05 probability level)
$\sigma_p$	: Phenotypic standard deviation of the trait

Further, the genetic advance as per cent mean was computed by using the following formula

### 3.6.2.5 Genetic advance as per cent mean (GAM)

The expected GA as per cent of mean was estimated as given below

$$\text{GA as per cent of mean} = \frac{\text{GA}}{\text{Grand mean}} \times 100$$

Where,

GA : Genetic advance

The per cent of mean of genetic advance was categorized as suggested by Johnson *et al.* (1955) as follows.

0 – 10%	- Low
10 – 20%	- Moderate
>20%	- High

### 3.6.2.6 Correlation

Genotypic ( $r_g$ ) and phenotypic ( $r_p$ ) coefficient of correlation were estimated by as suggested by Al – Jibouri *et al.* (1958)

$$\text{Genotypic correlation} = r_{xy}(g) = \frac{\text{Co V}_{xy}(G)}{\sqrt{V_x(G) \times V_y(G)}}$$

$$\text{Phenotypic correlation} = r_{xy}(p) = \frac{\text{Co V}_{xy}(P)}{\sqrt{V_x(P) \times V_y(P)}}$$

Where,

CoV<sub>xy</sub> (G) = Genotypic covariance between x and y

CoV<sub>xy</sub> (P) = Phenotypic covariance between x and y

V<sub>x</sub> (G) = Genotypic variance of character x

V<sub>x</sub> (P) = Phenotypic variance of character x

V<sub>y</sub> (G) = Genotypic variance of character y

V<sub>y</sub> (P) = Phenotypic variance of character y

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

### 3.6.2.7 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)

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

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

$$P_{01}r_{1p} + P_{02}r_{2p} + \dots + P_{op} = r_{0p}$$

Where  $P_{01}, P_{02}, \dots, P_{op}$  are the direct path effects of 1, 2, ..., P variables between dependent variable and independent variables and  $r_{01}, r_{02}, \dots, r_{0p}$  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  $P_{oj} \times r_{ij}$ .

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

$$P_{ox}^2 = 1 (P_{01}^2 + 2P_{01} P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \dots P_{02}^2 + 2P_{02} + 2P_{02} P_{03}r_{23} + \dots P_{0p}^2)$$

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

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

## IV. EXPERIMENTAL RESULTS

The present investigation was carried out involving twenty-eight genotypes of China aster on “Evaluation of China aster [*Callistephus chinensis* (L.) Nees] genotypes for growth, yield and flower quality” parameters are presented under the following headings.

4.1 Vegetative parameters

4.2 Flowering characters

4.3 Quality characters

4.4 Yield parameters

### 4.1 Vegetative parameters

#### 4.1.1 Plant height (cm)

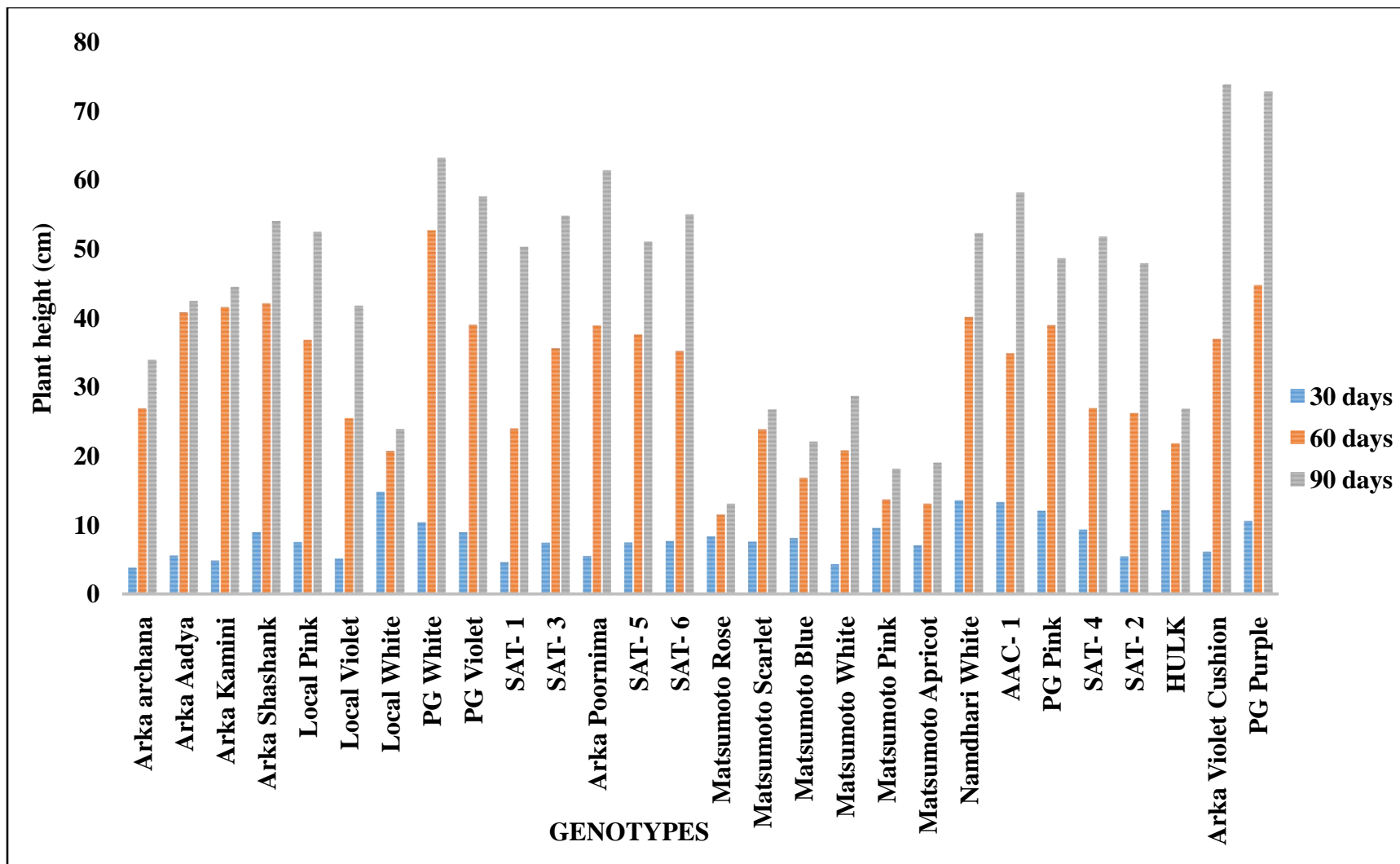
The genotypes varied significantly for plant height at 30, 60 and 90 days after transplanting (Table 2 and Figure 1). The plant height of China aster genotypes at 30 DAT was ranged from 3.78 cm to 14.75 cm. Among the genotypes, cv. Local white recorded significantly maximum plant height (14.75 cm) and it was on par with cv. Namdhari White which recorded plant height of 13.54 cm. Whereas, the least plant height was noticed in cv. Arka Archana (3.78 cm).

At 60 DAT, cv. Phule Ganesh White (52.65 cm) recorded significantly maximum plant height and it was followed by cvs. Phule Ganesh Purple (44.71 cm), Arka Shashank (42.07 cm), Arka Kamini (41.54 cm), Arka Aadya (40.79 cm) and Namdhari White (40.11 cm) and cv. Matsumoto Rose (11.50 cm) recorded minimum plant height.

The plant height at 90 DAT varied significantly among different cultivars studied and ranging from 13.09 cm to 73.86 cm. The cv. Arka Violet Cushion had significantly highest plant height (73.86 cm) and it was on par with cv. Phule Ganesh Purple (72.82 cm), whereas, the least plant height was noticed in cv. Matsumoto Rose (13.09 cm).

**Table 2. Mean performance of twenty-eight genotypes of China aster for vegetative characters**

Genotype	Plant height (cm)			Plant spread (cm)		No. of primary branches per plant	No. of secondary branches per plant
	30 days	60 days	90 days	(E-W)	(N-S)		
AAC- 1	13.27	34.85	58.17	57.70	50.72	10.50	25.40
Arka Aadya	5.56	40.79	42.47	45.34	42.33	11.50	15.30
Arka Archana	3.78	26.87	33.96	38.05	41.21	10.00	14.00
Arka Kamini	4.84	41.54	44.51	25.29	29.67	10.90	19.70
Arka Poornima	5.49	38.86	61.40	33.87	32.17	7.00	17.10
Arka Shashank	8.92	42.07	54.05	23.24	29.74	10.90	15.80
Arka Violet Cushion	6.13	36.94	73.86	35.89	32.98	19.00	32.50
Hulk	12.09	21.83	26.85	16.58	13.65	8.20	8.90
Local Pink	7.51	36.77	52.46	25.80	30.16	16.70	25.50
Local Violet	5.12	25.45	41.76	18.31	19.90	14.90	24.20
Local White	14.75	20.72	23.89	14.33	20.17	8.90	12.90
Matsumoto Apricot	7.05	13.08	19.04	14.95	14.72	10.20	13.00
Matsumoto Blue	8.11	16.83	22.07	15.28	11.96	7.20	11.20
Matsumoto Pink	9.54	13.71	18.16	13.74	12.67	5.80	9.10
Matsumoto Rose	8.34	11.50	13.09	10.80	14.66	7.90	10.30
Matsumoto Scarlet	7.55	23.85	26.73	13.89	13.95	6.70	10.70
Matsumoto White	4.32	20.78	28.68	16.70	15.34	6.20	8.80
Namdhari White	13.54	40.11	52.27	22.63	22.80	9.50	21.20
PG Pink	12.04	38.94	48.67	45.33	43.94	7.10	11.70
PG Purple	10.55	44.71	72.82	54.28	55.98	11.90	23.30
PG Violet	8.92	38.97	57.62	77.05	73.14	12.10	24.80
PG White	10.37	52.65	63.22	35.93	40.89	12.60	25.60
SAT- 1	4.60	23.98	50.31	34.83	37.04	12.10	21.40
SAT- 2	5.45	26.20	47.95	25.34	30.10	13.20	21.40
SAT- 3	7.40	35.57	54.82	30.17	34.20	15.30	24.40
SAT- 4	9.29	26.91	51.78	27.06	29.09	7.70	16.20
SAT- 5	7.45	37.60	51.08	63.26	68.00	15.40	24.10
SAT- 6	7.64	35.19	55.00	64.90	60.35	16.10	32.70
Mean S. Em±	0.44	1.23	1.45	0.66	1.62	0.85	1.01
CD @ 5 %	1.27	3.55	4.17	1.90	4.66	2.45	2.91



**Fig. 1: Plant height at 30, 60 and 90 days after transplanting in different genotypes of China aster**

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 37.31% and 37.59%, respectively, and high heritability (98.53%) with high genetic advance as per cent mean (76.29%) were observed for plant height at 90 DAT among different genotypes (Table 5).

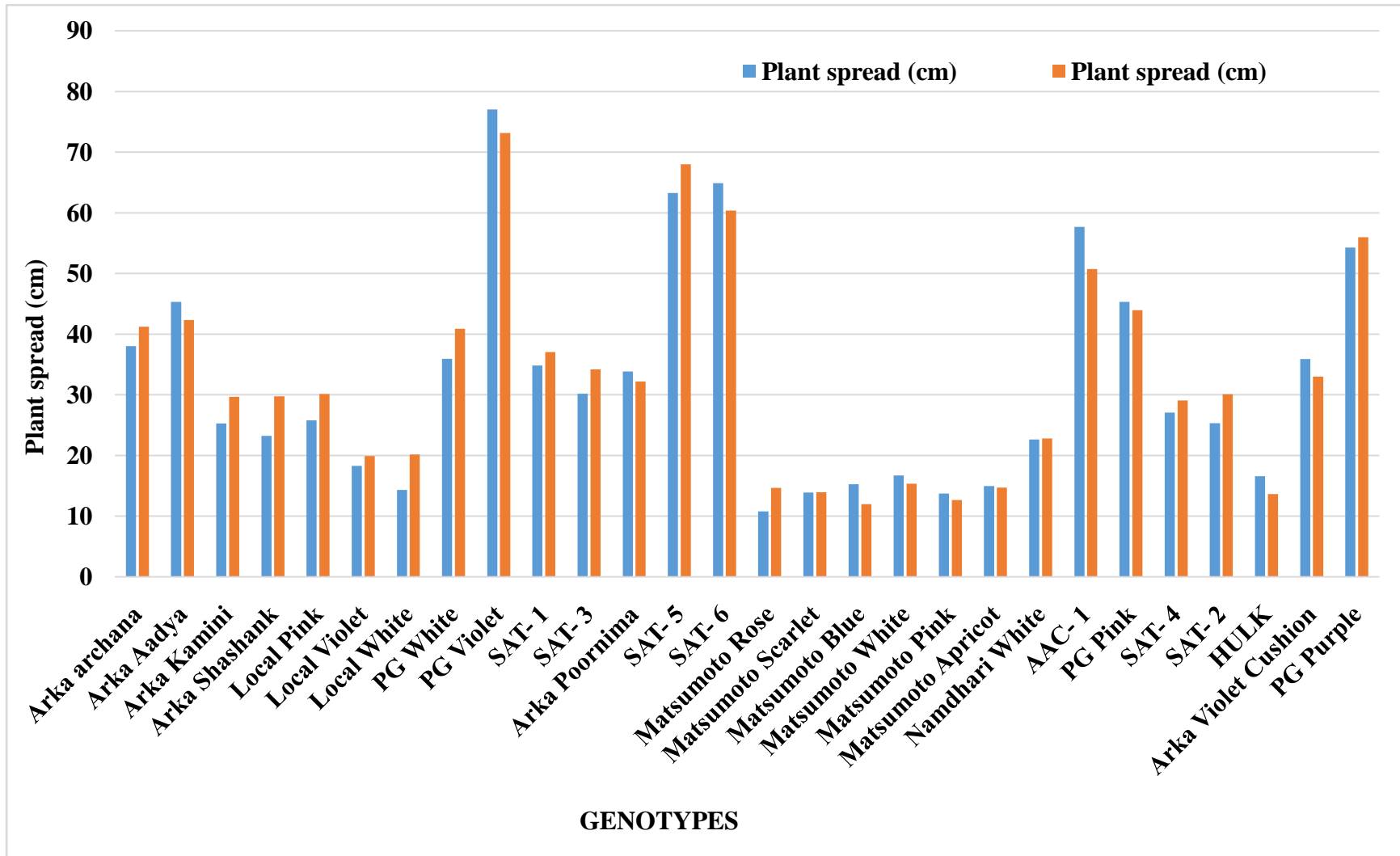
#### **4.1.2 Plant spread (cm<sup>2</sup>)**

Plant spread which was recorded at full flowering stage varied significantly among the China aster genotypes. The plant spread in East – West direction was maximum in Phule Ganesh Violet (77.05 cm), followed by SAT- 6 (64.90 cm) and minimum plant spread was recorded with Matsumoto Rose (10.80 cm). The plant spread in North – South direction was maximum in Phule Ganesh Violet (73.14 cm), followed by SAT- 5 and SAT- 6 which recorded the plant spread of 68.00 cm and 60.35 cm, respectively. The minimum plant spread in North - South direction (11.96 cm) was observed in Matsumoto Blue (Table 2 and Figure 2).

