

EVALUATION OF CHINA ASTER
[*Callistephus chinensis* (L.) Nees.] FOR CULTIVATION
IN TROPICAL PLAINS

By

ALFIN SANTHOSH

(2017-12-034)



DEPARTMENT OF FLORICULTURE AND LANDSCAPING

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

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THESIS

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DEPARTMENT OF FLORICULTURE AND LANDSCAPING
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680 656
KERALA, INDIA

2019

DECLARATION

I, hereby declare that the thesis entitled “**Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation in tropical plains**” is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara,

Date: 28-11-2019

Alfin Santhosh

(2017-12-034)

CERTIFICATE

Certified that the thesis entitled “**Evaluation of China aster [Callistephus chinensis (L.) Nees.] for cultivation in tropical plains**” is a record of research work done independently by **Alfin Santhosh (2017-12-034)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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LIST OF ABBREVIATIONS

ml	:	millilitre
°C	:	degree Celsius
mg	:	milligram
<i>viz.</i>	:	namely
<i>et al.</i>	:	co workers
g	:	gram
%	:	percentage
CD	:	Critical difference
CV	:	Coefficient of variation
cm	:	Centimetre
fig.	:	Figure
no.	:	Number
kg	:	Kilogram
m	:	metre
ha	:	hectare
nm	:	nanometre
MAP	:	Month after planting
DAP	:	Days after planting

Introduction

1. INTRODUCTION

China aster [*Callistephus chinensis* (L.) Nees.] belongs to the family Asteraceae and is native to China. The genus *Callistephus* derives its name from two Greek words *Kalistos* meaning ‘most beautiful’ and *Stephus* ‘a crown’ referring the head of the flower. It is one of the most important annual flower crops grown in most parts of the world. It is a hardy annual and commercial flower crop grown for loose flowers as well as cut flowers, as pot plant and for bedding purpose in landscapes. It has gained considerable importance in flower trade because of its short stature, wide range of colours, longer vase life and ability to stand rough handling in transport (Chaitra and Patil, 2007). As a hardy annual, it is well adapted to different agro climatic conditions and will bloom throughout the year. In India, China aster occupies an area of 6700 ha, with an annual production of 4000 tonnes, and commercial cultivation is mainly concentrated in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal (Kumari *et al.*, 2016). It ranks third next to chrysanthemum and marigold amongst the annual flowers and is grown mostly by the small and marginal farmers due to its ease of cultivation under open condition. The flowers fetch very good price and returns to farmers when their production coincides with the demand during particular season or festival. Flowers are mainly used for decorations, making garlands and for worshipping. They are also found suitable for dry flower making.

China aster is also an important commercial flower crop of Siberia, Russia, Japan, North America and Europe. It is mainly a winter season flowering annual and the most suitable temperature is around 15 °C (night) and performs well up to 20 °C (night) temperatures. A temperature range of 20-30 °C during day and 15-17 °C during night with relative humidity of 50-60% is ambient for proper colour development of flowers (Rao *et al.*, 2012). The success of a crop depends on the prevailing weather and climatic conditions at the time of transplanting and flowering.

In Kerala, the demand for annual flower crops is in rise, both as loose flowers and for landscaping purposes, but the cultivation is scarce in the state. China aster, due to its hardy nature can be popularised as a pure crop as well as an intercrop in coconut gardens and also as a garden plant (Janakiram, 1997). It is necessary to analyse the performance of a crop in a particular region before recommending for commercial cultivation. Investigation to assess the performance of China aster in tropical condition of Kerala has not been attempted. Hence the study is proposed to evaluate the performance of China aster genotypes in the tropical plains for recommending the crop for commercial cultivation.

Hence a study was undertaken at the Department of Floriculture and Landscaping in College of Horticulture, with an objective to evaluate the performance of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation in tropical plains.

Review of literature

2. REVIEW OF LITERATURE

China aster [*Callistephus chinensis* (L.) Nees.] is a winter annual having short duration. Ease of cultivation, availability of various colours and short plant stature make this flower a good substitute for chrysanthemum. The cultivation of the crop is mainly confined to states of Karnataka, Maharashtra, Andhra Pradesh and West Bengal. Studies on evaluation and cultivation of China aster in Kerala is very meagre.

Literature relating to the evaluation of China aster is reviewed here. Since reports on the evaluation of China aster are meager, informations regarding other flower crops has also been cited in the review. The review is presented under following headings.

2.1 Varietal evaluation studies

Manjunath (2000) analysed various genotypes of China aster and found that Violet Cushion, Shashank, Poornima and Kamini as most promising for cut flower production under Ghataprabha command area, Karnataka whereas Phule Ganesh series were found suitable for loose flower production.

Nagaraju *et al.* (2004) reported that flower quality as a primary varietal trait and is influenced by climatic conditions prevalent during the growing period. Suitable temperature and required photoperiod leads in obtaining superior blooms of good size and high quality flowers.

Kishanswaroop *et al.* (2004) evaluated four varieties *viz.* Poornima, Kamini, Shashank and Delhi Local at IARI, New Delhi and found that plant height (43.20 cm) and length of flower stalk (24.40 cm) was maximum in variety Delhi Local. The diameter of flower (7.44 cm) and single flower weight (7.5 g) was recorded maximum in variety Poornima.

Sreenivasulu *et al.* (2004) assessed the performance of six different cultivars of China aster during winter and summer seasons. The number of flowers per plant (58.03) and maximum stalk length (50.43 cm) was observed in

cultivar Phule Ganesh Pink followed by Phule Ganesh Violet (49.73 and 45.66 cm) and Phule Ganesh White (48.66 and 45.93 cm). The flower diameter was maximum in Phule Ganesh White (7.15 cm) and Phule Ganesh Pink (6.46 cm).

Poornima *et al.* (2006) evaluated five genotypes of China aster and observed maximum plant height in variety Poornima (51.80 cm) and minimum plant height in cv. Local (11.37cm) in an experiment to study the performance of China aster genotypes under the hill zones of Karnataka.

Kulkarni and Reddy (2006) reported that among the six varieties of China aster assessed for performance under North Karnataka conditions for four years, the variety Phule Ganesh White recorded highest plant height (66.40 cm). Phule Ganesh Purple recorded highest plant spread (2749.40 cm²). Highest number of primary branches was produced by the variety Phule Ganesh Violet (23.60) and flower yield per plant was maximum in Phule Ganesh White (327.90 g).

Chavan *et al.* (2010) observed that variety Phule Ganesh White recorded maximum number of days to open first flower (80.58), produced highest yield of flowers (151.39 kg/ha) and the highest number of flowers per plant (30.54) followed by Phule Ganesh Purple (23.66). The variety Phule Ganesh Pink recorded maximum plant spread (35.66 cm²).

In a field study conducted in Andhra Pradesh for evaluating China aster varieties, Zosiamliana *et al.* (2012) observed that Phule Ganesh varieties from Mahatma Phule Krishi Vidyapeeth, Rahuri were superior in terms of plant height. The variety Phule Ganesh Violet recorded maximum plant height at 60 and 90 days after planting (43.89 and 66.50 cm respectively). The cv. Local reported a plant height of 21.77 and 43.13 cm at 60 and 90 days after planting.

Arunkumar (2012) carried out a study on genetic variability for growth, seed yield and quality seed storage in China aster at KRC College of Horticulture, Arbahi with ten genotypes and among them Namdhari White took least number of days (43.70) to commence flowering while Phule Ganesh White took

maximum days to commence flowering (68.30). The variety Phule Ganesh White took maximum number of days for 50% flowering (79.30) whereas Local Pink took minimum number of days (64.90). Germination percentage was observed highest in Phule Ganesh Purple (99.03 %) whereas genotype Budigappa Local had the lowest percentage of germination.

In a study conducted with the objective of evaluating suitable varieties on growth and flower yield of China aster under the transitional tract of Northern Karnataka, variety Phule Ganesh Violet had the highest plant height (70.82 cm), plant spread (40.95 cm) and number of primary branches (33.42 cm) at 105 days after transplanting whereas variety Violet cushion recorded the least plant height and plant spread (Munikrishnappa *et al.*, 2013).

According to Zosiamliana *et al.* (2013) the performance of seven varieties of China aster was analysed at APHU, Hyderabad and the variety Phule Ganesh Pink recorded least number of days for first flower bud initiation (57.20), first flowering (66.73), 50% flowering (85.67) and flowering duration (60.96). However Phule Ganesh White produced maximum flower diameter (7.37 cm), stalk length (34.78 cm) vase life (9.13 days) and maximum number of flowers per plant (36.73).

In an experiment conducted in the mid hills of Uttarakhand, for evaluating the performance of China aster genotypes namely, Phule Ganesh Violet, Phule Ganesh Purple and Phule Ganesh Pink, maximum plant spread and number of primary branches per plant was noted in the variety Phule Ganesh Pink (25.80 cm and 20.70) (Pandey and Rao, 2014).

Munikrishnappa and Chandrashekhar (2015) stated that among ten varieties of China aster evaluated for physiological growth parameters under transitional tract of Northern Karnataka, the variety Phule Ganesh Violet was found superior with maximum leaf area per plant (44.06 cm²) at 105 days after transplanting.

Tirakannanavar *et al.* (2015) conducted a study on genotypic variability and correlation in China aster at KRC College of Horticulture, Arbhavi and among the ten genotypes Phule Ganesh White was noted with maximum number of flowers per plant (64.30) and Phule Ganesh Purple had highest seed yield per plant (10.76 g). The genotype Phule Ganesh Purple recorded the highest germination percentage (99.03).

Chowdhuri *et al.* (2016) evaluated eight varieties of China aster in West Bengal and identified the variety Phule Ganesh Violet with maximum number of leaves (197.50) but number of branches per plant was highest in Arka Archana (19.40). The number of flowers per plant was highest in variety Arka Shashank (81.83).

Seed setting studies in China aster was conducted by Khangjarakpam *et al.* (2016) at the experimental field of Division of Ornamental Crops Indian Institute of Horticulture Research, Bengaluru. Four varieties released from IIHR namely Kamini, Shashank, Poornima and Violet Cushion were used for the study and Shashank was recorded with highest number of disc florets per flower head (288.40) and number of disc florets per head was maximum in variety Poornima (132.40). The highest number of seed yield was observed in variety Kamini (6.23 g) while lowest seed yield was recorded in Violet Cushion (1.54 g).

Rai and Chaudhary (2016) conducted an experiment under the mid hill conditions of Himachal Pradesh with ten cultivars of China aster. They observed that Arka Shashank took least number of days to first flower opening (77.25) and days to 50 % flowering (92.45) while maximum number of days for first flower opening (106.25) and 50 % flowering (123.20) was recorded in Phule Ganesh White. Maximum flowering duration was recorded in Arka Aadhya (41.30). Vase life (14.42) and shelf life (8.30) were found to be maximum in Arka Archana.

A study was done to assess suitable varieties of China aster under tropical conditions of Tamil Nadu. Among the seven genotypes evaluated, the variety Kamini had the highest flower diameter (7.46 cm) and flower stalk length (65.68

cm). The variety Poornima was observed with highest number of flowers per plant (42.85) Kumar *et al.* (2017).

Kumari *et al.* (2017) evaluated F₁ hybrids and parents for quantitative and qualitative characters at IIHR, Bengaluru. Among 15 F₁ hybrids, Hybrid - 8 was found superior over the other hybrids with highest number of leaves per plant (312.47), number of branches per plant (23.19), number of flowers per plant (93.66), highest weight of flowers per plant (293 g) and flower yield per hectare (24.68 t).

An experiment was conducted in the Department of Floriculture and Landscape Architecture, College of Horticulture, Bengaluru and among the twenty eight genotypes evaluated AAC-1 recorded the maximum flowering duration (35.50 days), maximum stalk length (42.19 cm), flower yield (216.40 g) and seed yield (19.21 g). Highest individual flower weight (7.42 g) as well as flower diameter (7.33 cm) was recorded in Phule Ganesh White while number of flowers per plant (70.80) was recorded maximum in Arka Archana (Hallikeri *et al.*, 2019).

In an experiment conducted to study the performance of China aster genotypes in Rayalsema region of Andhra Pradesh, the variety Arka Aadya was found superior in terms of larger flower head (5.13 cm) and larger flower circumference (16.12 cm) among seven genotypes evaluated (Aditya *et al.*, 2019).

Patil *et al.* (2019) evaluated eight genotypes of China aster at South Gujarat conditions. Maximum stalk length (33.96 cm), vase life (8.67 days) was exhibited by Phule Ganesh White, while shelf life (4.31 days) was observed significantly maximum in Phule Ganesh Pink. Arka Archana took least number of days to 50 % flowering (77.31), maximum flower head diameter (5.81 cm), flowering duration (78.00), number of flowers per plant (58.73) and flower yield (15.30 t/ha).

Bhargav *et al.* (2019) assessed 42 genotypes of China aster at Indian Institute of Horticultural Research, Bengaluru to evaluate the performance of different varieties. The variety Phule Ganesh Pink was recorded with highest plant height (42.15 cm) and flower diameter (6.74 cm).

An experiment was carried out to evaluate the performance of different varieties of China aster for north eastern dry zone of Karnataka by Dharmendra *et al.* (2019). The genotype Phule Ganesh White was registered with highest flower diameter (6.35 cm) and flower yield per plant (214.67 g). The highest number of flowers was recorded in Poornima (68.53) followed by Arka Archana (66.67).

Sankari *et al.* (2019) conducted an experiment to evaluate the performance of China aster varieties for yield under Nilgiris. The variety Arka Kamini recorded highest flower diameter (5.16 cm) while Arka Poornima was observed with highest number of flowers per plant (28.00) and individual flower weight (4.51 g).

2.1.1 Evaluation studies on other flower crops

Dhiman (2003) evaluated, 11 varieties of Chrysanthemum in a field study conducted in Himachal Pradesh and the variety Pink Prince was superior in plant height (118.60 cm).

Ten cultivars of African marigold was screened for flower yield and carotenoid pigments by Rao *et al.* (2005). The plant growth was recorded better in cultivar Orange Double with maximum plant height (84.00 cm), leaf area (3762.00 cm²), maximum flowering duration (44.00 days), highest flower yield (295.80 g) and the highest total carotenoid per gram fresh weight of flower petals was observed in cultivar Pusa Narangi Gaiinda (2.69 mg/g). Seed yield was documented highest in cultivar Orange Double (1183.41 kg/ha) followed by Pusa Narangi Gaiinda (715.48 kg/ha).

Singh and Singh (2006) assessed the performance of 29 genotypes of African marigold under Uttaranchal conditions and found that maximum number

of primary branches per plant, number of flowers per plant and dry weight of leaf was reported in the genotype TEG 16. The genotype TEG 17 recorded maximum flower longevity (66.00 days) and dry weight of flower (6.68 g) while duration of flowering (135.33 days) was observed maximum in TEG 13.

Twenty nine cultivars of African marigold in Uttarakhand was compared by Singh *et al.* (2008). Plant height (73.10 cm), leaf biomass per plant (1548.10 g), flower diameter (10.80 cm), weight of seeds per peduncle (3.100 g) and seed yield per plant (164.47 g) was found highest in TEG 26. Maximum number of secondary branches per plant (47.00) and individual flower weight (26.06 g) were reported in variety TEG 17.

Narsude *et al.* (2010) evaluated 10 African marigold genotypes and the genotype Tuljapur Local-1 was found superior in terms of number of branches (21.46). Tuljapur Local-1 was also reported with maximum number of flowers (71.00) and flower yield per plant (630.48 g).

Chaudhary *et al.* (2014) recorded that Hisar Jaffri-2 was superior with respect to plant spread (77.72 cm), number of secondary branches per plant (150.97), number of buds per plant (217.10), duration of flowering (76.53 days) and flower yield per plot (20.99 kg). Highest diameter of flower (8.21 cm) was recorded in MGH-09-276.

Kumar *et al.* (2014) conducted a field experiment in Meerut, Uttar Pradesh to evaluate the performance of 38 varieties of Chrysanthemum and maximum number of flowers per plant (219.07) was recorded in variety Lilliput pursued by Yellow charm (191.85).

Keerti *et al.* (2017) evaluated 24 varieties of Chrysanthemum in the humid coastal zone of Andhra Pradesh and the results proved that variety Pusa Centenary recorded least number of days for flowering (63.01 days), maximum flower diameter (7.84 cm) and the highest flower yield (189.50 g/plant).

From the experiment carried out by Roopa *et al.* (2018), in order to identify suitable varieties of chrysanthemum under hill zones of Karnataka, it was observed that the variety Kolar Local was found superior in terms of flower diameter (5.75 cm), individual flower weight (3.24 g) and number of ray florets per flower (325.14).