High genotypic and phenotypic co-efficient of variations were recorded for plant spread in East-West direction *i.e.* 55.62% and 55.70%, respectively. High genotypic and phenotypic co-efficient of variation was recorded for plant spread in North-South direction *i.e.* 51.58% and 52.04%, respectively, and high heritability was recorded for plant spread both in East-West and North-South directions *i.e.* 99.73% and 98.24% with high genetic advance as per cent mean (114.43% and 105.32%) was observed (Table 5).

#### **4.1.3 Number of primary and secondary branches per plant**

Significant differences were observed among different China aster varieties for primary and secondary branches produced per plant at full flowering stage. The variety 'Arka Violet Cushion' (19.00) produced maximum number of primary branches per plant. It was on par with cv. 'Local Pink' (16.70). The cv. 'Matsumoto Pink' produced lowest number of primary branches (5.80) per plant. The cvs. 'Matsumoto Rose', 'SAT- 4', 'Matsumoto Blue', 'Phule Ganesh Pink', 'Arka Poornima', 'Matsumoto Scarlet' and 'Matsumoto White' were at par (7.90, 7.70, 7.20, 7.10, 7.00, 6.70 and 6.20, respectively). The highest number of secondary branches (32.70) per plant was recorded by 'SAT- 6'



**Fig. 2: Plant spread in East- West and North- South direction among the different China aster genotypes**

which was statistically on par with 'Arka Violet Cushion (32.50). The lowest number of secondary branches per plant was recorded in cv. 'Matsumoto White' (8.80) while other varieties like 'Hulk' (8.90) and 'Matsumoto Pink' (9.10) were on par with each other for secondary branches (Table 2).

High genotypic and phenotypic co-efficient of variations were recorded for number of primary branches per plant *i.e.* 31.46% and 33.31%, respectively. Similarly, high genotypic and phenotypic co-efficient of variations were also recorded for number of secondary branches per plant *i.e.* 37.46% and 38.23%, respectively, and high heritability was recorded for both number of primary and secondary branches *i.e.* 89.23% and 96.03% with high genetic advance as per cent mean (61.22% and 75.63%) were observed (Table 5).

#### **4.1.4 Plant type**

Visual assessment by a single observation of a group of plants or parts of plants was taken on the basis of DUS guidelines as follows erect type genotypes like AAC-1, Arka Violet Cushion, Hulk, Local Pink, Local Violet, Local White, Matsumoto Apricot, Matsumoto Blue, Matsumoto Pink, Matsumoto Rose, Matsumoto Scarlet, Matsumoto White, Namdhari White, PG White, SAT-1, SAT-2, SAT-3 and SAT-4. And semi-erect genotypes like Arka Poornima, PG Pink, PG Purple and PG Violet. And Spreading type genotypes like Arka Aadya, Arka Archana, SAT-5 and SAT-6 and also presented in table 1.

## **4.2 Flowering characters**

Data pertaining to flowering characters like days taken for first flowering, days taken for 50 per cent flowering and duration of flowering are furnished in table 3.

### **4.2.1 Days taken for the first flowering**

Cultivars varied significantly with respect to days taken for first flowering. The cv. Arka Aadya recorded the least number of days to first flowering (42.90 days), whereas, the cv. 'Phule Ganesh White' took the highest number of days for first

**Table 3. Mean performance of twenty-eight genotypes of China aster for flowering and quality characters**

Genotype	Days to first flowering	Days to 50% flowering	Flowering duration (days)	Flower diameter (cm)	Stalk length (cm)	Shelf life (days)	Vase life (days)	Individual flower weight (g)
AAC- 1	64.70	80.80	35.50	6.44	42.19	3.50	9.00	7.37
Arka Aadya	42.90	49.60	33.70	5.08	30.31	3.50	9.50	3.71
Arka Archana	46.90	62.20	32.00	4.97	27.62	2.50	4.50	2.63
Arka Kamini	75.90	86.60	26.40	6.39	33.09	3.50	8.50	1.94
Arka Poornima	74.30	87.70	29.30	5.22	31.61	3.50	8.00	4.47
Arka Shashank	68.70	78.00	29.70	4.79	26.64	2.50	9.50	2.37
Arka Violet Cushion	83.40	91.70	31.90	5.40	38.76	3.50	9.00	2.10
Hulk	45.20	55.70	21.10	3.85	18.12	3.00	9.00	3.17
Local Pink	63.80	74.90	30.90	5.39	29.14	3.50	7.50	2.51
Local Violet	65.20	72.30	32.50	5.49	27.19	3.50	6.50	4.71
Local White	61.70	72.70	30.80	5.70	21.43	3.50	5.50	2.56
Matsumoto Apricot	56.70	73.80	28.30	3.86	12.84	3.00	7.00	2.72
Matsumoto Blue	45.90	56.60	24.60	3.65	10.25	3.50	6.50	2.11
Matsumoto Pink	55.10	66.90	24.30	3.80	16.41	3.50	7.00	2.44
Matsumoto Rose	55.90	66.00	26.10	3.71	15.22	3.50	7.50	2.27
Matsumoto Scarlet	54.60	73.50	25.80	3.81	17.20	3.50	8.00	2.90
Matsumoto White	55.50	66.60	29.00	3.95	18.44	3.50	6.00	2.63
Namdhari White	54.20	64.20	27.70	5.46	25.43	3.50	8.00	2.84
PG Pink	64.40	70.60	30.30	6.74	24.49	3.50	9.00	5.52
PG Purple	74.10	84.10	30.60	6.31	36.41	3.50	9.00	4.59
PG Violet	64.40	79.20	25.60	6.87	41.90	3.50	9.00	4.36
PG White	84.70	89.20	26.40	7.33	30.91	3.50	9.00	7.42
SAT- 1	57.30	62.10	33.70	5.59	36.30	2.50	8.50	3.02
SAT- 2	74.90	85.20	28.90	6.58	23.03	2.50	8.00	2.99
SAT- 3	58.50	70.90	34.80	6.41	30.68	3.50	8.00	3.33
SAT- 4	61.90	66.70	33.60	5.71	26.20	2.50	9.00	3.99
SAT- 5	55.60	67.70	29.40	6.42	33.36	3.50	9.00	3.05
SAT- 6	55.80	65.80	31.70	5.47	23.28	3.50	9.00	3.55
Mean S. Em±	1.33	1.48	1.27	0.09	1.18	0.47	0.86	0.18
CD @ 5 %	3.81	4.21	3.64	0.26	3.38	1.36	2.49	0.53

flowering (84.70 days) and it was on par with the cv. 'Arka Violet Cushion' (83.40 days) (Table 3).

Moderate genotypic and phenotypic co-efficient of variations were recorded as 17.63% and 17.88%, respectively with high heritability (97.14%) and high genetic advance as per cent mean (35.79%) were noticed for days to first flowering (Table 5).

#### **4.2.2 Days taken to 50 per cent flowering**

The days taken for 50 per cent flowering varied significantly among different China aster cultivars. The cv. Arka Aadya took minimum number of days for 50 per cent of plants to flower (49.60 days) which was followed by cv. 'Hulk' (55.70 days) and other cultivars like 'Matsumoto Blue' (56.60 days), 'SAT- 1' (62.10 days) and 'Arka Archana' (62.20 days) were moderately early to put forth 50 per cent flowering. Whereas, cv. 'Arka Violet Cushion' was late (91.70 days) to reach 50 per cent flowering (Table 3).

Moderate genotypic and phenotypic co-efficient of variations were recorded as 14.66% and 14.94%, respectively with high heritability (96.38%) and high genetic advance as per cent mean (29.65%) were noticed for days to 50% flowering (Table 5).

#### **4.2.3 Duration of flowering**

Significant variation was observed among the different genotypes of China aster for duration of flowering (Table 3). The cv. 'AAC- 1' flowered for a maximum period of 35.50 days and it was on par with cv. 'SAT- 3' (34.80 days). Duration of flowering was minimum in cv. Hulk (21.10 days) and it was on par with cvs. Matsumoto Pink and 'Matsumoto Blue' (24.30 days and 24.60 days, respectively).

Moderate genotypic and phenotypic co-efficient of variations for duration of flowering were recorded as 11.16% and 12.68%, respectively with high heritability (77.42%) and high genetic advance as per cent mean (20.23%) were noticed (Table 5).

### **4.3 Quality characters**

#### **4.3.1 Flower diameter (cm)**

Significant difference was observed among the different genotypes of China aster with respect to flower diameter. It was maximum in cv. Phule Ganesh White (7.33 cm) however, it was on par with cvs. 'Phule Ganesh Violet' (6.87 cm) and 'Phule Ganesh Pink' (6.74 cm), whereas, it was recorded minimum in cv. Matsumoto Blue (3.65 cm) (Table 3).

High genotypic and phenotypic co-efficient of variations were recorded as 20.46% and 20.59%, respectively with high heritability (98.67%) and high genetic advance as per cent mean (41.86%) were noticed for flower diameter in different genotypes (Table 6).

#### **4.3.2 Stalk length (cm)**

Significant difference was observed among the different genotypes of China aster for stalk length (Table 3). It was maximum in cv. AAC- 1 (42.19 cm) and it was on par with cv. Phule Ganesh Violet (41.90 cm), whereas, it was minimum in the cv. Matsumoto Blue (10.25 cm).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 31.56% and 32.15%, respectively, and high heritability (96.34%) with high genetic advance as per cent mean (63.81%) were observed for stalk length in different genotypes (Table 6).

#### **4.3.3 Shelf life (days)**

There is no significant difference was observed among the different cultivars of China aster for shelf life. The shelf life of loose flowers ranged from 2.50 days to 3.50 days (Table 3).

Low genotypic and moderate phenotypic co-efficient of variations were recorded for shelf life as 7.66% and 18.65%, respectively with moderate heritability (40.99%) and moderate genetic advance as per cent mean (15.14%) were noticed (Table 6).

#### **4.3.4 Vase life (days)**

Significant difference was observed among the different cultivars of China aster for vase life. The vase life of cut flower ranged from 4.50 days to 9.50 days (table 3). Highest were recorded for genotypes like Arka Aadya and Arka Shashank. Lowest were recorded in Arka Archana.

Moderate genotypic and phenotypic co-efficient of variations were recorded as 11.92% and 19.31%, respectively with moderate heritability (38.14%) and moderate genetic advance as per cent mean (15.17%) were noticed for shelf life (Table 6).

#### **4.3.5 Individual flower weight (g)**

Significant difference was observed among the different genotypes of China aster for individual flower weight (Table 3). It was maximum in cv. Phule Ganesh White (7.42 g) however, it was on par with cv. AAC- 1 (7.37 g), whereas, it was minimum in the cv. Kamini (1.94 g).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 40.70% and 41.37%, respectively, and high heritability (96.76%) with high genetic advance as per cent mean (82.47%) were observed for individual flower weight among the different genotypes (Table 6).

### **4.4 Yield parameters**

#### **4.4.1 Number of flowers per plant**

The perusal data presented in Table 4 revealed that, the significantly maximum number of flowers were recorded in cv. 'Arka Archana' (70.80) and it was followed by the cvs. like SAT- 5 (64.90), 'Arka Aadya' (63.80), 'Arka Kamini' (60.70). Whereas, cv. Hulk (12.20) recorded minimum number of flowers.

**Table 4. Mean performance of twenty-eight genotypes of China aster for yield characters**

Genotype	No. of flowers per plant	Flower yield			Seed yield		
		Per plant (g)	Per sq. meter (kg)	Per hectare (t/ha)	Per plant (g)	Per sq. meter (g)	Per hectare (t/ha)
AAC- 1	43.00	216.40	2.48	20.75	19.21	211.31	2.11
Arka Aadya	63.80	135.36	1.50	14.95	4.65	51.15	0.51
Arka Archana	70.80	98.88	1.09	10.85	7.82	86.02	0.86
Arka Kamini	60.70	117.86	1.30	12.95	7.67	84.37	0.84
Arka Poornima	38.40	141.52	1.59	16.85	5.57	61.27	0.61
Arka Shashank	50.10	100.79	1.01	8.52	9.22	101.42	1.01
Arka Violet Cushion	52.10	109.13	1.20	11.95	3.93	43.23	0.43
Hulk	12.20	39.00	0.43	4.30	4.49	49.39	0.49
Local Pink	30.70	77.39	0.85	8.45	8.33	94.63	0.87
Local Violet	25.50	119.97	1.33	13.25	5.14	56.54	0.56
Local White	60.50	154.46	1.70	16.95	4.13	45.43	0.45
Matsumoto Apricot	25.60	69.20	0.76	7.60	3.25	35.75	0.35
Matsumoto Blue	20.40	43.55	0.49	4.85	2.56	28.16	0.28
Matsumoto Pink	15.40	37.30	0.41	4.10	2.65	29.15	0.29
Matsumoto Rose	21.40	48.59	0.54	5.35	3.74	41.14	0.41
Matsumoto Scarlet	20.50	59.76	0.66	6.60	3.92	43.12	0.43
Matsumoto White	18.90	49.02	0.54	5.40	4.08	44.88	0.45
Namdhari White	36.60	104.18	1.15	11.45	10.49	115.39	1.15
PG Pink	24.80	136.92	1.50	15.00	4.11	45.21	0.45
PG Purple	39.40	151.19	1.56	17.10	6.79	74.69	0.75
PG Violet	25.80	112.56	1.24	12.35	5.62	61.82	0.62
PG White	21.60	160.36	1.77	17.65	14.27	156.97	1.57
SAT- 1	51.10	154.69	1.71	17.05	7.43	81.73	0.82
SAT- 2	35.80	107.40	1.18	11.80	7.32	80.52	0.80
SAT- 3	47.80	159.31	1.75	17.50	8.93	98.23	0.98
SAT- 4	26.40	105.31	1.16	11.55	4.57	50.27	0.50
SAT- 5	64.90	117.91	1.18	8.75	5.95	53.45	0.53
SAT- 6	38.00	134.99	1.50	14.95	7.87	86.57	0.87
Mean S. Em±	1.56	8.17	0.09	0.90	0.83	9.16	0.09
CD @ 5 %	4.45	23.39	0.26	2.59	2.39	26.24	0.26

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 45.00% and 45.38%, respectively, and high heritability (98.35%) with high genetic advance as per cent mean (91.94%) were observed for number of flowers per plant (Table 6).

#### **4.4.2 Flower yield per plant (g)**

The data on flower yield of different genotypes of China aster presented in Table 11 exhibited significant differences (Table 4). The highest flower yield per plant (216.40 g) was recorded in the cv. AAC- 1 and it was followed by cvs. Phule Ganesh White (160.36 g) and Phule Ganesh Purple (151.19 g), whereas, the cv. Matsumoto Pink recorded least flower yield per plant (37.30 g).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 49.71% and 50.60%, respectively, and high heritability (96.50%) with high genetic advance as per cent mean (100.60%) were observed for flower yield per plant (Table 6).