Ten genotypes of marigold were assessed for growth, yield and essential oil content at CCS Haryana Agricultural University, Hisar. The results affirmed that the genotype MGH 160-9-2 was significantly superior over other genotypes with maximum plant height (117.67 cm), flower size (9.03 cm), fresh weight (12.69 g), dry weight (2.39 g), flower yield per plant (568.50 g), flower yield per plot (9.09 kg) and flower yield per acre (14.21 T) while number of flowers per plant (122.92) was observed highest in MGH 109-1-2 (Gulia *et al.*, 2017).

2.2 Effect of seasons

Mukhopadhyay and Randhawa (1986) suggested that winter and monsoon season as most suitable for the cultivation of China aster. But around Bengaluru and Pune it can be cultivated year around.

Bindumathi (1992) conducted a study in Pune and reported that monsoon season followed by winter as the best planting season to obtain high yield and quality cut flowers of China aster whereas winter season should be preferred for early crops as the flowering duration is least in winter season.

Jitendra (1995) reported that monsoon season planting significantly produced taller plants (87.26 cm) and it was significantly superior to winter season (83.83 cm). The number of days for the emergence of first flower was observed minimum in summer season (76.39) when compared to summer season (86.95).

Samantaray *et al.* (1999) reported that May planting of African marigold resulted in continued vegetative growth for an extended period and reduced flower yield, it was found unfavourable for Bhubaneswar conditions. For

improving the yield, September planting closely followed by July planting were found optimum times for planting. Early flower bud appearance was observed in January and November plantings however flower production was maximum when planted in September and October months that coincided with short day conditions. Planting in March resulted in highest plant dry matter content but, lowest flower yield. In variety Pusa Narangi Gaiinda, highest flower and seed yield was recorded in June planting.

Jane and Kawarkhe (2002) observed rise in plant height, number of branches per plant, plant spread, flower diameter, 100 flower weight and number of flowers per plant during October planting in China aster and the number of days taken for flower bud initiation was reduced. The planting dates had direct impact on the performance of China aster. Prasad and Reddy (2003) recorded highest flower yield in China aster when planted in October and November.

Ritu and Gupta (2004) conducted an experiment on African marigold to assess the effect of planting season and planting in February resulted in highest flower size (6.70 cm), number of flowers per plant (53.33) and flower yield per plant (296.10 g) although planting during July recorded maximum plant height (108.30 cm), plant spread (41.85 cm) and seed yield per plant (23.12 g).

Raju *et al.* (2006) recorded maximum flower yield in French marigold from June planting while flower weight and flower diameter were reported maximum from August planting.

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

According to a field study on chrysanthemum, by Laxmi and Pratap (2011), July planting produced highest plant height (25.89 cm), plant spread

(21.37 cm), number of branches per plant (13.25), flower diameter (3.88 cm), duration of flowering (58.67 days) and flower yield per plant (157.94 g).

In China aster better plant height, plant spread, number of flowering stems per plant, number of flowers per plant and yield of flowers per stem were reported when sown on 6th of April (Kaushal *et al.*, 2014).

Two varieties of African marigold were evaluated by Prakash (2015), to find the effect of seasons and pinching on growth and flower yield. The study was carried out in three seasons namely pre monsoon (January sown), monsoon (May sown) and post monsoon (September) with Pusa Narangi Gainda and Pusa Basanti Gainda varieties of African marigold. The maximum plant height (124.86 cm) was reported in variety Pusa Narangi Gainda sown during May without pinching whereas highest number of flowers (125.16) was observed in January sown crop of Pusa Narangi Gainda with pinching and maximum flower yield was documented in Pusa Basanti Gainda sown during January with pinching.

Nimisha (2016) evaluated the performance of eight African marigold cultivars under open field and rain shelter conditions in two different planting seasons in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara *viz.* July – November and January – April and reported that all the vegetative, floral and seed characters were found to be superior in the first season. Among the cultivars, Orange Giant exhibited maximum plant height (113.00 cm), flower diameter (6.56 cm), flower weight (12.29 g) and total flower yield (668.06 g/plant) all along the first season.

2.3 Correlation and path analysis in different flower crops

Singh and Katiyar (2001) conducted correlation and path coefficient analysis for flower yield in twenty genotypes of damask rose and reported that flower yield per plant was positively and directly associated with number of flowers per plant and number of primary branches per plant.

Kumar (2003) reported that at phenotypic level, high positive and significant relationship was recorded for number of flowers, leaf area per plant and flower yield per plant in China aster.

Sreenivasulu *et al.* (2007) studied the association of yield with yield contributing character in China aster using six different genotypes. The results showed that yield per hectare was positively and significantly associated with number of flowers per plant, plant height, number of secondary branches, days taken for 50 per cent flowering, duration of flowering, diameter of flower, fresh weight of flower, fresh and dry weight of plant.

Poornima (2006) found that the phenotypic correlation coefficients were higher than phenotypic correlation coefficients and yield of flower per plant was found to be significantly and positively correlated with plant spread, number of branches per plant, number of leaves per plant and stalk length.

Kumari *et al.* (2017) reported that path coefficient analysis using correlation coefficients in China aster revealed that 100 flowers weight contributed highest positive direct effect on weight of flowers per plant followed by number of leaves per plant and number of flowers per plant.

Materials and methods

3. MATERIALS AND METHODS

The experiment was conducted during the year 2018-19, at the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara. The planting was done in October. The objective of the experiment was to evaluate China aster [*Callistephus chinensis* (L.) Nees.] for cultivation under tropical plains. The details of the materials used and methods adopted during the course of investigation are discussed in this chapter.

3.1 LOCATION AND CLIMATE OF THE SITE

The experimental site was laid out in the open field of the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara. The area is located at 10°32' North latitude and 76°16' East longitude at an elevation of 22.5 m above the mean sea level. The experimental area enjoys a tropical warm humid climate.

3.2 TREATMENTS

3.2.1 Varieties

The following varieties of China aster were used in the study.

- 1) T₁-Arka Kamini
- 2) T₂-Arka Shashank
- 3) T₃-Arka Archana
- 4) T₄-Phule Ganesh White
- 5) T₅-Phule Ganesh Violet
- 6) T₆-Phule Ganesh Pink
- 7) T₇-Phule Ganesh Purple
- 8) T₈-AAC-1



T₁-Arka Kamini



T₂- Arka Shashank



T₃- Arka Archana

Plate 1.a. China aster varieties



T₄- Phule Ganesh White



T₅- Phule Ganesh Violet



T₆- Phule Ganesh Pink

Plate 1.b. China aster varieties



T₇.Phule Ganesh Violet

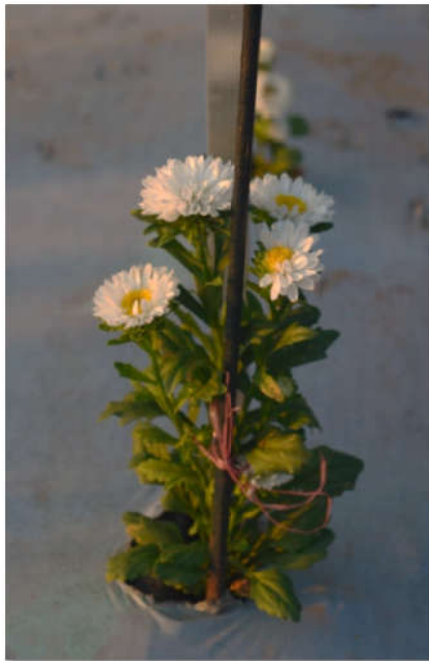


T₈.AAC-1

Plate 1.c. China aster varieties



T₉-Local Pink



T₁₀-Mat White

Plate 1.d. China aster varieties

- 9) T₉-Local Pink
- 10) T₁₀- Mat White

3.3 SEASON

The crop was planted in October (winter crop).

3.4 EXPERIMENTAL DESIGN

The experiment was laid out in Randomised Block Design (RBD) with three replications.

3.5 PLANTING MATERIAL

All the varieties were collected from Indian Institute of Horticultural Research, Bengaluru. Seeds were sown in pro-trays in soilless media comprised of cocopeat + vermiculite + perlite in 3:1:1 ratio. Forty five days old healthy seedlings were transplanted in the main field.

3.6 LAND PREPARATION AND PLANTING

The area for the experiment was selected and cleared, levelled and ploughed to a fine tilth. Raised beds of size 2.1 × 1.2 m were taken and the seedlings were transplanted on the beds at a spacing of 0.3 × 0.3 m. After levelling the beds, drip lines were laid out and beds were covered with 30 micron silver black polythene sheet.

3.7 CARE AND MANAGEMENT

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

3.7.1 Application of Fertilizers

Well rotten farm yard manure was incorporated into the beds at the rate of 30 kg/bed and powder formulation of *Trichoderma viridae* was applied to each bed at the rate of 250 g. Fertilizer was applied as per the recommended dose of 180:120:60 kg NPK/ha per ha in the form of Factamphos, Urea and Muriate of Potash respectively.