#### **4.4.3 Flower yield per square meter (kg)**

Difference was significant among the different genotypes of China aster for flower yield per square meter (Table 4). Cv. AAC- 1 (2.48 kg) recorded highest flower yield per square meter, which was followed by cvs. Phule Ganesh White (1.77 kg) and Phule Ganesh Purple (1.56 kg) however, cv. Matsumoto Pink recorded lowest flower yield (0.41 kg).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 49.71% and 50.61%, respectively, and high heritability (96.47%) with high genetic advance as per cent mean (100.58%) were recorded for flower yield per square meter (Table 6).

#### **4.4.4 Flower yield per hectare (tones)**

There was significant difference among the genotypes with respect to flower yield per hectare (Table 4). Highest flower yield per hectare was recorded in the cv. AAC- 1 (20.75 tones) and it was followed by cvs. Phule Ganesh White (17.65 tones) and Phule Ganesh Purple (17.10 tones) while lowest flower yield was in the cv. Matsumoto Pink (4.10 tones).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 49.71% and 50.61%, respectively, and high heritability (96.47%) with high genetic advance as per cent mean (100.58%) were observed for flower yield per hectare (Table 6).

#### **4.4.5 Seed yield per plant (g)**

Significant difference was observed for seed yield per plant (Table 4) in different genotypes of China aster. The highest seed yield per plant was recorded in the cv. AAC- 1 (19.21 g) and it was followed by cvs. Phule Ganesh White (14.27 g) and Namdhari White (10.49 g) whereas, the cv. Matsumoto Blue recorded lowest seed yield per plant (2.56 g).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 56.64% and 59.01%, respectively, and high heritability (92.13%) with high genetic advance as per cent mean (112.00%) were observed for seed yield per plant among the different genotypes (Table 6).

#### **4.4.6 Seed yield per square meter (g)**

Significant difference was observed for seed yield per square meter (Table 4) in different cultivars of China aster. The highest seed yield per plot was recorded in the cv. AAC- 1 (211.31 g) and it was followed by cvs. Phule Ganesh White (156.97 g) and Namdhari White (115.39 g) whereas, the cv. Matsumoto Blue recorded lowest seed yield per square meter (28.16 g).

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 56.64% and 59.01%, respectively, and high heritability (92.13%) with high genetic advance as per cent mean (112.00%) were observed for seed yield per square meter (Table 6).

**Table 5. Mean, range, variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance for vegetative and flowering traits in China aster**

Character	Mean	Range	G.V.	P.V.	G.C.V. (%)	P.C.V. (%)	Heritability (%)	GA	GAM (%)
Plant height at 90 DAT (cm)	44.52	13.09-63.22	275.97	280.10	37.31	37.59	98.53	33.97	76.29
Plant spread in East- West (cm)	32.16	10.80-77.05	320.03	320.89	55.62	55.70	99.73	36.80	114.43
Plant spread in North- South (cm)	32.91	11.96-73.14	288.18	293.33	51.58	52.04	98.24	34.66	105.32
Number of primary branches	10.91	5.80-16.70	11.78	13.21	31.46	33.31	89.23	6.68	61.22
Number of secondary branches	18.61	8.80-32.70	48.63	50.64	37.46	38.23	96.03	14.08	75.63
Days to first flowering	61.51	42.90-84.70	117.52	120.98	17.63	17.88	97.14	22.01	35.79
Days to 50% flowering	72.19	49.60-89.20	112.04	116.25	14.66	14.94	96.38	21.41	29.65
Duration of flowering (days)	29.45	24.30-35.50	10.80	13.95	11.16	12.68	77.42	5.96	20.23

DAT – Days after transplanting

GA – Genetic advance

GCV – Genotypic co-efficient of variation

PCV – Phenotypic co-efficient of variation

GAM – Genetic advance as per cent of mean

GV – Genotypic variance

PV – Phenotypic variance

**Heritability**

Low = 0-30 %

Moderate = 30-60 %

High = >60 %

**GAM**

Low = 0-10 %

Moderate = 10-20 %

High = 20 % and above

**GCV and PCV**

Low = 0-10 %

Moderate = 10-20 %

High = 20 % and above

**Table 6. Mean, range, variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance for quality and yield traits in China aster**

Character	Mean	Range	G.V.	P.V.	G.C.V. (%)	P.C.V. (%)	Heritability (%)	GA	GAM (%)
Flower diameter (cm)	5.37	3.65-7.33	1.21	1.22	20.46	20.59	98.67	2.25	41.86
Stalk length (cm)	26.73	10.25-42.19	71.16	73.87	31.56	32.15	96.34	17.06	63.81
Shelf life (days)	3.29	2.50-3.50	0.16	0.38	7.66	18.65	40.99	0.56	15.14
Vase life (days)	8.00	4.50-9.50	0.91	2.39	11.92	19.31	38.14	1.21	15.17
Individual flower weight (g)	3.47	1.94-7.42	2.00	2.07	40.70	41.37	96.76	2.86	82.47
Number of flowers per plant	37.22	15.40-70.80	280.58	285.28	45.00	45.38	98.35	34.22	91.94
Flower yield per plant (g)	120.46	37.30-316.40	3586.26	3716.23	49.71	50.60	96.50	121.19	100.60
Flower yield per square meter (Kg)	1.33	0.41-3.48	0.43	0.45	49.71	50.61	96.47	1.33	100.58
Flower yield per hectare (tones)	13.26	4.10-34.75	43.48	45.07	49.71	50.61	96.47	13.34	100.58
Seed yield per plant (g)	7.03	2.56-19.21	15.84	17.19	56.64	59.01	92.13	7.87	112.00
Seed yield per square meter (g)	77.28	28.16-211.31	1916.15	2079.74	56.64	59.01	92.13	86.55	112.00
Seed yield per hectare (tones)	0.77	0.28-2.11	0.19	0.21	57.04	59.43	92.11	0.87	112.77

DAT – Days after transplanting  
GA – Genetic advance

GCV – Genotypic co-efficient of variation  
PCV – Phenotypic co-efficient of variation  
GAM – Genetic advance as per cent of mean

GV – Genotypic variance  
PV – Phenotypic variance

**Heritability**

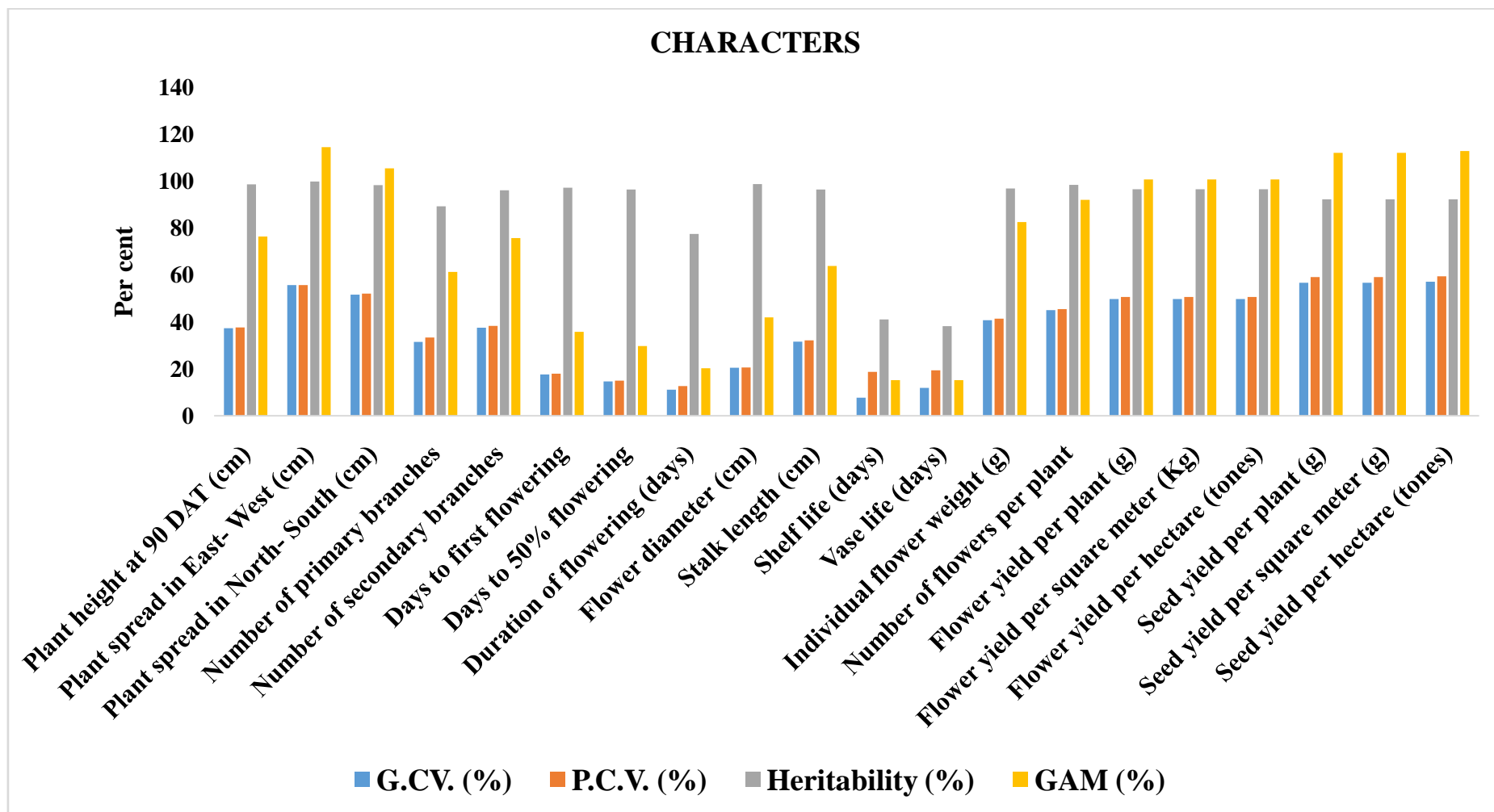
Low = 0-30 %  
Moderate = 30-60 %  
High = >60 %

**GAM**

Low = 0-10 %  
Moderate = 10-20 %  
High = 20 % and above

**GCV and PCV**

Low = 0-10 %  
Moderate = 10-20 %  
High = 20 % and above



**Fig. 3. Genotypic and phenotypic co-efficient of variation, heritability and genetic advance as per cent mean for different traits in China aster**

#### **4.4.7 Seed yield per hectare (tones)**

There was significant difference among the genotypes of China aster with respect to seed yield per hectare (Table 4). The highest seed yield (2.11 tones) per hectare was recorded in the cv. AAC- 1 and it was followed by cvs. Phule Ganesh White (1.57 tones) and Namdhari White (1.15 tones) while, lowest seed yield (0.28 tones) was recorded in the cv. Matsumoto Blue.

High genotypic and phenotypic co-efficient of variations were recorded *i.e.* 57.04% and 59.43%, respectively, and high heritability (92.11%) with high genetic advance as per cent mean (112.77%) were observed seed yield per hectare (Table 6).

### **4.5 Correlation co-efficient**

The genotypic and phenotypic correlation coefficients are presented in Table 7 and 8 respectively. Correlation studies were carried out to understand the intensity and direction of association among the twelve characters namely plant height, plant spread in East- West (cm), plant spread in North- South (cm), number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, flower diameter, stalk length, individual flower weight (g), number of flowers per plant and flower yield per plant (g). The results are presented in different headings.

#### **4.5.1 Genotypic and phenotypic correlations**

In general, genotypic correlation co-efficient were higher than the phenotypic correlation co-efficient among the characters. This indicates the presence of inherent association between various characters (Table 7 and 8).

#### **4.5.2 Plant height (cm)**

The plant height had highly significant and positive correlation with plant spread in East- West (0.652 and 0.647), plant spread in North- South (0.678 and 0.672), number of primary branches per plant (0.617 and 0.575), number of secondary branches per plant (0.810 and 0.789), days to first flowering (0.649 and 0.640), days to 50% flowering (0.560 and 0.555), flower diameter (0.749 and 0.737), stalk length (0.841 and 0.820), individual flower weight (0.463 and 0.458), number of flowers per plant (0.318 and 0.311) and flower yield per plant (0.647 and 0.631) both at genotypic and phenotypic levels, respectively.

#### **4.5.3 Plant spread in East- West (cm)**

The plant spread in East-West had highly significant and positive correlation with plant height (0.652 and 0.647), plant spread in East- West (0.984 and 0.974), number of primary branches (0.443 and 0.417), number of secondary branches (0.621 and 0.603), flower diameter (0.645 and 0.639), stalk length (0.725 and 0.709), individual flower weight (0.483 and 0.475), number of flowers per plant (0.340 and 0.336) and flower yield per plant (0.611 and 0.598) both at genotypic and phenotypic levels, respectively.

#### **4.5.4 Plant spread in North- South (cm)**

Positive and significant correlation was observed in plant spread with plant height (0.678 and 0.672), plant spread in East-West (0.984 and 0.974), number of primary branches (0.504 and 0.466), number of secondary branches (0.642 and 0.628), flower diameter (0.721 and 0.713), stalk length (0.747 and 0.736), individual flower weight (0.449 and 0.445), number of flowers per plant (0.422 and 0.416) and flower yield per plant (0.640 and 0.625) both at genotypic and phenotypic levels, respectively.

#### **4.5.5 Number of primary branches per plant**

Number of primary branches per plant was significant and positively correlated with plant height (0.617 and 0.575), plant spread in East-West (0.443 and 0.417), plant spread in North-South (0.504 and 0.466), number of secondary branches per plant (0.916 and 0.839), days to first flowering (0.369 and 0.355), days to 50% flowering (0.307 and 0.310), flower diameter (0.499 and 0.467), stalk length (0.554 and 0.527), number of flowers per plant (0.409 and 0.406) and flower yield per plant (0.320 and 0.319) both at genotypic and phenotypic levels, respectively.

**Table 7. Estimate of genotypic correlation ( $r_g$ ) among different characters in China aster**

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	0.652**	0.678**	0.617**	0.810**	0.649**	0.560**	0.749**	0.841**	0.463**	0.318*	0.647**
2		1.000	0.984**	0.443**	0.621**	0.155	0.162	0.645**	0.725**	0.483**	0.340*	0.611**
3			1.000	0.504**	0.642**	0.219	0.210	0.721**	0.747**	0.449**	0.422**	0.640**
4				1.000	0.916**	0.369**	0.307*	0.499**	0.554**	0.024	0.409**	0.320*
5					1.000	0.526**	0.484**	0.666**	0.714**	0.311*	0.326*	0.537**
6						1.000	0.957**	0.599**	0.501**	0.346**	0.049	0.381**
7							1.000	0.510**	0.466**	0.290*	0.047	0.371**
8								1.000	0.754**	0.585**	0.361**	0.683**
9									1.000	0.447**	0.506**	0.729**
10										1.000	-0.175	0.623**
11											1.000	0.515**
12												1.000

\*significant at 5% level, \*\* significant at 1% level

1. Plant height at 90 DAT (cm)
2. Plant spread in East- West (cm)
3. Plant spread in North- South (cm)
4. Number of primary branches per plant

5. Number of secondary branches per plant
6. Days to first flowering
7. Days to 50% flowering
8. Flower diameter (cm)

9. Stalk length (cm)
10. Individual flower weight (g)
11. Number of flowers per plant
12. Flower yield per plant (g)

#### **4.5.6 Number of secondary branches per plant**

Number of secondary branches per plant was significant and positively correlated with plant height (0.810 and 0.789), plant spread in East-West (0.621 and 0.603), plant spread in North-South (0.642 and 0.628), number of primary branches per plant (0.916 and 0.839), days to first flowering (0.526 and 0.516), days to 50% flowering (0.484 and 0.463), flower diameter (0.666 and 0.648), stalk length (0.714 and 0.703), individual flower weight (0.311 and 0.296) number of flowers per plant (0.326 and 0.318), and flower yield per plant (0.537 and 0.513) both at genotypic and phenotypic levels, respectively.

#### **4.5.7 Days to first flowering**

Positive and significant correlation was observed in days to first flowering with plant height (0.649 and 0.640), number of primary branches per plant (0.369 and 0.355), number of secondary branches per plant (0.526 and 0.516), days to 50% flowering (0.957 and 0.930), flower diameter (0.599 and 0.584), stalk length (0.501 and 0.492), individual flower weight (0.346 and 0.340) and flower yield per plant (0.381 and 0.372) both at genotypic and phenotypic levels, respectively.

#### **4.5.8 Days to 50% flowering**

Positive and significant correlation was observed in days to 50% flowering with plant height (0.560 and 0.555), number of primary branches per plant (0.307 and 0.310), number of secondary branches per plant (0.484 and 0.463), days to first flowering (0.957 and 0.930), flower diameter (0.510 and 0.500), stalk length (0.466 and 0.459), individual flower weight (0.290 and 0.299) and flower yield per plant (0.371 and 0.372) both at genotypic and phenotypic levels, respectively.

#### **4.5.9 Flower diameter (cm)**

The flower diameter showed positive and highly significant correlation with plant height (0.749 and 0.737), plant spread in East-West (0.645 and 0.639), plant spread in North-South (0.721 and 0.713), number of primary branches per plant (0.499 and 0.467), number of secondary branches per plant (0.666 and 0.648), days to first flowering (0.599

**Table 8. Estimate of phenotypic correlation ( $r_g$ ) among different characters in China aster**

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	0.647**	0.672**	0.575**	0.789**	0.640**	0.555**	0.737**	0.820**	0.458**	0.311*	0.631**
2		1.000	0.974**	0.417**	0.603**	0.153	0.159	0.639**	0.709**	0.475**	0.336*	0.598**
3			1.000	0.466**	0.628**	0.216	0.211	0.713**	0.736**	0.445**	0.416**	0.625**
4				1.000	0.839**	0.355**	0.310*	0.467**	0.527**	0.029	0.406**	0.319*
5					1.000	0.516**	0.463**	0.648**	0.703**	0.296*	0.318*	0.513**
6						1.000	0.930**	0.584**	0.492**	0.340*	0.051	0.372**
7							1.000	0.500**	0.459**	0.299*	0.051	0.372**
8								1.000	0.737**	0.572**	0.357**	0.671**
9									1.000	0.438**	0.503**	0.714**
10										1.000	-0.168	0.626**
11											1.000	0.518**
12												1.000

\*significant at 5% level, \*\* significant at 1% level

1. Plant height at 90 DAT (cm)
2. Plant spread in East- West (cm)
3. Plant spread in North- South (cm)
4. Number of primary branches per plant

5. Number of secondary branches per plant
6. Days to first flowering
7. Days to 50% flowering
8. Flower diameter (cm)

9. Stalk length (cm)
10. Individual flower weight (g)
11. Number of flowers per plant
12. Flower yield per plant (g)

and 0.584), days to 50% flowering (0.510 and 0.500), stalk length (0.754 and 0.737), individual flower weight (0.585 and 0.572), number of flowers per plant (0.361 and 0.357) and flower yield per plant (0.683 and 0.671) both at genotypic and phenotypic levels, respectively.

#### **4.5.10 Stalk length (cm)**

The flower stalk length was found positive and highly significant correlation with plant height (0.841 and 0.820), plant spread in East-West (0.725 and 0.709), plant spread in North-South (0.747 and 0.736), number of primary branches per plant (0.554 and 0.527), number of secondary branches per plant (0.714 and 0.703), days to first flowering (0.501 and 0.492), days to 50% flowering (0.466 and 0.459), flower diameter (0.754 and 0.737), individual flower weight (0.447 and 0.438), number of flowers per plant (0.506 and 0.503) and flower yield per plant (0.729 and 0.714) both at genotypic and phenotypic levels, respectively.

#### **4.5.11 Individual flower weight (g)**

The Individual flower weight showed positive and significant correlation with plant height (0.463 and 0.458), plant spread in East-West (0.483 and 0.475), plant spread in North-South (0.449 and 0.445), number of secondary branches per plant (0.311 and 0.296), days to first flowering (0.346 and 0.340), days to 50% flowering (0.290 and 0.299), flower diameter (0.585 and 0.572), stalk length (0.447 and 0.438), and flower yield per plant (0.623 and 0.626) both at genotypic and phenotypic levels, respectively.

#### **4.5.12 Number of flowers per plant**

The Number of flowers per plant had positive and significant correlation with plant height (0.318 and 0.311), plant spread in East-West (0.340 and 0.336), plant spread in North-South (0.422 and 0.416), number of primary branches per plant (0.409 and 0.406), number of secondary branches per plant (0.326 and 0.318), flower diameter (0.361 and 0.357), stalk length (0.506 and 0.503), and flower yield per plant (0.515 and 0.518) both at genotypic and phenotypic levels, respectively.

#### **4.5.13 Flower yield per plant (g)**

The weight of flowers per plant was positive and significantly correlated with plant height (0.647 and 0.631), plant spread in East-West (0.611 and 0.598), plant spread in North-South (0.640 and 0.625), number of primary branches per plant (0.320 and 0.319), number of secondary branches per plant (0.537 and 0.513), days to first flowering (0.381 and 0.372), days to 50% flowering (0.371 and 0.372), flower diameter (0.683 and 0.671), stalk length (0.729 and 0.714), individual flower weight (0.623 and 0.626) and number of flowers per plant (0.515 and 0.518) both at genotypic and phenotypic levels, respectively.

### **4.6 Path coefficient analysis**

The correlation coefficients only indicate the relationship of independent variable with the dependent variable without specifying cause and effect relationship. Using path coefficient analysis, it is possible to resolve the correlations, which will provide direct and indirect contribution of different quantitative traits. The analysis was done for flower yield per plant as yield, which is dependent variable. Both genotypic and phenotypic paths for the dependent variable were computed. The genotypic and phenotypic path coefficients are presented in Table 9 and 10, respectively.

#### **4.6.1 Genotypic path coefficient analysis for flower yield per plant**

The path analysis of flower yield per plant on weight basis was done with eleven independent characters involving growth, quality, flowering and yield parameters.

#### **4.6.2 Plant height (cm)**

Plant height showed negative direct effect (-0.0333) towards flower yield, further it was recorded positive indirect effect towards days to first flowering (0.0216), days to 50% flowering (0.0187), while it was recorded negative indirect effect with plant spread in East-West (-0.0217), plant spread in North-South (-0.0226), number of primary branches per plant (-0.0206), number of secondary branches per plant (-0.0270), flower diameter (-0.0250), stalk length (-0.0280), individual flower weight (-0.0154) and number of flowers per plant (-0.0106).

#### **4.6.3 Plant spread in East-West (cm)**

Plant spread in East-West showed positive direct effect (0.1292) towards flower yield, further it was recorded positive indirect effect with plant height (0.0843), plant spread in North-South (0.1272), number of primary branches per plant (0.0573), number of secondary branches per plant (0.0803), days to first flowering (0.0200), days to 50% flowering (0.0210), flower diameter (0.0833), stalk length (0.0938), individual flower weight (0.0625) and number of flowers per plant (0.0440).

#### **4.6.4 Plant spread in North-South (cm)**

Plant spread in North-South showed positive direct effect (0.1492) towards flower yield, further it was recorded positive indirect effect with plant spread in East-West (0.1469), number of primary branches per plant (0.0753), number of secondary branches per plant (0.0958), and number of flowers per plant (0.0630), however it recorded negative indirect effect with plant height (-0.1012), days to first flowering (-0.0328), days to 50% flowering (-0.0315), flower diameter (-0.1077), stalk length (-0.1115) and individual flower weight (-0.0670).

#### **4.6.5 Number of primary branches per plant**

Number of primary branches per plant showed positive direct effect (0.0469) towards flower yield, further it was recorded positive indirect effect with plant height (0.0289), plant spread in East-West (0.0208), plant spread in North-South (0.0237), number of secondary branches per plant (0.0430), days to first flowering (0.0173), days to 50% flowering (0.0144), flower diameter (0.0234), stalk length (0.0260), individual flower weight (0.0012) and number of flowers per plant (0.0192).

#### **4.6.6 Number of secondary branches per plant**

Number of secondary branches per plant showed positive direct effect (0.0361) towards flower yield, further it was recorded positive indirect effect with plant spread in

**Table 9. Direct (diagonal) and indirect effects of different traits on flower yield per plant at genotypic level**

	1	2	3	4	5	6	7	8	9	10	11	r <sub>g</sub>
<b>1</b>	<b>-0.0333</b>	-0.0217	-0.0226	-0.0206	-0.0270	0.0216	0.0187	-0.0250	-0.0280	-0.0154	-0.0106	0.647**
<b>2</b>	0.0843	<b>0.1292</b>	0.1272	0.0573	0.0803	0.0200	0.0210	0.0833	0.0938	0.0625	0.0440	0.611**
<b>3</b>	-0.1012	0.1469	<b>0.1492</b>	0.0753	0.0958	-0.0328	-0.0315	-0.1077	-0.1115	-0.0670	0.0630	0.640**
<b>4</b>	0.0289	0.0208	0.0237	<b>0.0469</b>	0.0430	0.0173	0.0144	0.0234	0.0260	0.0012	0.0192	0.320*
<b>5</b>	-0.0292	0.0224	0.0232	-0.0331	<b>0.0361</b>	-0.0190	-0.0175	0.0240	-0.0258	-0.0112	0.0118	0.537**
<b>6</b>	-0.0395	-0.0094	-0.0134	-0.0225	-0.0320	<b>-0.0609</b>	-0.0583	-0.0365	-0.0306	-0.0211	-0.0030	0.381**
<b>7</b>	0.0347	0.0101	0.0130	0.0190	0.0300	0.0592	<b>0.0619</b>	0.0316	0.0289	0.0180	0.0030	0.371**
<b>8</b>	0.0290	0.0250	0.0280	0.0194	0.0258	0.0233	0.0198	<b>0.0388</b>	0.0292	0.0227	0.0140	0.683**
<b>9</b>	0.0043	0.0037	0.0038	0.0028	0.0036	0.0025	0.0024	0.0038	<b>0.0051</b>	0.0023	0.0026	0.729**
<b>10</b>	0.0013	0.0013	0.0012	0.0001	0.0008	0.0009	0.0008	0.0016	0.0012	<b>0.0027</b>	-0.0005	0.623**
<b>11</b>	-0.0012	0.0013	0.0016	0.0015	0.0012	-0.0002	-0.0002	0.0013	-0.0019	0.0007	<b>-0.0037</b>	-0.0019

Residual effect: 0.011; r<sub>g</sub>: Correlation co-efficient with flower yield per plant

Diagonal values are indicating direct effect

1. Plant height at 90 DAT (cm)
2. Plant spread in East- West (cm)
3. Plant spread in North- South (cm)
4. Number of primary branches per plant

5. Number of secondary branches per plant
6. Days to first flowering
7. Days to 50% flowering
8. Flower diameter (cm)

9. Stalk length (cm)
10. Individual flower weight (g)
11. Number of flowers per plant

East-West (0.0224), plant spread in North-South (0.0232), flower diameter (0.0240) and number of flowers per plant (0.0118), however it recorded negative indirect effect with plant height (-0.0292), number of primary branches per plant (-0.0331), days to first flowering (-0.0190), days to 50% flowering (-0.0175), stalk length (-0.0258) and individual flower weight (-0.0112).

#### **4.6.7 Days to first flowering**

Days to first flowering showed negative direct effect (-0.0609) towards flower yield, while it was recorded negative indirect effect with plant height (-0.0395), plant spread in East-West (-0.0094), plant spread in North-South (-0.0134), number of primary branches per plant (-0.0225), number of secondary branches per plant (-0.0320), days to 50% flowering (-0.0583), flower diameter (-0.0365), stalk length (-0.0306), individual flower weight (-0.0211) and number of flowers per plant (-0.0030).

#### **4.6.8 Days to 50% flowering**

Days to 50% flowering showed positive direct effect (0.0619) towards flower yield, while it was recorded positive indirect effect with plant height (0.0347), plant spread in East-West (0.0101), plant spread in North-South (0.0130), number of primary branches per plant (0.0190), number of secondary branches per plant (0.0300), days to first flowering (0.0592), flower diameter (0.0316), stalk length (0.0289), individual flower weight (0.0180) and number of flowers per plant (0.0030).

#### **4.6.9 Flower diameter (cm)**

Flower diameter showed positive direct effect (0.0388) towards flower yield, further it was recorded positive indirect effect with plant height (0.0290), plant spread in East-West (0.0250), plant spread in North-South (0.0280), number of primary branches per plant (0.0194), number of secondary branches per plant (0.0258), days to first flowering (0.0233), days to 50% flowering (0.0198), stalk length (0.0292), individual flower weight (0.0277) and number of flowers per plant (0.0140).

#### **4.6.10 Stalk length (cm)**

Stalk length showed positive direct effect (0.0051) towards flower yield, further it was recorded positive indirect effect with plant height (0.0043), plant spread in East-West (0.0037), plant spread in North-South (0.0038), number of primary branches per plant (0.0028), number of secondary branches per plant (0.0036), days to first flowering (0.0025), days to 50% flowering (0.0024), flower diameter (0.0038), individual flower weight (0.0023) and number of flowers per plant (0.0026).

#### **4.6.11 Individual flower weight (g)**

Individual flower weight showed positive direct effect (0.0027) towards flower yield, further it was recorded positive indirect effect with plant height (0.0013), plant spread in East-West (0.0013), plant spread in North-South (0.0012), number of primary branches per plant (0.0001), number of secondary branches per plant (0.0008), days to first flowering (0.0009), days to 50% flowering (0.0008), flower diameter (0.0016) and stalk length (0.0012), however it recorded negative indirect with number of flowers per plant (-0.0005).

#### **4.6.12 Number of flowers per plant**

Number of flowers per plant showed negative direct effect (-0.0037) towards flower yield, further it was recorded positive indirect effect with plant spread in East-West (0.0013), plant spread in North-South (0.0016), number of primary branches per plant (0.0015), number of secondary branches per plant (0.0012), flower diameter (0.0013) and individual flower weight (0.0007), however it recorded negative indirect effect with plant height (-0.0012), days to first flowering (-0.0002), days to 50% flowering (-0.0002) and stalk length (-0.0019).