3.7.2 Cultural Operations

The beds were irrigated daily throughout the season. Periodic hand weeding was done whenever necessary. Pinching of the main shoot was done one month after planting and staking was given to avoid lodging of plants at the time of flowering.

3.7.3 Plant Protection

Plant protection measures were taken up whenever necessary.

3.8 HARVESTING

Flowers were harvested when they are fully opened and attained full size. Harvested flowers were used for recording the floral and post-harvest observations and for estimation of anthocyanin content. Flowers for seed extraction were harvested when they are fully dried and matured.

3.9 OBSERAVTIONS

3.9.1 Vegetative characters

Observations on vegetative parameters were recorded upto three months after transplanting. Five plants were selected in each replication and the vegetative characters were recorded. The following vegetative characters were recorded during the study.

3.9.1.1 Plant height

The plant height was measured from collar region to the growing tip of the plant and expressed in cm. Observations were recorded in five individual plants and average was worked out.

3.9.1.2 Plant spread


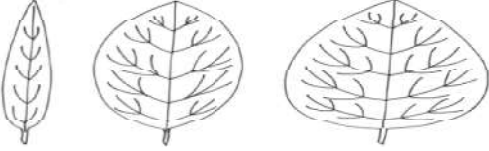

The spread of the plant in north-south and east-west directions was measured and the sums of both directions were worked out and mean value was expressed in cm.

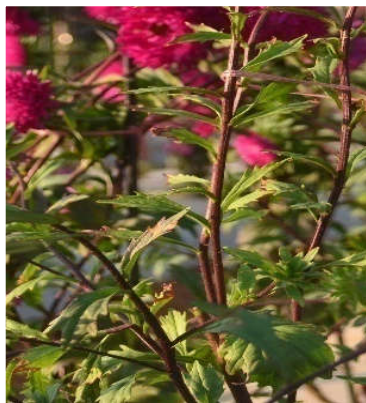
3.9.1.3 Number of primary branches

The number of primary branches arising from the main stem was observed and average number of primary branches per plant was calculated.

3.9.1.4 Stem girth

Stem girth was measured 10 cm above the collar region of the plant, using digital vernier calliper in centimetres.

Qualitative characters	IIHR Descriptor	
Leaf dentations	Absent/Present	
Leaf shape	Linear/ Elliptic/Ovate	
Stem colouration	Absent/Present	
Mid-rib colouration	Absent/Present	
Flower type	Semi-double Powderpuff	



Presence of stem colouration



Absence of stem colouration

Plate 2. Qualitative vegetative and floral characters of China aster

3.9.1.5 Number of leaves per plant

Number of leaves per plant were counted and recorded.

3.9.1.6 Leaf area

Four healthy fully opened leaves were taken from selected plants and leaf area was measured using leaf area meter and the mean value was calculated and denoted in cm².

3.9.1.7 Leaf dentation

Five healthy leaves were observed for presence of dentation till three months of planting.

3.9.1.8 Leaf shape

Leaves were observed for leaf shapes *viz.* elliptic/linear/ovate till third month of planting.

3.9.1.9 Stem colouration

All the varieties were observed for presence of stem colouration and varieties with colouration were recorded.

3.9.1.10 Leaf mid-rib colouration

Varieties were observed for presence of leaf mid-rib colouration and varieties with colouration was recorded.

3.9.2 Floral Characters

3.9.2.1 Days to bud initiation

The number of days taken for bud initiation was calculated by counting the days from transplanting to the initiation of bud and expressed as number of days.

3.9.2.2 Days to complete flower opening

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

3.9.2.3 Days to 50 per cent flowering

The number of days taken for 50 per cent flowering of the plant was figured out by counting the days from transplanting to 50 per cent flowering and denoted as number of days.

3.9.2.4 Number of flowers per plant

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

3.9.2.5 Stalk length

The stalk length of five randomly selected flowers was measured in centimetres and mean length was calculated.

3.9.2.6 Flower weight

The flower weight was figured out by weighing five individual randomly selected flowers of a variety and mean weight was calculated and denoted in grams.

3.9.2.7 Flower diameter

Fully opened flowers from each of the observation plants were harvested and five flowers were randomly selected and diameter was measured in centimetres and mean flower diameter was calculated.

3.9.2.8 Number of disc florets per head

Disc florets were separated from five randomly selected flowers and number of disc florets per flower head was counted and the mean number was calculated.

3.9.2.9 Number of ray florets per head

Ray florets were separated from five randomly selected flowers and number of ray florets per flower head was counted and average number was figured out.

3.9.2.10 Flower yield per plant

The flower yield from selected plants of different varieties were recorded separately and mean flower yield was worked out and expressed in grams.

3.9.2.11 Flower colour

Flower colour difference among different genotypes were identified by matching the flower colour with Royal Horticultural Society Colour Chart (RHSCC).

3.9.2.12 Flower type

Flower type was identified by the visual difference in the arrangement of ray and disc florets and was categorized into semi double and powderpuff types.

3.9.2.13 Duration of flowering

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

3.9.2.14 Seed yield per flower

All dried flowers from selected plants were collected and the weight of the seeds obtained from individual flower was noted and mean seed yield was expressed in gram.

3.9.2.15 Seed germination percentage

Seeds taken from flowers of each replication were sown in pro-trays filled with 3:1:1 cocopeat, vermiculite, perlite media and mean percentage of seed germination was calculated.

3.9.3 Incidence of pest and diseases

The incidence of pest and diseases were noted at nursery and field level.

3.9.4 Post Harvest Parameter

3.9.4.1 Shelf life of flower

Five flowers were selected randomly from each treatment and kept in ambient condition and flowers were discarded when they started wilting. Thus the number of days upto wilting was calculated as shelf life of flower.

3.9.4.2 Vase life of flower

To estimate vase life, flowers were harvested when the outer whorl of disc florets opened. The stems were uniformly cut and lower leaves were removed and immediately they were put in distilled water taken in 300 ml bottle. Wilting of one or two florets was considered as the end of vase life and number of days taken for wilting of flower was counted and average vase life of each variety was worked out.

3.9.4.3 Physiological loss in weight

The flowers harvested were weighed freshly (initial weight) and also at the end of shelf life (final weight). It is expressed in percentage.

$$PLW = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.9.4.4 Total water intake

The water intake of flower was calculated by measuring the initial volume and final volume of water in a measuring cylinder as and when the flower kept in the vase shows signs of wilting.

3.9.4.5 Anthocyanin content of flowers

For the estimation of anthocyanin content of flowers, 2.5 g of flower petal was taken in a pestle and mortar, into which 25 ml of ethanolic HCl was added and transferred to a 25ml volumetric flask and made upto volume. It was kept overnight in darkness at 4°C in refrigerator. The sample was filtered using Whatman No.1 filter paper and optical density of the extract was recorded at 535nm in a UV-Vis Spectrophotometer. The anthocyanin content was calculated using the formula given below and expressed in mg⁻¹(Ranganna, 1997).

Total Optical density/100 g = O.D × Volume made up × 100 ÷ Weight of sample

Total anthocyanin (mg/100 g) = Total O.D / 100 g ÷ 98.2

3.10 TABULATION AND STATISTICAL ANALYSIS

Observations on different characters were tabulated and statistically analysed using the WASP 2.0 package.

3.11 DIVERSITY ANALYSIS

Diversity plays a major role in stability of a species as it helps to survive with the changes in the environment by providing adaptation to existing biotic and abiotic environmental conditions.

3.11.1 D² Statistics

Based on qualitative and quantitative characters of China aster varieties, a dendrogram was constructed by agglomerative method (Day and Edelsbrunner, 1984) and clustering analysis was done based on Jaccard's similarity matrix and measured by Euclidean distance using NTSYS pc software. The genetic

association between varieties based on qualitative and quantitative characters was measured by Euclidean distance using NTSYS pc software.

3.12 CORRELATION STUDIES

Correlation analysis was conducted to ascertain the relationship between different vegetative and floral characters. The correlation analysis was conducted by SPSS software.