## **4.7 Phenotypic path analysis**

### **4.7.1 Plant height (cm)**

Plant height showed negative direct effect (-0.0333) towards flower yield, further it was recorded positive indirect effect with days to first flowering (0.0049) and days to 50% flowering (0.0042), however it recorded negative indirect effect with plant spread in East-West (-0.0049), plant spread in North-South (-0.0051), number of primary branches per plant (-0.0044), number of secondary branches per plant (-0.0060), flower diameter (-0.0056), stalk length (-0.0062), individual flower weight (-0.0035) and number of flowers per plant (-0.0024).

### **4.7.2 Plant spread in East-West (cm)**

Plant spread in East-West showed positive direct effect (0.1292) towards flower yield, further it was recorded positive indirect effect with plant height (0.0045), plant spread in North-South (0.0068), number of primary branches per plant (0.0029), number of secondary branches per plant (0.0042), days to first flowering (0.0011), days to 50% flowering (0.0011), flower diameter (0.0045), stalk length (0.0050), individual flower weight (0.0033) and number of flowers per plant (0.0024).

### **4.7.3 Plant spread in North-South (cm)**

Plant spread in North-South showed positive direct effect (0.0094) towards flower yield, further it was recorded positive indirect effect with plant spread in East-West (0.0092), number of primary branches per plant (0.0044), number of secondary branches per plant (0.0059), and number of flowers per plant (0.0039), however it recorded negative indirect effect with plant height (-0.0064), days to first flowering (-0.0020), days to 50% flowering (-0.0020), flower diameter (-0.0067), stalk length (-0.0070) and individual flower weight (-0.0042).

### **4.7.4 Number of primary branches per plant**

Number of primary branches per plant showed positive direct effect (0.0089) towards flower yield, further it was recorded positive indirect effect with plant height (0.0051), plant spread in East-West (0.0037), plant spread in North-South (0.0042), number of secondary branches per plant (0.0075), days to first flowering (0.0032), days to 50% flowering (0.0028), flower diameter (0.0042), stalk length (0.0047), individual flower weight (0.0003) and number of flowers per plant (0.0036).

**Table 10. Direct (diagonal) and indirect effects of different traits on flower yield per plant at phenotypic level**

	1	2	3	4	5	6	7	8	9	10	11	$r_p$
<b>1</b>	<b>-0.0076</b>	-0.0049	-0.0051	-0.0044	-0.0060	0.0049	0.0042	-0.0056	-0.0062	-0.0035	-0.0024	0.631**
<b>2</b>	0.0045	<b>0.0070</b>	0.0068	0.0029	0.0042	0.0011	0.0011	0.0045	0.0050	0.0033	0.0024	0.598**
<b>3</b>	-0.0064	0.0092	<b>0.0094</b>	0.0044	0.0059	-0.0020	-0.0020	-0.0067	-0.0070	-0.0042	0.0039	0.625**
<b>4</b>	0.0051	0.0037	0.0042	<b>0.0089</b>	0.0075	0.0032	0.0028	0.0042	0.0047	0.0003	0.0036	0.319*
<b>5</b>	-0.0027	0.0021	0.0022	-0.0029	<b>0.0035</b>	-0.0018	-0.0016	0.0022	-0.0024	-0.0010	0.0011	0.513**
<b>6</b>	-0.0075	-0.0018	-0.0025	-0.0041	-0.0060	<b>-0.0116</b>	-0.0108	-0.0068	-0.0057	-0.0040	-0.0006	0.372**
<b>7</b>	0.0073	0.0021	0.0028	0.0041	0.0061	0.0122	<b>0.0131</b>	0.0065	0.0060	0.0039	0.0007	0.372**
<b>8</b>	0.0095	0.0082	0.0092	0.0060	0.0084	0.0075	0.0064	<b>0.0129</b>	0.0095	0.0074	0.0046	0.671**
<b>9</b>	0.0032	0.0027	0.0028	0.0020	0.0027	0.0019	0.0018	0.0029	<b>0.0039</b>	0.0017	0.0019	0.714**
<b>10</b>	0.0056	0.0058	0.0055	0.0004	0.0036	0.0042	0.0037	0.0070	0.0054	<b>0.0123</b>	-0.0021	0.626**
<b>11</b>	-0.0046	0.0049	0.0061	0.0059	0.0047	-0.0007	-0.0008	0.0052	-0.0074	0.0025	<b>-0.0146</b>	0.0076

Residual effect: 0.427;  $r_p$ : Correlation co-efficient with flower yield per plant

Diagonal values are indicating direct effect

1. Plant height at 90 DAT (cm)
2. Plant spread in East- West (cm)
3. Plant spread in North- South (cm)
4. Number of primary branches per plant

5. Number of secondary branches per plant
6. Days to first flowering
7. Days to 50% flowering
8. Flower diameter (cm)

9. Stalk length (cm)
10. Individual flower weight (g)
11. Number of flowers per plant

#### **4.7.5 Number of secondary branches per plant**

Number of secondary branches per plant showed positive direct effect (0.0035) towards flower yield, further it was recorded positive indirect effect with plant spread in East-West (0.0021), plant spread in North-South (0.0022), flower diameter (0.0022) and number of flowers per plant (0.0011), however it recorded negative indirect effect with plant height (-0.0027), number of primary branches per plant (-0.0029), days to first flowering (-0.0018), days to 50% flowering (-0.0016), stalk length (-0.0024) and individual flower weight (-0.0010).

#### **4.7.6 Days to first flowering**

Days to first flowering showed negative direct effect (-0.0116) towards flower yield, while it was recorded negative indirect effect with plant height (-0.0075), plant spread in East-West (-0.0018), plant spread in North-South (-0.0025), number of primary branches per plant (-0.0041), number of secondary branches per plant (-0.0060), days to 50% flowering (-0.0108), flower diameter (-0.0068), stalk length (-0.0057), individual flower weight (-0.0040) and number of flowers per plant (-0.0006).

#### **4.7.7 Days to 50% flowering**

Days to 50% flowering showed positive direct effect (0.0131) towards flower yield, while it was recorded positive indirect effect with plant height (0.0073), plant spread in East-West (0.0021), plant spread in North-South (0.0028), number of primary branches per plant (0.0041), number of secondary branches per plant (0.0061), days to first flowering (0.0122), flower diameter (0.0065), stalk length (0.0060), individual flower weight (0.0039) and number of flowers per plant (0.0007).

#### **4.7.8 Flower diameter (cm)**

Flower diameter showed positive direct effect (0.0129) towards flower yield, further it was recorded positive indirect effect with plant height (0.0095), plant spread in East-West (0.0082), plant spread in North-South (0.0092), number of primary branches per plant (0.0060), number of secondary branches per plant (0.0084), days to first flowering (0.0075), days to 50% flowering (0.0064), stalk length (0.0095), individual flower weight (0.0074) and number of flowers per plant (0.0046).

#### **4.7.9 Stalk length (cm)**

Stalk length showed positive direct effect (0.0039) towards flower yield, further it was recorded positive indirect effect with plant height (0.0032), plant spread in East-West (0.0027), plant spread in North-South (0.0028), number of primary branches per plant (0.0020), number of secondary branches per plant (0.0027), days to first flowering (0.0019), days to 50% flowering (0.0018), flower diameter (0.0029), individual flower weight (0.0017) and number of flowers per plant (0.0019).

#### **4.7.10 Individual flower weight (g)**

Individual flower weight showed positive direct effect (0.0123) towards flower yield, further it was recorded positive indirect effect with plant height (0.0056), plant spread in East-West (0.0058), plant spread in North-South (0.0055), number of primary branches per plant (0.0004), number of secondary branches per plant (0.0036), days to first flowering (0.0042), days to 50% flowering (0.0037), flower diameter (0.0070) and stalk length (0.0054), however it recorded negative indirect with number of flowers per plant (-0.0021).

#### **4.7.11 Number of flowers per plant**

Number of flowers per plant showed negative direct effect (-0.0146) towards flower yield, further it was recorded positive indirect effect with plant spread in East-West (0.0049), plant spread in North-South (0.0061), number of primary branches (0.0059), number of secondary branches (0.0047), flower diameter (0.0052), individual flower weight (0.0025), however it recorded negative indirect effect with plant height (-0.0046), days to first flowering (-0.0007), days to 50% flowering (-0.0008) and stalk length

## V. DISCUSSION

The crop improvement largely depends on the genetic variability. Existence of genetic variability for different characters including quantitative traits has its own significance for survival of crop species in nature.

Genetic variability, its nature and magnitude among the genotypes form a base for any successful breeding and crop improvement programme. It is not just enough if we know the extent of variability, as the extent of heritability and genetic advance present in the crop are important too for a breeder. Without the knowledge of these, the selection would be unfruitful. As we are aware most of the characteristics are inter-related in plants and the selection based on a single characteristic may influence the other traits. Therefore, the method of direct selection based on single characteristics may not be that effective and it necessitates study of inter-relationship among the characteristics for improvement through breeding. Further, correlating yield and other traits may not give a complete idea. Inter-relationship that exist among the traits, which influence the yield directly or indirectly, have to be worked out by path co-efficient analysis.

With this perspective, in the present study, twenty-eight genotypes of China aster were evaluated for twenty parametric characters to estimate phenotypic and genotypic co-efficient of variability, heritability in broad sense and per cent genetic advance as per cent mean. The association among the characters and their direct as well as indirect effect on yield were also computed. And the obtained results are discussed in this chapter.

- 5.1 Genetic components of variation
- 5.2 Character association among different parameters
- 5.3 Path co-efficient analysis

### 5.1 Genetic components of variation

#### 5.1.1 Performance of China aster varieties in terms of growth, flowering, quality and yield parameters

The information on growth, flowering, quality and yield parameters is important in selecting varieties for genetic improvement, as it gives an overall performance of varieties. Mean performance indicated a wide range of variation among the varieties for all the growth, flowering, quality and yield parameters studied.

#### 5.1.2 Vegetative parameters

The varieties differed with respect to vegetative parameters. Plant height was significantly influenced by different cultivars throughout the experimental period. The cv. Arka Violet Cushion was vigorous in growth in terms of plant height. Whereas, the other cvs. like Phule Ganesh White, Arka Poornima, AAC-1 and Phule Ganesh Violet were medium in vigour in terms of plant height. The cv. Matsumoto Rose were recorded minimum plant height. Plant height being a genetically controlled factor, it varied among the cultivars. Similar variation in plant height due to cultivars was also observed in China aster by Rao and Negi (1990), Kulkarni and Reddy (2004), Poornima *et al.* (2006) and Munikrishnappa (2011).

China aster genotypes differed significantly for plant spread. Maximum plant spread per plant towards north to south direction and east to west direction was recorded in the genotype Phule Ganesh Violet. The minimum plant spread per plant in the north to south and east to west direction was recorded with the genotype Matsumoto Rose. The difference in plant spread per plant is a varietal trait and is probably governed by the genetic makeup. These results are in conformity with the results reported earlier

in China aster by Kulkarni and Reddy (2006), Rao and Negi (1990), Ravikumar (2002), Munikrishnappa (2011), Zosiamliaana *et al.* (2012), and Rao *et al.* (2005), Singh and Singh (2006) in marigold.

With respect to the number of branches per plant, the numbers of primary branches produced per plant were maximum in Arka Violet Cushion, while it was recorded minimum in Matsumoto Pink. The differences in the number of primary branches per plant could be attributed to the genetic makeup of the genotypes. As for as secondary branches per plant are concerned, the highest number of secondary branches per plant was recorded by 'SAT- 6' which was statistically on par with cv. 'Arka Violet Cushion'. The lowest number of secondary branches per plant was recorded in cv. 'Matsumoto White' while other varieties like 'Hulk' and 'Matsumoto Pink' were on par with each other with respect to secondary branches per plant. The difference in secondary branches per plant among the cultivars could be due to the influence of genetic makeup of the cultivars. Similar variations for number of branches per plant were also observed in China aster by Rao and Negi (1990), Munikrishnappa (2011), Zosiamliaana *et al.* (2012), and Baskaran *et al.* (2004) in chrysanthemum.

### 5.1.3 Flowering parameters

Flowering parameters including days taken for first flowering, 50 per cent flowering and duration of flowering significantly differed among the China aster cultivars studied.

The days taken for first flowering and 50 per cent flowering were less in cv. Arka Aadya. Hence, these genotypes were said to be early in flowering. Flowering was late in cvs. Phule Ganesh White and Arka Violet Cushion. Duration of flowering was highest in AAC- 1 and lowest was recorded in cv. Hulk. The variations in flower character may be due to genetic trait and may be influence of solar radiation and temperature. Similar findings with respect to this parameter were earlier reported in China aster by Negi *et al.* (1983) Munikrishnappa (2011) and Zosiamliaana *et al.* (2012). Similarly, variations in flowering characters have been reported by Vijayalaxmi (1998) in marigold.

As far as flowering duration is concerned, the cv. AAC- 1 flowered for maximum duration. Whereas, flowering duration was minimum in cvs. Hulk, Matsumoto Pink and Matsumoto Blue. These results are in conformity with the China aster reports of Poornima *et al.* (2006) and Zosiamliaana *et al.* (2012).

### 5.1.4 Quality parameters

Flower quality parameters decide the significance of suitability of the particular cultivars for commercial cultivation. The important biometric characters deciding the size and nature of flowers like flower weight, flower diameter, stalk length and vase life. Significant differences were observed among the cultivars for these flower quality parameters.

Significant difference was observed among different cultivars of China aster with respect to flower diameter. Maximum flower diameter was recorded in the cv. Phule Ganesh White, whereas, minimum flower diameter was recorded in the cv. Matsumoto Blue. The variation in flower diameter may be due to the genotypic expression of the cultivars. These results are in conformity with the results reported earlier in China aster (Poornima *et al.*, 2006, Zosiamliaana *et al.*, 2012 and Choudhary *et al.*, 2016) and chrysanthemum (Dilta *et al.*, 2005).

Cultivars showed significant influence on stalk length during the experimental period. The stalk length was maximum in cvs. AAC-1 and Phule Ganesh Violet. The differences in stalk length among the cultivars might be attributed to the inherent genetic character associated with the cultivars. Similar variation in stalk length was also reported in different cultivars of China aster by Zosiamliaana *et al.* (2012).

There is No significant difference was observed among the different cultivars of China aster for shelf life. The shelf life of loose flower ranged from 2.50 days to 3.50 days (table 3).

Vase life of flowers significantly differed among different cultivars. Maximum vase life was observed in cvs. Arka Shashank and Arka Aadya. Vase life of flower seems to be an inherent capacity of the cultivar. These are in accordance with China aster results of Zosiamliaana *et al.* (2012) and Gayatri *et al.* (2014).

Cultivars showed significant influence on individual flower weight during the experimental period. The individual flower weight was maximum in cvs. AAC-1 and Phule Ganesh White. The differences in individual flower weight among the cultivars might be attributed to the inherent genetic character associated with the cultivars. Similar variation in individual flower weight was also reported in different cultivars of French marigold by Anil *et al.* (2014) and Deepti and Santosh (2008).