3.13 PATH COEFFICIENT ANALYSIS

Path coefficient analysis proposed by Wright (1921) and elaborated by Dewey and Lu (1959) were worked out to find the direct and indirect effect of vegetative and floral characters on flower yield. The following equations were used for finding direct and indirect effects.

$$r_{1y} = a + r_{12}b + r_{13}c + \dots + r_{1i}$$

$$r_{2y} = a + r_{21}a + b + r_{23}c + \dots + r_{2i}$$

$$r_{1y} = r_{11}a + r_{12}b + r_{13}c + \dots + I$$

Where,

r_{1y} to r_{iy} = Coefficient of correlation between casual factors 1 to I with dependent variable y.

r_1 to r_I = Coefficient of correlation among casual factors.

a,b,c...I = Direct effect of characters 'a' to 'I' on y.

Scale for path analysis

Lenka and Mishra (1973) suggested a scale to classify the direct and indirect effects of independent variable as follows:

Rate of scale	Values of direct and indirect effects
Negligible	0.00-0.09
Low	0.10-0.19
Moderate	0.20-0.29
High	0.30-0.99
Very high	More than 0.99

Results

4. RESULTS

The experiment was conducted at Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara, during the year 2018-19, to evaluate the performance of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation under tropical plains. The study was done in October 2018. Ten genotypes were evaluated for vegetative, floral and post harvest characters. The experimental results are arranged in this chapter under four major headlines.

4.1. Vegetative characters

4. 2. Floral characters

4. 3. Incidence of pest and diseases

4.4. Post harvest characters

4.1 VEGETATIVE CHARACTERS

4.1.1 *Quantitative vegetative characters*

Data with respect to quantitative vegetative characters are presented in table 4.1.1 and 4.1.2.

4.1.1.1 **Plant height (cm)**

During the entire period of observation, the highest plant height was observed in variety Phule Ganesh Pink which was 21.32 cm, 61.93 cm, 68.86 cm at one, two and three month after planting (MAP) respectively. The variety Phule Ganesh Pink was closely followed by variety Phule Ganesh White with a height of 17.04 cm at one MAP. The varieties Phule Ganesh Violet (48.96 cm, 55.88 cm) and Phule Ganesh White (48.16 cm, 54.65 cm) were statistically on par at two and three MAP.



Plate 3. Different stages of nursery



Plate 4. Field view of China aster at full blooming stage

Table 4.1.1 Quantitative vegetative characters of China aster varieties

Varieties	Plant height (cm)			Number of Primary branches		Plant spread (cm)	
	1 MAP	2 MAP	3 MAP	2 MAP	3 MAP	2 MAP	3 MAP
Arka Kamini	13.42 ^{cd}	28.43 ^{ef}	36.05 ^{3de}	5.87 ^{cd}	7.13 ^{cd}	14.48 ^c	17.18 ^f
Arka Shashank	16.27 ^{bc}	32.26 ^{de}	44.23 ^{bcd}	4.12 ^{de}	5.98 ^d	18.82 ^c	22.44 ^{cdef}
Arka Archana	12.35 ^d	22.75 ^f	30.85 ^e	4.78 ^d	7.07 ^{cd}	13.92 ^c	19.67 ^{ef}
PG White	17.04 ^b	48.16 ^b	54.65 ^b	8.15 ^b	10.63 ^b	27.23 ^b	29.22 ^c
PG Violet	14.23 ^{bcd}	48.96 ^b	55.88 ^{ab}	8.96 ^b	10.44 ^b	35.88 ^a	40.08 ^b
PG Pink	21.32 ^a	61.93 ^a	68.86 ^a	11.53 ^a	14.25 ^a	41.17 ^a	50.08 ^a
PG Purple	14.61 ^{bcd}	40.09 ^c	49.34 ^{bc}	8.20 ^b	10.93 ^b	27.30 ^b	28.51 ^{cd}
AAC-1	16.16 ^{bc}	35.27 ^{cde}	39.68 ^{cde}	7.93 ^{bc}	10.35 ^b	28.49 ^b	26.83 ^{cde}
Local Pink	14.71 ^{bcd}	36.49 ^{cd}	40.99 ^{cde}	7.45 ^{bc}	8.52 ^{bc}	17.61 ^c	20.85 ^{def}
Mat White	8.49 ^e	11.92 ^g	14.32 ^f	2.06 ^e	2.39 ^e	6.25 ^d	7.69 ^g
C.V (%)	14.00	12.19	17.70	2.55	2.44	7.33	7.85
C.D (0.05)	3.57	7.66	13.20	19.04	16.27	18.47	17.43

The lowest plant height was recorded in variety Mat White during the entire period of observation (8.49 cm, 11.92 cm and 14.32 cm at one, two and three MAP respectively).

4.1.1.2 Plant spread (cm)

The observation for plant spread was taken only at two MAP and three MAP. The varieties Phule Ganesh Pink and Phule Ganesh Violet were on par in terms of plant spread at two MAP (41.17 cm and 35.88 cm respectively) whereas Phule Ganesh Pink was found to have maximum plant spread (50.08 cm) which was closely followed by Phule Ganesh Violet (40.08 cm) at three MAP. During the entire period of study variety Mat White was observed with lowest plant spread.

4.1.1.3 Number of primary branches

The observation regarding number of primary branches were also taken only at two MAP and three MAP. The number of primary branches was significantly highest in variety Phule Ganesh Pink (11.53) at two MAP. For this character, Phule Ganesh Violet (8.96), Phule Ganesh Purple (8.20) Phule Ganesh White (8.15), AAC-1 (7.93) and Local Pink (7.45) were on par at two MAP. The same trend was observed at three MAP. The lowest number of primary branches was produced by variety Mat White (2.06 and 2.39) during the study.

4.1.1.4 Stem girth (cm)

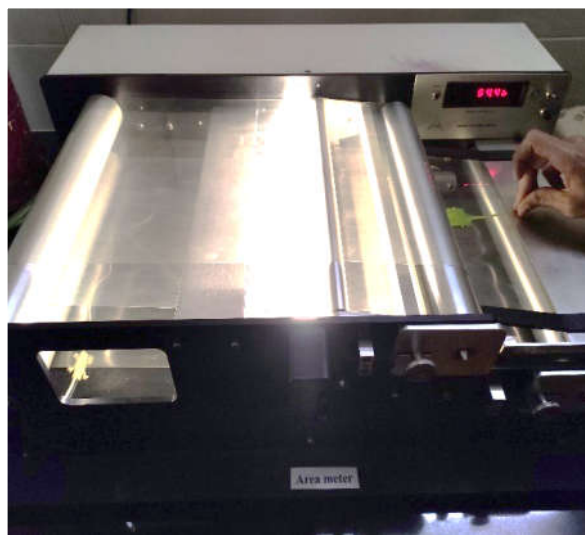
The maximum stem girth was observed in variety Phule Ganesh Pink (4.37 cm) which was on par with AAC-1 (3.71 cm) and lowest stem girth was exhibited by Mat White (2.51 cm) at one MAP

Table 4.1.2 Quantitative vegetative characters of China aster varieties – Contd.

Varieties	Number of leaves			Stem girth (cm)			Leaf area (cm ²)		
	1 MAP	2 MAP	3 MAP	1 MAP	2 MAP	3 MAP	1 MAP	2 MAP	3 MAP
Arka Kamini	8.67	19.20 ^d	26.47 ^e	3.49 ^{bc}	4.24 ^{cde}	5.12 ^{de}	11.42 ^d	18.08 ^c	23.49 ^{cd}
Arka Shashank	6.80	25.08 ^d	31.69 ^{cde}	2.79 ^{cd}	3.98 ^{de}	5.05 ^{de}	4.99 ^e	18.57 ^c	22.14 ^d
Arka Archana	6.00	23.05 ^d	28.43 ^{de}	3.02 ^{bcd}	4.04 ^{de}	4.56 ^{de}	12.92 ^{cd}	17.69 ^c	24.03 ^{cd}
PG White	7.60	40.05 ^b	48.22 ^{ab}	3.32 ^{bcd}	9.24 ^a	11.04 ^a	22.39 ^a	31.12 ^a	34.31 ^a
PG Violet	5.47	33.66 ^{bc}	41.84 ^{bc}	2.93 ^{bcd}	7.72 ^{ab}	8.95 ^{ab}	11.06 ^d	19.82 ^c	27.46 ^{bcd}
PG Pink	10.87	46.87 ^a	56.48 ^a	4.37 ^a	9.11 ^a	11.09 ^a	16.43 ^{bc}	24.9 ^b	28.66 ^{abc}
PG Purple	7.73	32.20 ^c	38.40 ^{bcd}	3.47 ^{bc}	6.02 ^{bc}	7.41 ^{bc}	17.38 ^b	26.27 ^b	30.52 ^{ab}
AAC-1	7.93	36.00 ^{bc}	39.18 ^{bcd}	3.71 ^{ab}	5.57 ^{cd}	6.21 ^{cd}	12.08 ^d	26.87 ^b	27.32 ^{bcd}
Local Pink	8.13	23.97 ^d	29.97 ^{de}	3.35 ^{bc}	4.72 ^{cd}	5.61 ^{cd}	12.35 ^{cd}	28.17 ^{ab}	28.65 ^{abc}
Mat White	5.80	6.76 ^e	12.69 ^f	2.51 ^d	2.54 ^e	3.19 ^e	2.59 ^e	5.72 ^d	8.02 ^e
C.V (%)		6.51	11.28	0.83	1.91	2.23	4.16	3.85	5.94
C.D (0.05)	NS	13.24	18.62	14.61	19.51	19.05	19.64	10.32	17.70



Measurement of vegetative characters



Measurement of leaf area using Leaf area meter



Measurement of flower stalk length

Plate 5. Measurement of different observations of China aster varieties

. Maximum stem girth was recorded in variety Phule Ganesh White (9.24 cm and 11.04 cm) which was on par with Phule Ganesh Pink (9.11 cm and 11.09 cm) and Phule Ganesh Violet (7.72 cm and 8.95 cm) and lowest in variety Mat White (2.54 cm and 3.19 cm) at two and three MAP respectively.

4.1.1.5 Number of Leaves

There was no significant variation among varieties with regard to number of leaves at one MAP. Significant variation in number of leaves could be observed at two and three MAP. The variety Phule Ganesh Pink was found to have maximum number of leaves at two MAP (46.87). Phule Ganesh Pink and Phule Ganesh White were on par in terms of this parameter at three MAP (56.48 and 48.22 respectively). The lowest number of leaves was recorded in the variety Mat White at two and three MAP (6.76 and 12.69).

4.1.1.6 Leaf area (cm²)

The leaf area differed significantly among the varieties. Maximum leaf area was observed in variety Phule Ganesh White followed by Phule Ganesh Purple at one MAP (22.39 cm² and 17.38 cm² respectively). Local Pink was on par with Phule Ganesh White in terms of this parameter at two MAP (28.17 cm² and 31.12 cm² respectively) whereas Phule Ganesh White, Phule Ganesh Purple, Phule Ganesh Pink and Local Pink which were superior and on par with respect to leaf area at three MAP (34.31 cm², 30.52 cm², 28.66 cm² and 28.65 cm² respectively). The lowest leaf area was reported in Mat White (2.59 cm², 5.72 cm² and 8.02 cm²) at all stages of observations taken.

4.1.2 Qualitative vegetative characters

The data pertaining to qualitative vegetative characters are depicted in table 4.1.2.1.

4.1.2.1 Leaf shape

The result reveals that, all the varieties except Arka Shashank were having ovate leaf shape and linear leaf shape was observed in this variety.

4.1.2.2 Leaf dentations

Leaf dentation was observed in all varieties evaluated.

4.1.2.3 Stem colouration

Stem colouration was absent in varieties *viz.* Arka Shashank, Arka Archana, Phule Ganesh White and Mat White which were having white flowers. Presence of stem colouration was observed in varieties namely Arka Kamini, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1 and Local Pink.

4.1.2.4 Leaf mid-rib colouration

Leaf mid-rib colouration was present in varieties such as Arka Kamini, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1 and Local Pink. Mid-rib coloration was absent in varieties which produced white coloured flowers such as Arka Shashank, Arka Archana, Phule Ganesh White and Mat White.

Table 4.1.2.1 Qualitative vegetative characters of China aster varieties

Varieties	Leaf dentation	Leaf mid-rib colouration	Stem colouration	Leaf shape
Arka Kamini	Present	Present	Present	Ovate
Arka Shashank	Present	Absent	Absent	Linear
Arka Archana	Present	Absent	Absent	Ovate
PG White	Present	Absent	Absent	Ovate
PG Violet	Present	Present	Present	Ovate
PG Pink	Present	Present	Present	Ovate
PG Purple	Present	Present	Present	Ovate
AAC-1	Present	Present	Present	Ovate
Local Pink	Present	Present	Present	Ovate
Mat White	Present	Absent	Absent	Ovate

4.2 FLORAL CHARACTERS

4.2.1 *Quantitative floral characters*

Data regarding to quantitative floral characters are presented in table 4.2.1 and 4.2.2.

4.2.1.1 Days to bud initiation

Early bud initiation was observed in variety Arka Shashank (44.40 Days after planting DAP) which was on par with varieties Arka Kamini (45.27 DAP), Mat White (46.27 DAP) and Arka Archana (47.13 DAP). The variety Phule Ganesh White took maximum number of days for bud initiation (73.67 DAP).

4.2.1.2 Days to complete flower opening

Days to complete flower opening among different varieties showed wide variation. The lowest number of days for complete flower opening was recorded in variety Arka Shashank (59.60 DAP) which was on par with varieties Arka Archana (60.80 DAP), Arka Kamini (61.40 DAP) and Mat White (63.40 DAP). The variety Phule Ganesh White (90.20 DAP) varied significantly among all other varieties with regard to this parameter and it took maximum number of days for complete flower opening followed by Phule Ganesh Violet (77.67 DAP) which was statistically on par with the variety Phule Ganesh Purple (76.20 DAP) and Phule Ganesh Pink (75.47 DAP).

4.2.1.3 Days to 50 per cent flowering

Among the varieties, the variety Arka Archana (67.00 DAP) exhibited minimum number of days for 50 per cent flowering and was on par with varieties, Arka Kamini (68.33 DAP), Mat White (69.33 DAP) and Arka Shashank (70.67



45 Days after planting



53 Days after planting



70 Days after planting



60 Days after planting

Plate 6. Different stages of flower development in China aster

DAP). The variety Phule Ganesh White (104.06 DAP) recorded maximum days to 50 per cent flowering.

4.2.1.4 Number of flowers per plant

The varieties varied significantly in terms of number of flowers per plant. Maximum number of flowers were produced by variety Arka Shashank (20.20) which was on par with varieties Arka Archana (18.47), Local Pink (18.47), Phule Ganesh Pink (17.73), Phule Ganesh White (16.93) and Arka Kamini (16.27). The variety Mat White (5.20) was registered with lowest number of flowers per plant.

4.2.1.5 Flower stalk length (cm)

Flower stalk length was the highest in Phule Ganesh Pink (21.13 cm) which was on par with other varieties Phule Ganesh Purple (20.61 cm), Phule Ganesh Violet (19.73 cm), AAC-1 (18.27 cm) and Phule Ganesh White (17.77 cm). This was followed by variety Local Pink (13.56 cm) and was statistically on par with variety Arka Kamini (11.95 cm) and Arka Archana (11.07 cm). The lowest flower stalk length was noticed in Mat White (3.02 cm).

4.2.1.6 Flower weight (g)

The flower weight differed significantly among the varieties and highest flower weight was recorded in the variety Phule Ganesh Pink (6.94 g) followed by variety Phule Ganesh White (5.45 g) and this was on par with AAC-1 (4.70 g). The lowest flower weight was recorded in Mat White (1.63 g) which was on par with other varieties Arka Shashank (1.93 g) Arka Archana (1.94 g) and Arka Kamini (2.35 g).



Local Pink



PG Purple



Mat White



PG Violet



PG Pink



PG White

Plate 7. Flowers of different varieties of China aster

Table 4.2.1 Quantitative floral characters of China aster varieties

Varieties	Days to bud initiation	Days to complete flower opening	Days to 50% flowering	Number of flowers/plant	Flower stalk length (cm)	Flower weight (g)	Flower head diameter (cm)
Arka Kamini	45.27 ^f	61.40 ^e	68.33 ^d	16.27 ^{abc}	11.95 ^{bc}	2.35 ^{de}	5.46 ^{bc}
Arka Shashank	44.40 ^f	59.60 ^e	70.67 ^d	20.20 ^a	9.71 ^c	1.93 ^e	3.89 ^{de}
Arka Archana	47.13 ^{ef}	60.80 ^e	67.00 ^d	18.47 ^{ab}	11.07 ^{bc}	1.94 ^e	4.71 ^{cd}
PG White	73.67 ^a	90.20 ^a	104.06 ^a	16.93 ^{abc}	17.77 ^a	5.45 ^b	5.78 ^b
PG Violet	59.80 ^b	77.67 ^b	88.00 ^b	15.27 ^{bc}	19.73 ^a	3.96 ^c	6.27 ^{ab}
PG Pink	55.53 ^c	75.47 ^{bc}	81.67 ^c	17.73 ^{ab}	21.13 ^a	6.94 ^a	7.07 ^a
PG Purple	55.87 ^{bc}	76.20 ^{bc}	90.00 ^b	14.80 ^{bc}	20.61 ^a	4.15 ^c	6.22 ^{ab}
AAC-1	52.87 ^{cd}	72.33 ^{cd}	80.20 ^c	13.47 ^c	18.27 ^a	4.70 ^{bc}	6.04 ^{ab}
Local Pink	51.07 ^{de}	70.13 ^d	82.13 ^c	18.47 ^{ab}	13.56 ^b	3.57 ^{cd}	5.66 ^{bc}
Mat White	46.27 ^f	63.40 ^e	69.33 ^d	5.20 ^d	3.02 ^d	1.63 ^E	3.31 ^e
CV (%)	4.51	3.75	3.99	15.17	15.23	16.96	11.35
C.D (0.05)	4.12	4.54	4.37	4.08	3.84	1.26	1.06