### 5.1.5 Yield parameters

Maximum number of flowers per plant was produced in the cv. Arka Archana, while the cv. Hulk produced the least number of flowers per plant. The number of flowers produced per plant may be directly related to production of more number of leaves, plant spread per plant, number of branches per plant, there by synthesis of more photosynthates result in production of good number of developed flower buds on the branches. The similar results were observed in China aster by Munikrishnappa (2011) and Zosiamliaiana *et al.* (2012).

The flower yield per plant, per square meter and per hectare was highest in cv. AAC- 1. The increased flower yield was because of increased number of flowers per plant with high individual flower weight as in case of cv. AAC- 1. The flower yield was less in cv. Matsumoto Pink. Variation in flower yield was also observed previously in China aster (Negi and Raghava, 1985, Munikrishnappa, 2011, Zosiamliaiana *et al.*, 2012) and in chrysanthemum (Chezhian *et al.*, 1985, Laskar and Yadav, 1991).

The highest seed yield per plant, per meter square and per hectare was recorded in the cv. AAC- 1 followed by cvs. Phule Ganesh White and Namdhari White. The cv. Matsumoto Blue recorded the lowest seed yield per plant, per meter square and per hectare. The variation might be due to the cultivar ability to set seeds as it is a genetically controlled factor. The results on yield of seeds were in agreement with the findings of Ravikumar (2002) and Munikrishnappa (2011) in China aster cultivars.

## 5.2 Genetic variability

The genetic improvement of any crop depends mainly on the substantial magnitude of variability in the varieties. To understand the extent to which the observed variations are due to environmental factors and genetic variability, phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were estimated. It is evident from the results that; large amount of variability was noticed for most of the character under study. The character wise details of these variability parameters are discussed below.

Data pertaining to mean, range, variance, genotypic and phenotypic co-efficient of variation, heritability and genetic advance as per cent mean has been presented.

In the present study, the phenotypic co-efficient of variation were higher than the genotypic co-efficient of variation for all the characters, which indicated greater genotype and environment interaction. Similar results were also obtained in China aster (Negi *et al.*, 1983; Ravikumar and Patil, 2003), in dahlia (Singh, 2003), in chrysanthemum (Sirohi and Behera, 1999; Pal and George, 2002), in African marigold (Nandakishore and Raghava, 2001) and (Mishra *et al.*, 2013) in chrysanthemum. Narrow difference between genotypic and phenotypic co-efficient of variation were also recorded for all the characters except shelf and vase life indicating little environmental influence on the expression of character.

The high genotypic co-efficient of variation was recorded for plant height, plant spread per plant in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight, number of flowers per plant, flower yield per plant, flower yield per square meter, flower yield per hectare, seed yield per plant, seed yield per square meter and seed yield per hectare. The moderate genotypic co-efficient of variation was recorded for days to first flowering, days to 50% flowering, vase life and duration of flowering.

The low genotypic co-efficient of variation was recorded for shelf life. The similar results were observed in China aster by Munikrishnappa (2011) and Zosiamliaiana *et al.* (2012).

The characters like plant height, plant spread in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight, number of flowers per plant, flower yield per plant, flower yield per

square meter, flower yield per hectare, seed yield per plant, seed yield per square meter and seed yield per hectare has shown high genotypic co-efficient of variation coupled with narrow difference between the genotypic and phenotypic co-efficient of variation, hence, could be utilized in further breeding programme.

### 5.3 Heritability and genetic advance

The effectiveness of selection for any character depends not only the amount of variability but also on the extent to which the variability is heritable. The magnitude of heritable variability is the most important aspect of the genetic constitution of the breeding material, which has close bearing on the response to selection (Panse, 1957). The genotypic co-efficient of variation together with heritability estimates would give the best picture of the amount of variability was thus determined with the help of broad sense heritability estimates (Burton, 1952). Heritability includes additive, dominant and epistatic genic effects.

Although, heritability estimates are useful while making selection based on phenotype, their use would be limited as they are influenced by the biometrical method adopted, generation of hybrid, sample size of the experimental material and environment. Therefore, heritability along with genetic advance is more useful in predicting the resultant effect of selecting the best individuals (Johnson *et al.*, 1955).

In the present study, the magnitude of heritability in broad sense was high for all the characters except for shelf and vase life (Table 7). The high heritability for most of the quantitative traits has also been reported by Rao (1982), Patil and Rane (1995) and Ravikumar and Patil (2003) in China aster and Kumar *et al.* (2012) in gerbera. Such high heritability estimates have been found to be helpful in making selection of superior genotypes on the basis of phenotypic performance with respect to the quantitative traits (Ravikumar and Patil, 2003) in China aster.

Heritability estimates were ranged from 38.14% (vase life) to 99.73% (Plant spread per plant in East- West). Similar results were also reported by Rao (1982) and Raghava and Negi (1994) in China aster, Talukdar *et al.* (2003) in chrysanthemum, Kumari *et al.* (2011) and Kumar *et al.* (2012) in gerbera, Vikas *et al.* (2011) in dahlia and Sharma and Raghuvanshi (2011) in marigold.

Johnson *et al.* (1995) suggested that, heritability along with genetic advance is more useful in predicting the resultant effect of selecting the best individuals. In the present study, high heritability coupled with high genetic advance as per cent mean was recorded for plant height, plant spread per plant in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, duration of flowering, flower diameter, stalk length, individual flower weight, number of flowers per plant, flower yield per plant, flower yield per square meter, flower yield per hectare, seed yield per plant, seed yield per square meter and seed yield per hectare, indicating the possible role of additive gene action. Thus, these characters can be improved through pure line selection.

High heritability coupled with high genetic advance as per cent mean has also reported for plant height (Ashwath and Parthasarathy, 1993; Patil and Rane, 1995), number of branches per plant (Ashwath and Parthasarathy, 1993), flower diameter (Ashwath and Parthasarathy, 1993, Raghava and Negi, 1994), flower stalk length (Ashwath and Parthasarathy, 1993), flower yield per plant (Rao, 1982; Ashwath and Parthasarathy, 1993; Raghava and Negi, 1994 and Ravikumar and Patil, 2003) in China aster. Number of flowers per plant (Anuja, and Jahnavi, 2012) in French marigold. Talukdar *et al.* (2003) in chrysanthemum, Kumari *et al.* (2011) and Kumar *et al.* (2012) in gerbera, Vikas *et al.* (2011) in Dahlia, and Sharma and Raghuvanshi (2011) in marigold has also been recorded high heritability with high genetic advance in most of the characters. High heritability associated with high genetic advance proves more useful for efficient improvement of character through selection.

### 5.4 Correlation co-efficients

Correlation analysis is a biometrical technique used to find out the nature and degree of associations among various traits. Knowledge of association among the traits is necessary for making indirect selection for improvement of economically important traits. The expression of character in a plant is the sequence of a chain of inter- relationship between characters either directly or through other events. Character association as correlation is a measure of the degree of association prevailing between highly heritable characters with most economic characters and gives better understanding of the contribution of

each trait in building up the genetic makeup of the crop. 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. High positive correlation between the traits indicates that selection for improvement of one characteristics leads to the simultaneous improvement in the other characteristics. Hence, it is of greater significance and could be effectively utilized in formulating and effective selection scheme.

Data pertaining to genotypic and phenotypic correlation coefficient among different characters in China aster is presented.

In the present investigation, the estimates of genetic correlations in general were higher than phenotypic correlation, indicating the presence of inherent association between various characters. In all instances, however, more reliance may be placed on the genotypic correlation. Higher magnitude of genetic correlation co-efficient was observed in China aster (Baweja, 2000; Patil and Rane, 1995), in dahlia (Mishra *et al.*, 1987) and in African marigold (Janakiram and Rao, 1995).

The plant height was highly significant and positively correlated with plant spread in East- West, plant spread in North- South, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, flower diameter, stalk length, individual flower weight and flower yield per plant. Similar results were reported by Negi *et al.* (1983) and Shantappa *et al.* (2015) in China aster, Mukesh *et al.* (2012) in chrysanthemum, Shivakumar, (2014) in marigold and Tarannum and Naik (2014) in carnation.

Plant spread in East- West was highly significant and positively correlated with plant height, plant spread in North- South direction, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight and flower yield per plant. This trend was confirmed by Tarannum and Naik (2014) in carnation, Mathew *et al.* (2005) for plant spread in marigold.

Plant spread in North-South direction had positive and highly significant correlation with plant height, plant spread in East- West direction, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight, number of flowers per plant and flower yield per plant. Similar results were found by Mahesh *et al.* (2015) and Shivakumar *et al.* (2014) in marigold.

Number of primary branches per plant showed positive and highly significant correlation with plant height, plant spread in East- West direction, plant spread in North- South direction, the number of secondary branches per plant, days to first flowering, flower diameter, stalk length and number of flowers per plant. This trend was confirmed by Shantappa *et al.* (2015) in China aster, Tarannum and Naik (2014) for plant spread and flower yield in carnation, Mathew *et al.* (2005) for plant spread per plant and flower yield per plant in marigold and Shivakumar *et al.* (2014) in marigold for number of flowers per plant.

Number of secondary branches per plant showed positive and highly significant correlation with plant height, plant spread per plant in East- West, plant spread per plant in North- South, the number of primary branches per plant, days to first flowering, days to 50% flowering, flower diameter, stalk length and flower yield per plant. This trend was confirmed by Shantappa *et al.* (2015) in China aster, Tarannum and Naik (2014) for plant spread and flower yield in carnation, Mathew *et al.* (2005) for plant spread per plant and flower yield per plant in marigold and Shivakumar, (2014) in marigold for number of flowers.

Days to first flowering had positive and highly significant correlation with plant height, number of primary branches per plant, number of secondary branches per plant, days taken for fifty per cent flowering, flower diameter, stalk length and flower yield per plant. Similar results were found by Negi *et al.* (1983) in China aster.

Days to fifty per cent flowering had highly significant and positive correlation with plant height, number of secondary branches per plant, days to first flowering, flower diameter, stalk length, number of flowers per plant and flower yield per plant. These results are in conformity with Shivakumar, (2014) in marigold.

Flowers diameter showed positive and highly significant correlation with plant height, plant spread in East- West direction, plant spread in North- South direction, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, stalk length, individual flower weight, number of flowers per plant and flower yield per plant. Similar results were reported by Patil and Rane (1995) and Ravikumar and Patil (2003) in China aster, Karuppaiah and Kumar (2010) in marigold.

Stalk length showed positive and highly significant correlation with plant height, plant spread in East- West direction, plant spread in North- South direction, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, flowers diameter, individual flower weight, number of flowers per plant and flower yield per plant. Improvement in flower stalk length can also improve the flower yield. Genotypes with long flower stalk are suitable for cut flowers. There is scope for direct selection of this character. Hedge and Gopinath, (2003) and Ravikumar and Patil (2003) has also reported similar results.

Individual flowers weight has also shown positive significant correlation with flower yield per plant. Similar results were reported by Tarannum and Naik (2014) in carnation.

Number of flower per plant showed positive and highly significant correlation with number of primary branches per plant, number of secondary branches per plant, flowers diameter, stalk length and flower yield per plant. Similar results were reported by Gayatri *et al.* (2014) in China aster and it had negative significant correlation with individual flower weight.

Flower yield per plant showed positive and highly significant correlation with plant height, plant spread in East- West direction, plant spread in North- South direction, number of secondary branches per plant, days to first flowering, days to 50% flowering, flowers diameter, stalk length, individual flower weight and number of flowers per plant. In China aster, Ravikumar and Patil (2003) reported positive correlation of weight of flowers with flower diameter and number of flowers per plant. In chrysanthemum, Chaugule (1985) reported positive and significant correlation with plant height and number of flowers per plant. Baweja (2000) in China aster also reported positive and highly significant correlation of yield with number of flowers and branches per plant. Therefore, direct selection of this character results quality flowers with higher yield.

## 5.5 Path co-efficient analysis

An association between two traits is product of the interaction of direct and indirect causes. Correlation co-efficient measures only the extent of association between any two characteristics but fails to give a complete picture of the other characters involved in the complicated pathway leading to the end point. Thus, correlation co-efficients together with path co-efficients values will be more useful in finding out the character associations.

Path co-efficient analysis furnishes a means of partitioning the direct and the indirect effect through variables and measures, the relative importance of the causal factor involved. The values assigned, to these paths in terms of path co-efficients is defined as the portion of the standard deviation of an independent variable arising as a result of the variation in the dependent variable.

Data pertaining to genotypic and phenotypic path co-efficient among different characters in China aster is presented.

Genotypic path co-efficient analysis for flower yield per plant revealed that the characters namely days to first flowering and days to 50 per cent flowering recorded positive direct effect on flower yield per plant indicating direct selection based on these traits will be rewarding for crop improvement. Whereas, characters like plant height, plant spread in East-West direction, plant spread in North-South direction, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight and number of flowers per plant recorded negative indirect effect on flower yield per plant.

Plant height, plant spread in East- West direction, plant spread in North- South direction, number of primary branches per plant, days to first flowering, days to 50 per cent flowering, flower diameter, stalk length, individual flower weight and number of flowers per plant had significant positive correlation on

flower yield per plant, but its direct effects on flower yield per plant was recorded negative mainly because of high negative indirect effect via days to first flowering. Hence, direct selection based on these characters is not effective. These results were in accordance with the findings of Raghava *et al.* (1992), Sirohi and Behera (1999) in chrysanthemum and Mathad *et al.* (2003) in African marigold.

With regard to indirect effect, it was observed that plant spread in North- South direction, plant spread in East- West direction, days to 50 per cent flowering, number of primary branches per plant, flower diameter, stalk length and individual flower weight. It is suggested that, for selecting genotypes with higher yield, the indirect influence of different traits should be given due weightage along which exerted direct effects.

Path co-efficient analysis for flower yield per plant in the present studies revealed that significant positive correlation between flower yield per plant and plant height, plant spread in East- West direction, spread in North- South direction, days to first flowering, days to 50 per cent flowering, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, number of flowers per plant and individual flower weight are mainly due to direct effect and these traits are important from breeding point of view. Similar effects were obtained in chrysanthemum (Sirohi and Behera, 1999) and in gerbera (Anuradha and Narayanagowda, 2000).

There was direct positive influence on flower yield per plant from plant spread in North- South direction, plant spread in East- West direction, days to 50 per cent flowering, number of primary branches per plant, flower diameter, stalk length and individual flower weight. Similar effects were obtained in chrysanthemum (Sirohi and Behera, 1999).

Days to 50 per cent flowering influences indirectly and positively on flower yield per plant through plant height, plant spread in East-West direction, plant spread in North-South direction, number of primary branches per plant, number of secondary branches per plant, days to first flowering, flower diameter, stalk length, individual flower weight and number of flowers per plant. Days to first flowering indirectly and negatively influenced the flower yield per plant through plant height, plant spread in East-West direction, plant spread in North-South direction, number of primary branches per plant, number of secondary branches per plant, days to 50 percent flowering, flower diameter, stalk length, individual flower weight and number of flowers per plant.