4.2.1.7 Flower head diameter (cm)

The flower diameter significantly differed in all the varieties and maximum flower diameter was observed in variety Phule Ganesh Pink (7.07 cm). This was on par with varieties Phule Ganesh Violet (6.27 cm), Phule Ganesh Purple (6.22 cm) and AAC-1 (6.04 cm). The flower diameter was exhibited as the lowest in variety Mat White (3.31 cm) which was on par with variety Arka Shashank (3.89 cm).

4.2.1.8 Number of disc florets per head

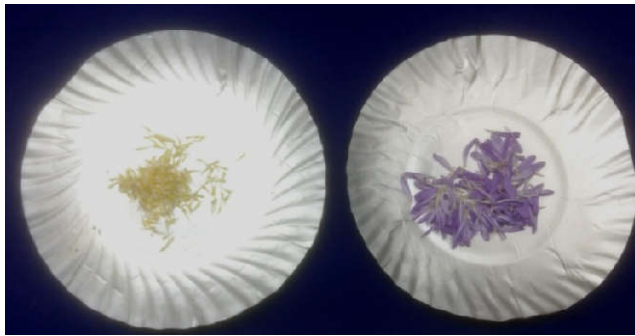
The highest number of disc florets was observed in the variety Phule Ganesh White (251.00) followed by Local Pink (223.87) and AAC-1 (204.4). The lowest number of disc florets was documented in the variety Arka Shashank (55.87) which was on par with variety Mat White (69.93).

4.2.1.9 Number of ray florets per head

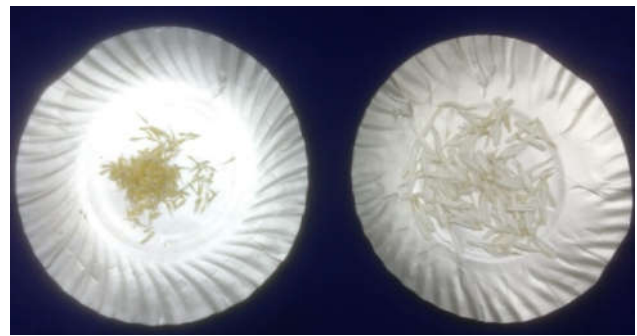
The number of ray florets varied significantly among different varieties of China aster and highest number of ray florets were observed in variety Phule Ganesh Pink (201.2) followed by Phule Ganesh Purple (158.27) and Phule Ganesh Violet (146.07). The lowest number of ray florets was registered in variety Mat White (55.67).

4.2.1.10 Flower yield per plant (g)

Flower yield per plant varied significantly among different varieties of China aster. The maximum flower yield was observed in variety Phule Ganesh Pink (55.99 g) followed by Phule Ganesh White (44.50 g) and was at par with varieties Local Pink (40.43 g), Phule Ganesh Purple (38.09 g) and AAC-1 (35.19 g). Lowest flower yield was recorded in Mat White (4.16 g).



a.



b.



c.



d.

Plate 8. Disc and ray florets of China aster varieties
a. PG Purple b. PG White c. PG Violet d. AAC 1

4.2.1.11 Duration of flowering

The data reveals that maximum duration of flowering was recorded in variety Local Pink (62.40 days) which was significantly superior from all other varieties of China aster evaluated and was on par with variety Phule Ganesh Pink (60.60 days). This was followed by Phule Ganesh White (58.47 days). The duration of flowering was recorded the lowest in the variety Mat White (45.20 days) and Arka Archana (47.83 days) which were on par with each another.

4.2.1.12 Seed yield per flower (g)

The seed yield per flower was observed highest in variety Phule Ganesh White (1.27 g) followed by AAC-1 (1.15 g), Local Pink (1.04 g), Arka Shashank (0.86 g) which were on par with one another. The lowest seed yield was registered in Mat White (0.44 g).

4.2.1.13 Seed germination (%)

Seed germination was recorded highest in variety Phule Ganesh White (65.28) which was followed by Phule Ganesh Pink (62.50), AAC-1 (56.94), Mat White (53.33) and Local pink (43.33). The lowest germination was observed in variety Arka Shashank (6.25) which was on par with Arka Archana (6.25).

Table 4.2.2 Quantitative floral characters of China aster varieties – Contd.

Varieties	Number of disc florets/head	Number of ray florets/head	Flower yield (g)	Duration of flowering (days)	Seed yield per flower (g)	Seed germination (%)
Arka Kamini	189.73 ^c	84.53 ^f	21.39 ^e	51.53 ^{ef}	0.70 ^{bcd}	27.08
Arka Shashank	55.87 ^g	65.20 ^g	21.62 ^e	48.40 ^{fg}	0.86 ^{abcd}	6.25
Arka Archana	158.67 ^d	82.93 ^f	24.58 ^{de}	47.83 ^g	0.49 ^d	6.25
PG White	251.00 ^a	108.00 ^d	44.50 ^b	58.47 ^{bc}	1.27 ^a	65.28
PG Violet	11.009 ^e	146.07 ^c	33.73 ^{cd}	53.37 ^{de}	0.48 ^d	18.06
PG Pink	97.00 ^f	201.20 ^a	55.99 ^a	60.60 ^{ab}	0.58 ^{cd}	62.5
PG Purple	96.93 ^f	158.27 ^b	38.09 ^{bc}	56.20 ^{cd}	0.64 ^{cd}	8.33
AAC-1	204.40 ^c	88.47 ^{ef}	35.19 ^{bc}	52.80 ^{de}	1.15 ^{ab}	56.94
Local Pink	223.87 ^b	95.27 ^e	40.43 ^{bc}	62.40 ^a	1.04 ^{abc}	43.33
Mat White	69.93 ^g	55.67 ^h	4.16 ^f	45.20 ^g	0.44 ^d	53.33
CV (%)	6.99	4.94	18.98	3.99	16.81	
C.D (0.05)	17.58	9.19	10.41	3.67	0.53	

4.2.2 Qualitative floral characters

The qualitative floral characters of China aster varieties are depicted in table 4.2.2.1.

4.2.2.1 Flower colour

All the varieties were categorised under different colour groups as per RHS colour chart. The flower colour was Vivid reddish purple A in variety Arka Kamini. The varieties Arka Shashank, Arka Archana, Phule Ganesh White and Mat white were under white group NN 155 with colour White group C. The variety Phule Ganesh Violet came under violet blue group 93 with Strong violet B colour. Phule Ganesh Pink was under colour group red purple 73 having Deep purplish pink A colour. Phule Ganesh Purple was under purple violet group N 82 with Strong purple B. The variety AAC-1 and Local Pink were under red purple group NN 66 with Vivid purplish pink A.

4.2.2.2 Flower type

The variety Arka Shashank was having powderpuff type flower whereas flowers of all other varieties were semi double type.

Varieties		Colour group	Colour
Arka Kamini		Red purple group N74	Vivid reddish purple-B
Arka Shashank		White group NN155	White C
Arka Archana		White group NN155	White C
PG White		White group NN155	White C
PG Violet		Violet blue group-93	Strong Violet B
PG Pink		Red purple group 73	Deep purplish pink A
PG Purple		Purple-Violet group N82	Strong purple B
AAC-1		Red purple group NN66	Vivid purplish pink B
Local Pink		Red purple group NN66	Vivid purplish pink B
Mat white		White group NN155	White C

Plate 9. Colour variation among China aster varieties

Table 4.2.2.1 Qualitative floral characters in different China aster varieties

Varieties	Colour group	Colour	Flower Type
Arka Kamini	Red purple group N 74	Vivid reddish purple A	Semi double
Arka Shashank	White group NN 155	White group C	Powderpuff
Arka Archana	White group NN 155	White group C	Semi double
PG White	White group NN 155	White group C	Semi double
PG Violet	Violet blue group 93	Strong Violet B	Semi double
PG Pink	Red purple group 73	Deep purplish pink A	Semi double
PG Purple	Purple violet group N 82	Strong purple B	Semi double
AAC-1	Red purple group NN 66	Vivid purplish pink A	Semi double
Local Pink	Red purple group NN 66	Vivid purplish pink A	Semi double
Mat White	White group NN 155	White group C	Semi double

4.3 INCIDENCE OF PESTS AND DISEASES

Pest and disease incidence was comparatively less in China aster. At nursery level, infestation of leaf eating caterpillar was observed and Ekalux sprayed at the rate of 2 ml per litre of water. Minor attack of leaf miner was also noticed in nursery stage. Damping off was a serious disease at nursery level. To control the disease, irrigation was minimized and antracol was sprayed at the rate of 1g per litre of water.