Number of flowers per plant indirectly and positively influenced flower yield per plant through plant spread in East-West direction, plant spread in North-South direction, number of primary branches per plant, number of secondary branches per plant and flower diameter.

## **Future line of work**

Studies on variability in China aster revealed the presence of variability among the genotypes which is an important criterion for selection. Following are the points for future line of work in China aster.

1. The promising characters identified can further be taken for multi-seasonal trials to confirm their superiority.
2. The identified superior traits could be used in China aster hybridization.
3. The characters having highly significant and positive correlation with yield may be used for selection.

## VI. SUMMARY

The present investigation on 'Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] genotypes for growth, quality and yield' in the experimental field of Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru during 2017-2018. With following objectives.

1. To access the performance of China aster genotypes for growth, flowering, yield and quality.
2. To estimate the genetic variability among the China aster genotypes.
3. To know the association among the different characters influencing the flower yield.

The experimental data were subjected to statistical analysis for elucidating the information on genetic variation existing between different components of growth, flowering, yield and quality. The genetic variation was assessed using parameters like genotypic and phenotypic over mean. The inter character association and path analysis was also carried out to know the relationship among various growth and other characters. The results obtained and discussed are summarizing here under:

- In the present study, the phenotypic co-efficient of variation were higher than the genotypic co-efficient of variation for all characters.
- The high genotypic co-efficient of variation was recorded for plant height, plant spread per plant in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight, number of flowers per plant, flower yield per plant, flower yield per square meter, flower yield per hectare, seed yield per plant, seed yield per square meter and seed yield per hectare.
- The magnitude of heritability in broad sense was high for all the characters under study except for shelf life and vase life. Heritability estimates were ranged from 38.14% (vase life) to highest 99.73% (plant spread per plant in East- West).
- High heritability coupled with high genetic advance over mean was recorded for characters like plant height, plant spread per plant in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, flower diameter, stalk length, individual flower weight, number of flowers per plant, flower yield per plant, flower yield per square meter, flower yield per hectare, seed yield per plant, seed yield per square meter and seed yield per hectare.
- In correlation studies the plant height had highly significant and positively correlated with plant spread per plant in East- West, plant spread per plant in North- South, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, flower diameter, stalk length, individual flower weight and flower yield per plant.
- Days to first flower opening had highly significant and positively correlated with plant height, number of secondary branches per plant, days to 50% flowering, flower diameter, stalk length, individual flower weight and flower yield per plant.
- The flower diameter showed highly significant and positive correlation with characters like plant height, plant spread per plant in East-West, plant spread per plant in North-South, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, stalk length, individual flower weight, number of flowers per plant and flower yield per plant.
- The flower stalk length was exhibited highly significant and positively correlated with characters like plant height, plant spread per plant in East-West, plant spread per plant in North-South, number of primary branches per plant, number of secondary branches per plant, days to first flowering, days to 50% flowering, flower diameter, individual flower weight, number of flowers per plant and flower yield per plant.

- The number of flowers per plant was positive and highly significant with characters like plant spread per plant in North-South, number of primary branches per plant, flower diameter, stalk length and flower yield per plant.
- The flower yield per plant was highly significant and positively correlated with characters like plant height, plant spread per plant in East-West, plant spread per plant in North-South, number of secondary branches per plant, days to first flowering, days to 50% flowering, flower diameter, stalk length, individual flower weight and number of flowers per plant.
- In path analysis genotypic path co-efficient analysis for plant spread per plant in North- South, plant spread per plant in East- West recorded maximum positive direct effect on flower yield per plant followed by days to 50% flowering, number of primary branches per plant, flower diameter, stalk length and individual flower weight.
- Plant spread in North-South indirectly positively influences flower yield per plant through plant spread per plant in East-West, number of primary branches per plant, number of secondary branches per plant and number of flowers per plant.

## VII. REFERENCES

- Al-Jibouri, H. A., Miller, P. A. and Robinson, H. F., 1958, Genotypic and environment variances in an upland cotton crops of interspecific origin. *Agron. J.*, 50: 633-634.
- Anil, K., Bhanu, P. and Karma, B., 2014, Studies on genetic variability and character association in French marigold (*Tagetes patula* L.) *Indian J. Hort.*, 7(2): 122-124.
- Anuja, S. and Jahnavi, K., 2012, Variability, heritability and genetic advance studies in French marigold (*Tagetes patula* L.) *Asian J. Hort.*, 7(2): 362-364.
- Anuradha, S. and Narayanagowda, J. V., 1999, Quantitative genetic studies in gerbera. *Mysore J. Agric. Sci.*, 33(2): 224-227.
- Agandi, S. M., 2000, Studies on the performance of China aster [*Callistephus chinensis* (L.) Nees.] cultivars. *M.Sc. Thesis*, Univ. Agric. Sci., Dharwad.
- Ashwath, C. and Parthasarathy, V. A., 1993, Heritability and correlation studies in China aster [*Callistephus chinensis* (L.) Nees.] *Indian J. Hort.*, 50(1): 89-92.
- Bailey, L. H., 1963, The standard Cyclopaedia of Horticulture, Vol. I. The Macmillan Company, New York.
- Barigidad, H., Patil, A. A. and Nalawadi, U.G., 1992, Variability studies in chrysanthemum. *Prog. Hort.*, 24(1-2): 73-78.
- Baskaran, V., 2001, Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cultivars for growth, yield, and vase life. *M. Sc. (Hort.) Thesis*, submitted to Univ. Agric. Sci., Bangalore, India.
- Baskaran, V. Janakiram, T. and Jayanthi, R., 2004, Varietal evaluation in chrysanthemum. *Karnataka J. Hort.*, 1(1): 23-27.
- Baskaran, V. Janakiram, T. and Jayanthi, R., 2004 Correlation and path coefficient analysis studies in chrysanthemum. *J. Orn. Hort.*, 7(3): 44.
- Baweja, H. S., 2000, Correlation studies in China aster. *Indian J. Hill Farming*. 13(1):93-94.
- Beura, S. Maharana, T. and Jagadev, P. N., 1995, Genetic variability and character association in dahlia. *J. Trop. Agric.*, 33: 20-22.
- Bhanupratap, G. N., Tewari. and Jagadev, P. N., 1995, Genetic variability and character association in dahlia. *J. Trop. Agric.*, 33: 20-22.
- Bhanupratap, G. N., Tewari, and Mihra, L. N., 1999, Correlation studies in marigold. *J. Orn. Hort.*, 2(2): 84-88.
- Bhattacharjee, S. K., 1981, Studies on the performance of different varieties of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) hybrid under Bangalore conditions. *Lalbaugh*, 26:16-23.
- Bhattacharyya, A. P., Pandey, H. S. and Yadav, L. P., 1976, Studies on the performance of some varieties of dahlia under Calcutta climate. *Prog. Hort.*, 8: 51-56.
- \*Burton, G. W. 1953, Quantitative inheritance in grasses. *Proc. of the 5<sup>th</sup> Int. Grassland Congress*. 1: 273-277
- Chaugule, B. B., 1985, Studies on genetic variability in chrysanthemum (*Chrysanthemum morifolium* Ram.). *M. Sc. (Agri.) Thesis* submitted to the Mahatma Phule Krishi Vidyapeeth., Rahuri.

- Chezian, N., Ponnuswami, V., Thamburaj, S., Khader, T. M. A., Nangan, K. and Gunashekar, 1985, Evaluation of chrysanthemum cultivars. *South Indian Hort.*, 33: 279-282.
- Choudhary, M. L., 1987, Genetic variability in dahlia. *Prog. Hort.*, 19(1-2): 58-60.
- Chowdhary, T. K., Rout, B., Sadhukhan, R. and Mondal, T., 2016, Performance evaluation of different varieties of China aster [*Callistephus chinensis* (L.) Nees.] in sub-tropical belt of West Bengal. *Int. J. Pharm. Sci. Invention*, 5(8): 15-18.
- Deepti, S. and Santosh, K., 2008, Studies on genetic variability, heritability, genetic advance and correlation in marigold. *J. Orn. Hort.*, 11(1): 27-31.
- Desai, B. L., 1967, Flower description in China aster [*Callistephus chinensis* (L.) Nees.] in seasonal flowers. ICAR Publication, New Delhi, pp. 53-56.
- Dewey, D. R. and Lu, K. U., 1959, A correlation path co-efficient analysis of component of crested wheat grass production. *Agron. J.*, 51: 515-515.
- Dhane, A. V., Nimbalkar, C. A. and Sonawane, P. C., 2002, Variability and heritability studies in dahlia. *J. Maharashtra Agric. Univ.* 27(2): 138-140.
- Dhiman, M. R., 2003, Assessment of chrysanthemum germplasm for commercial cultivation under Kullu-Valley condition. *J. Orn. Hort.*, 6(4): 394-396.
- Dilta, B. S., Sharma, Y. D. and Verda, V. K., 2005, Evaluation of chrysanthemum cultivars under sub-tropical region of Himachal Pradesh. *J. Orn. Hort.*, 8(2): 149-151.
- Emsweller, S. L., Brierley, P., Lumsden, D. V. and Mulferd, F. L., 1937, Breeding of ornamental plants. U. S. D. A. Year book of Agriculture, U. S. Dept. of Agri., pp. 926-929.
- \*Fisher, R. A., 1918, The correlation between relatives on the supposition of mendelian inheritance. *Trans. Royal Society, Edinburg*, 52:399-433.
- Galton, F., 1889, *National inheritance*, Mc. Million and Co., London
- Gayatri, K., Rajiv, K., Seetharamu, G.K. Manjunath Rao, T., Dhanajaya, M.V., Venugopalan, R. and Padmini, K., 2014, Genetic variability for quantitative traits in China aster [*Callistephus chinensis* (L.) Nees] *J. Hort. Sci.*, 9(2): 141-144.
- Goulden, G. 1959, Methods of statistical analysis. *Asia Publishing House*, Calcutta. Pp. 150
- Harland, S. L., 1939, *Genetics of cotton*. Jonathan Cape, London.
- Hedge, P. S. and Gopinath, G., 2003, Genetic variability, heritability and genetic advance in *Gaillardia pulchella*. *J. Orn. Hort.*, 6(3): 277-279.
- \*Heidemans, C. and Stolk, T. H., 1984, Chrysanthemum cultivars for spring culture. *Vakblad varrada Bloemisterij*, 39(51/52): 57-60.
- Hemalatha, B., Patil, A. A. and Nalawadi, U. G., 1992, Variability studies in chrysanthemum. *Prog. Hort.*, 24(1-2): 55-59.
- Howe, T. K. and Waters, W. E., 1984, Evaluation of flowering annuals during fall 1982, marigold and zinnia. *Proc. Florida State Hort. Soci.*, 96: 131-135.
- Huziwara, Y. 1954, *Kromosomo*, 21: 773-776.
- Jain, S. P., 1982, Statistical techniques in quantitative genetics. Indian Agril Stat. Res. Inst., New Delhi.

- Janakiram, T. and Rao, T. M., 1991, Genetic improvement of marigold. *In Floriculture Technology, Trade and Trends*, Ed. Prakash J and Bhandary K R, Oxford and IBH Co. Pvt. Ltd., New Delhi, pp. 331-335.
- Janakiram, T. and Rao, T. M., 1995, Effect of plant density on genetic parameters in African marigold (*Tagetes erecta* L.). *Indian J. Hort.*, 52(4):309-312.
- Jawaharlal, M., Rajamani, K., Sundharam, S. K. and Balakrishnamurthy, G., 1998, Evaluation of gerbera genotypes for certain floral characters, flower yield and vase life. *South Indian Hort.*, 46: 291-293.
- \*Johnson, W. L., 1909, *Elements des exatetes exblich keitslchire Gustum Fisher*.
- \*Johnson, H. W., Robinson, H. F. and Comstock, R. E., 1955, Estimates of genetic and environmental variability in soyabeans. *Agron. J.*, 47:314-318.
- Joshi, R. P., Mishra, Y. K. and Solanki, S. S., 1997, Performance of dahlia cultivars under UP hill conditions.
- Kandpal, K. Kumar, S. Srivastava, R. and Chandra, R., 2003, Evaluation of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) cultivars under tarai condition. *J. Orn. Hort.*, New Series 6: 3, 252-255.
- Kannan, M. and Ramdas, S., 1990, Variability and heritability studies in gerbera. *Prog. Hort.*, 22:72-76.
- Kavitha, R. and Anburani, A., 2010, Genetic variability in African marigold (*Tagetes erecta* L.). *The Asian J. Hort.*, 5(2): 344-346.
- Karuppaiah, P. and Kumar, P. S., 2010, Correlation and path analysis in African marigold (*Tagetes erecta* L.). *Electronic J. Plant Breeding*, 1(2): 217-220.
- Karuppaiah, P., Sudhakaran, K., Kumar, P. S. and Kathiravan, J., 2004, Correlation and path analysis for yield, yield attributes and xanthophylls content in African marigold (*Tagetes erecta* L.). *South Indian Hort.*, 54(1-6): 304-310.
- Kumar, R., Deka, B. C. and Venugopalan, R., 2012, Genetic variability and trait association studies in gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) for quantitative traits. *Indian J. Agril. Sci.*, 82(7): 615-619.
- Kulkarni, B. S., 2003, Evaluation of varieties and effects of planting date and growth regulators on the performance of chrysanthemum (*Dendranthema indicum* L.). *Ph. D. Thesis*, Univ. Agric. Sci., Dharwad.
- Kulkarni, B. S. and Reddy, B. S., 2004, Vegetative growth, flower yield and quality of different chrysanthemum cultivars. *J. Orn. Hort.*, 7 (3-4): 32-36.
- Kulkarni, B. S. and Reddy, B. S., 2006, Vegetative growth and flower yield as influenced by different cultivars of China aster. *Haryana J. Hort. Sci.*, 35: 3/4, 269.
- Kumar, R., Deka, B. C. and Venugopalan, R., 2012, Genetic variability and trait association studies in gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) for quantitative traits. *Indian J. Agril. Sci.*, 82(7): 615-619.
- Kumar, R. and Yadav, D. S., 2005, Evaluation of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) cultivars under the tropical hills of Meghalaya. *J. Orn. Hort.*, 8(3): 212-215.
- Kumari, A., Patel K.S. and Choudhry M., 2011, Genetic variability studies in gerbera. *Res. in plant bio.*, 1(5): 01-04.
- Laskar, M. A. and Yadav, L. P., 1991, Varietal performance with chrysanthemum in the plains of West Bengal. *Environ. and Eco.*, 9: 979-982.

- Losser, H., 1986, Annuals for summer cutflower. *Deutscher Gartenbau*, 40: 1468-1469.
- Lenka, D. and Misra, B., 1973, Path-coefficient analysis of yield in rice varieties. *Indian J. Agric. Sci.*, 43: 376 – 379.
- Magar, S. D., Warade, S. D., Nalge, N. A. and Nimbalkar, C. A., 2010, Performance of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) under naturally ventilated polyhouse condition. *Int. J. Pl. Sci.*, 5(2): 609-612.
- Magar, S. D., Warade, S. D., Nalge, N.A. and Nimbalkar, C. A., 2010, Correlation and path analysis studies in gerbera (*Gerbera jamesonii* Bolus ex Hooker F.). *Int. J. Plant Sci.*, 5(2): 553-555.
- Mahanta, P., Choudhry, S., Paswan, L. and Talukdar, M. C., 1998a, Studies on variability and heritability of some quantitative characters in gerbera. *South Indian Hort.*, 46(1-2): 43-46.
- Mahanta, P., Choudhary S., Paswan L., Talukdar, M. C. and Sharma, D., 1998b, Correlation and path analysis in gerbera (*Gerbera jamesonii* Bolus ex Hooker F.). *Horti. J.*, 11(2): 79-85.
- Mahesh, C., Beniwal, B. S. and Anop, K., 2015, Character association and path-coefficient analysis studies in marigold. *Eco. Env. & Cons.*, 21(1): 165-171.
- Mathad, G., Hegde, L., Reddy, B. S. and Mulge, R., 2003, Genetic variability, heritability and genetic advance in African marigold. *The Karnataka J. Hort.*, 1(3): 37-42.
- Mathew, R., Hatia, S. K., Beniwal, B. S. and Deswal, D. P., 2005, Correlation and path analysis in flower production and seed yield in marigold. *Nation. Symp. on Recent Trend and Future Strategies in Orn. Hort.*, 9(4) 466-469.
- Mishra, R. L., Verma, T. S., Thakur, P. C. and Singh, H.B., 1987, Variability and correlation studies in dahlia. *Indian J. Hort.*, 44(3-4): 269-273.
- Mishra, M., Mohanty, C. R. and Mahapatra, K. C., 2001, Genetic variability with respect to floral traits in dahlia. *J. Orn. Hort.*, 4(2): 79-82.
- Mishra, R. L. and Saini, H. C., 1997, Genotypic and phenotypic variability in dahlia (*Dahlia variabilis* L.). *Indian J. Hort.*, 17: 148-152.
- Mishra, S., Mandal, T., Vanlalruati and Das, S. K., 2013, Correlation and path co-efficient analysis for yield contributing parameters in spray chrysanthemum. *J. Hort. Letters*, 3(1): 14-16.
- Mukesh, K., Sanjay, K., Singh, M., Malik, S. and Arvind, K., 2012, Studies on correlation and path analysis in chrysanthemum (*Dendranthema grandiflora* Tzvelcv.). *Int. J. Plant Res.*, 25(2): 62-65.
- Munikrishnappa, P. M., 2011, Study on the standardization of production technology in China aster under transitional tract of north Karnataka. *Ph D. Thesis*, Univ. Agric. Sci., Dharwad.
- Naik, B. H., Patil, Basavaraj, N. and Patil, V. S., 2004, Correlation studies in African marigold (*Tagetes erecta* L.) genotypes. *J. Orn. Hort.*, 7(3-4): 81-86.
- Nair, A. S. and Shiva, K. N., 2003, Genetic variability, correlation and Path coefficient analysis in gerbera. *J. Orn. Hort.*, 6(3): 180-187.
- Nalawadi, U. G., 1982, Nutritional studies in some varieties of marigold (*Tagetes erecta* L.) *Ph.D. Thesis*, Univ. of Agric. Sci., Dharwad.
- Nandkishore and Raghava S. P. S., 2001, Variability studies in African marigold. *J. Orn. Hort.*, 4(2):124-125.

- Narsude, P. B., Kadam, A. S. and Patil, V. K., 2010, Studies on the growth and yield attributes of different African marigold genotypes under Marathwada conditions. *The Asian J. Hort.*, 5 (2): 284-286.
- Negi, S. S., Rao, T. M. and Janakiram. T., 1988, Varietal evaluation in chrysanthemum. In *Floriculture Technology, Trade and Trends*, Ed. Prakash J and B handary K R, Oxford and IBH Co. Pvt. Ltd., New Delhi, pp. 340-344.
- Negi, S. S., Raghava, S. P. S., Sharma, T. V. R. S. and Srinivasan, V. R., 1983, Variability and correlation in China aster [*Callistephus chinensis* (L.) Nees.] *Indian J. Hort.*, 40: 102-106.
- Negi, S. S. and Janakiram. T., 1990, *Annual Report*. IIHR., Bangalore.
- Negi, S. S. and Raghava, S. P. S., 1982, Improvement of aster through breeding. *Annual report for 1982*, IIHR, Bangalore.
- Negi, S. S. and Raghava, S. P. S., 1985, Improvement of chrysanthemum and China aster through breeding. *Annual report for 1985*, IIHR, Bangalore.
- Nimbalkar, C. A., Dhane, A. V. and Bajaj, V. H., 2004, Relative contribution of component characters on yield of dahlia. *J. Maharashtra Agric. Univ.*, 29(3): 351-352.
- Pal, P. and George, V. S., 2002, Genetic variability and correlation studies in chrysanthemum. *The Hort. J.*, 15(2): 75-81.
- Panse, V. G., 1957, Genetics of quantitative characters in relation to plant breeding. *Indian. J. Genet.*, 17: 318-328.
- Panse, V. G. and Sukhatme, P. V., 2002, Statistical methods for agricultural workers. Indian. Agril. Res. Inst., New Delhi., 2: 381.
- Pandita, P. N. and Bhan, M. K., 1989, Genotypic and phenotypic correlation in pyrethrum. pesticides, 23(2): 28-29.
- Patil, S. S. D. and Rane, D. A., 1995, Studies on heritability estimates in China aster. *J. Maharashtra Agril. Univ.*, 20(1): 137-138.
- Ponnuswami, V. Chezhiyan, N. Thamburaj, S. and Khader, A. M. D. P., 1985, Genetic variability in chrysanthemum. *South Indian Hort.*, 33(3): 211-213.
- Poornima, G., Kumar, D. P. and Seetharamu, G. K., 2006, Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] genotypes under hill zone of Karnataka. *J. Orn. Hort.*, 9(3): 208-211.
- Raghava, S. P. S., Negi, S. S. and Nancharaiah, D., 1992, Genetic variability, correlation and path analysis in chrysanthemum. *Indian J. Hort.*, 49(2): 200-204.
- Raghava, S. P. S. and Negi, S. S., 1994, Genetic analysis of various quantitatives traits in China aster [*Callistephus chinensis* (L.) Nees.] *Indian J. Hort.*, 51(1): 106-110.
- Rao, C. C., Goud, P. V., Reddy, K. M. and Padmaja. G., 2005, Screening of African marigold (*Tagetes erecta* L.) cultivars for flower yield and carotenoid pigments. *Indian J. Hort.*, 62(3): 276-279.
- Rao, T.M., Kumar, R. and Gaddagimath, P. B., 2012, China aster. *Extension Bulletin*. Director, IIHR, Bengaluru. pp. 20.
- Rao, T. M., 1982, Studies in genetic variability and correlation in China aster [*Callistephus chinensis* (L.) Nees.] *M.Sc.(Hort.) Thesis*, Univ. Agric. Sci., Bangalore.

- Rao, T. M. and Negi, S. S., 1990, Heritable components of biometric characters in China aster. *In Floriculture Technology, Trade and Trends*, Ed. Prakash J and Bhandary K R, Oxford and IBH Co. Pvt. Ltd., New Delhi, pp. 318-321.
- Rajashekaran, L. R., Shanmugavelu, K. G. and Nataraja, N. S., 1985, New varieties of horticultural crops released by Tamil Nadu Agri. Univ., Coimbatore during 1985, MDV-1 chrysanthemum. *South Indian Hort.*, 33: 70-71.
- Rao, T. M., Negi, S. S., Janakiram, T. and Raghava, S. P. S., 1996, 'Kamini'- A new China aster cultivar from IIHR, *Flori. Today*, pp. 40-41.
- Rajivkumar, Yadav, D. S. and Roy, A. R., 2007, Performance of chrysanthemum (*Dendratherma grandiflora* Tzvelcv.) cultivars under subtropical midhills altitude of Meghalaya. *Environ. Ecol.*, 255 (34): 941-944.
- Ravikumar, 2002, Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] genotypes under transitional zone of north Karnataka. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad.
- Ravikumar, H. and Patil, V. S., 2003, Genetic variability and character association studies in China aster [*Callistephus chinensis* (L.) Nees.] genotypes. *J. Orn. Hort.*, 6(3): 222-228.
- Reena, Beniwal, B. S., Bhatia, S. K. and Deswal, D. P., 2005, Variability and correlation studies in African marigold (*Tagetes erecta* L.). *Res. Crops*, 6(2): 663-6656.
- Robinson, H. F., Comstock, R. E. and Harvey, P. M., 1966, Estimates of heritability and degree of dominance in corn. *Agron. J.*, 41:353-359.
- Sharama, B. P., and Raghuvanshi, A., 2011, Genetic variability and correlation studies in French marigold. *Prog. Agric.*, 11(1): 54-57.
- Shantappa, T., Abhishek, K., Jagadeesha, R. C. and Halesh, G. K., 2015, Studies on genotypic evaluation and correlation studies in China aster [*Callistephus chinensis* (L.) Nees.]. *Indian Res. J. Genet. & Biotech*, 7(2): 179-186.
- Shivakumar, 2014, Evaluation of marigold (*Tagetes erecta* L.) genotypes under hill zone of Karnataka. *M. Sc. (Hort.) Thesis*, Univ. Agric. Hort. Sci., Shivamogga.
- Singh and Sen, N. L., 2000, Genetic variability, heritability and genetic advance in marigold. *J. Orn. Hort.*, 3(2): 75-78.
- Singh, D., Sen, N. L. and Sindhu, S. S., 2004, Evaluation of marigold germplasm under semi-arid conditions of Rajasthan. *Haryana J. Hort. Sci.*, 32(3/4): 206-209.
- Singh, D., Kumar, S., Singh, A. K. and Kumar, P., 2008, Assessment of African marigold (*Tagetes erecta* L.) genotypes in Uttarakhand. *J. Orn. Hort.*, 11(2): 112-117.
- Singh, D. and Kumar, S., 2008, Studies on genetic variability, heritability, genetic advance and correlation in marigold. *J. Orn. Hort.*, 11(1): 27-31.
- Singh, D. and Singh, A.K., 2005, Correlation and path analysis in marigold (*Tagetes* spp.). *Prog. Hort.*, 37(2): 385-388.
- Singh, D. and Sigh, A. K., 2006, Characterization of African marigold (*Tagetes erecta* L.) genotypes using morphological characters. *J. Orn. Hort.*, 9(1): 40-42.
- Singh, R. H. and Chowdhary, B. D., 1979, Biometrical methods in quantitative genetic analysis. Kalyani Publishers, Ludhiana.
- Singh, R. K., 2003, Variability studies in dahlia for some quantitative traits. *J. Orn. Hort.*, 7(1): 58-60.

- Sirohi, P. S. and Behera, T. K., 1999, Correlation and path analysis in chrysanthemum. *J. Orn. Hort.*, New series, 2(2): 80-83.
- Sirodhi, P. S. and Behera, T. K., 2000, Genetic variability in chrysanthemum. *J. Orn. Hort.* New series, 3(1): 34-36.
- Srinivasulu, G. B., Kulkarni, B. S., Reddy, B. S. and Adiga, J. D., 2004, Yield and quality parameters as influenced by seasons and genotypes in China aster. *J. Orn. Hort.*, 7 (3-4): 122-124.
- Srinivasulu, G. B., Kulkarni, B. S., Nataraj, S. K., Reddy, B. S., Naik, K. M. and Chandan. K., 2007, Correlation studies for yield and yield contributing characters in China aster [*Callistephus chinensis* (L.) Nees.] *Asian J. Hort.*, 2(2): 192-194.
- Suman, C. L., Wahi, S. D. and Bhattacharjee, S. K., 1980, Genetic analysis in dahlia. *Def. Agric. Sci. Digest*, Karnal, 11(4): 190-194.
- Syamal, M. M. and Kumar, A., 2002, Genetic variability and correlation studies in dahlia. *J. Orn. Hort.*, New Series, 5(1): 40-42.
- Tewari, G. N. and Umashankar, 1990, Evaluation of chrysanthemum (*Chrysanthemum morifolium* Ram.) cultivars for cutflowers with special reference to export. In *Floriculture Technology, Trade and Trends*, Ed. Prakash J and Bhandary K R, Oxford and IBH Co. Pvt. Ltd., New Delhi, pp. 136.
- Talukdar, M. C., Mahanta, S. and Sarma, B., 2006, Evaluation of standard chrysanthemum (*Dendrathera grandiflora* Tzvelve.) cultivars under polyhouse cum rain shelter and open field conditions. *J. Orn. Hort.*, 9(2): 110-113.
- Talukdar, M. C., Mahanta, S., Sharma, B. and Das, S., 2003, Extent of genetic variation for growth and floral characters in chrysanthemum cultivars under Assam condition. *J. Orn. Hort.*, 6(3): 201-211.
- Tarannum, and Naik, B., 2014, Performance of carnation (*Dianthus caryophyllus* L.) genotypes for qualitative and quantitative parameters to assess genetic variability among genotypes. *American Inte. J. Res. in Form, Appl. & Nat. Sci.*, 5(1): 96-101.
- Vasudevan, V. and Rao, V. K., 2010, Evaluation of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) genotypes under mid hill conditions of Garhwal Himalaya. *Abstract published in Nation. Symp. on lifestyle floriculture: challenges and opportunities held at the Dr. Y.S. Parmar Univ. of Hort. and For.*, Nauni, Solan. pp: 19.
- Vijayalaxmi, P., 1998, Evaluation of dwarf marigold (*Tagetes patula* L.) varieties under Northern traditional tract of Karnataka. *M.Sc.(Agri.) Thesis*, Univ. Agric. Sci., Dharwad.
- Vikas, H. M., Patil, V. S., Agasimani, A. D. and Parveenkumar, D. A., 2011, Studies on genetic variability in dahlia (*Dahlia variabilis* L.). *Int. J. Sci. and Nature*, 2(2): 372-375.
- \*Wright, S., 1921, Correlation and causation. *J. Agric. Res.*, 20: 557-585
- Zosiamlia, J. H., Reddy, G. S. N. and Rymbai, H., 2012, Growth, flowering and yield characters of some cultivars of China aster [*Callistephus chinensis* (L.) Nees.] *J. Nat. Prod. Plant Resour.*, 2 (2): 302-305.

## APPENDIX

### Meteorological data recorded during the experimental period

Month	Total Rainfall (mm)	Temperature (°C)		Relative Humidity (%)	
		Max.	Min.	Max.	Min.
October, 2017	264.0	28.1	19.0	91.0	56.0
November, 2017	11.4	26.9	17.5	90.0	60.0
December, 2017	8.8	26.3	14.9	89.0	58.0
January, 2018	0.0	27.4	14.1	87.0	52.0
February, 2018	3.0	29.4	15.3	86.0	48.0
March, 2018	62.2	32.0	17.7	75.0	35.0

\*AICRP on Agrometeorology, GKVK, UAS, Bengaluru