At field level, leaf eating caterpillar and flower eating caterpillar were observed and were controlled by spraying Ekalux at the rate of 2ml per litre of water.

4.4 POST HARVEST PARAMETERS

The data on different post harvest characters are presented in the Table 4.4.1

4.4.1 Shelf life of flower (days)

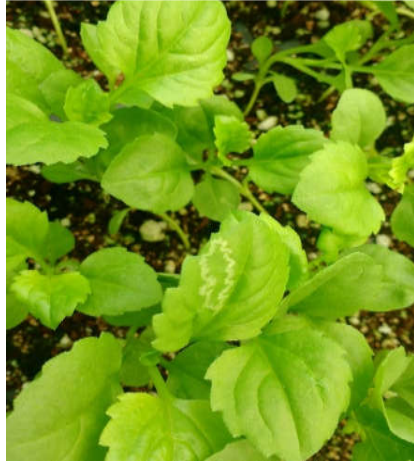
Longest shelf life was observed in the variety Phule Ganesh Pink (3.67 days) which was on par with Phule Ganesh White (3.33 days). The varieties Mat White, Arka Kamini, AAC-1 recorded lowest shelf life of 1.67 days which was on par with Local Pink (2.00 days), Arka Shashank (2.33 days) and Arka Archana (2.33 days).

4.4.2 Physiological loss in weight (%)

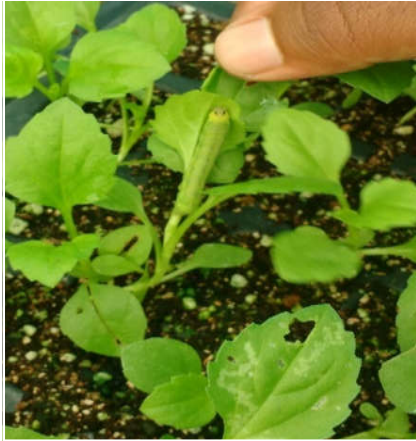
The variety Phule Ganesh White was registered with maximum physiological loss of weight (35.70 per cent) which was on par with the variety Phule Ganesh Purple (35.47 per cent), Arka Shashank (35.31 per cent), Phule Ganesh Violet (33.22 per cent) and AAC-1 (28.79 per cent). The lowest physiological loss of weight was recorded in Mat White (20.42 per cent).



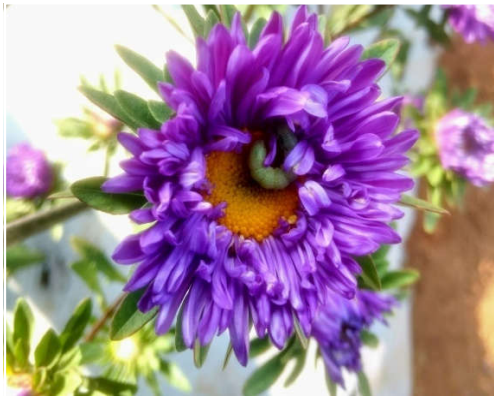
Damping off



Leaf miner



Leaf eating caterpillar



Flower eating caterpillar

Plate 10. Incidence of pests and diseases in China aster



Vase life studies



Shelf life studies



Flower extracts for anthocyanin estimation

Plate 11. Post harvest studies of China aster varieties

4.4.3 Vase life of flower (days)

The vase life was highest in variety Phule Ganesh Pink (13.93 days) which was on par with Phule Ganesh Violet (12.20 days). This was followed by Phule Ganesh Purple (11.67 days) which was on par with varieties Phule Ganesh White (11.20 days), Local Pink (11.13 days), Arka Kamini (11.07 days), AAC-1 (10.47 days) and Arka Shashank (10.07 days). The lowest vase life was observed in variety Mat White (6.95 days).

4.4.2 Total water intake (ml)

The total water uptake was maximum in Phule Ganesh Pink (20.27 ml) which was on par with Arka Kamini (17.67 ml) and the minimum water uptake was recorded in Mat White (12.43 ml) which was on par with varieties Phule Ganesh Purple (12.80 ml), Local Pink (13.13 ml), Phule Ganesh Violet (13.13 ml) and AAC-1 (14.40 ml).

4.4.5 Anthocyanin content of flowers (mg/g)

The variety Phule Ganesh Violet recorded highest anthocyanin content of flowers (51.87 mg/g) followed by Arka Kamini (48.62 mg/g). Anthocyanin content was the lowest in Phule Ganesh Purple (40.36 mg/g). In white flowered varieties, anthocyanin was not detected.

Table 4.4.1 Post harvest characters of China aster varieties

Varieties	Shelf life of flower (days)	Physiological loss in weight (%)	Vase life of flower (days)	Total water uptake (ml)	Anthocyanin content (mg/g)
Arka Kamini	1.67 ^d	23.96 ^{bc}	11.07 ^{bc}	17.67 ^{ab}	48.62
Arka Shashank	2.33 ^{cd}	35.31 ^a	10.07 ^{bc}	14.87 ^{bc}	*ND
Arka Archana	2.33 ^{cd}	23.62 ^{bc}	9.07 ^{cd}	14.20 ^{bc}	*ND
PG White	3.33 ^{ab}	35.70 ^a	11.20 ^{bc}	14.00 ^{bc}	*ND
PG Violet	2.67 ^{bc}	33.22 ^a	12.20 ^{ab}	13.13 ^c	51.87
PG Pink	3.67 ^a	24.86 ^{bc}	13.93 ^a	20.27 ^a	43.11
PG Purple	2.33 ^{cd}	35.47 ^a	11.67 ^b	12.80 ^c	40.36
AAC-1	1.67 ^d	28.79 ^{ab}	10.47 ^{bc}	14.40 ^c	42.47
Local Pink	2.00 ^{cd}	22.87 ^{bc}	11.13 ^{bc}	13.13 ^c	44.18
Mat White	1.67 ^d	20.42 ^c	6.95 ^d	12.43 ^c	*ND
CV (%)	16.43	16.33	15.28	14.69	
CD (0.05)	0.93	7.91	2.21	3.62	

*ND- Not detected

4.5 DIVERSITY ANALYSIS

The extent of diversity among the varieties determines the success of any breeding programme. Selection of parents from diverse varieties results in better improvement on the characters. Cluster analysis was done using D^2 statistics and dendrogram was constructed by Agglomerative method (Day and Edelsbrunner, 1984).

4.5.1 Cluster analysis based on qualitative characters

The varieties included in different clusters of dendrogram based on qualitative characters are furnished in table 4.5.1. Two main clusters were formed among the 10 varieties. The varieties Arka Kamini, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1 and Local Pink were included under cluster one. The most important character that divided these varieties into two clusters was the flower colour. The varieties with Purple or Pink colour flower was grouped together to form cluster 1 and the varieties with white coloured flowers were placed in cluster 2. Cluster 2 had 4 varieties *viz.*, Arka Shashank, Arka Archana, Phule Ganesh White and Mat White. In addition to flower colour, stem colouration, and leaf mid-rib colouration were the other important characters used for cluster formation.

4.5.2 Cluster analysis based on quantitative characters

Dendrogram was constructed considering the quantitative characters and the result showed wide variation exist among the varieties and each variety fall into distinct class.

Table 4.5.1 Different clusters among the varieties of China aster

Cluster No.	No. of varieties	Name of varieties	Similar characters shared between varieties
Cluster 1	6	Arka Kamini, PG Violet, PG Pink, PG Purple, AAC-1, Local Pink	Purple/pink- flower colour Stem colouration present, Leaf mid-rib colouration present
Cluster 2	4	Arka Shashank, Arka Archana, Mat White, PG White	White-flower colour Stem colouration absent, Leaf mid-rib colouration absent

4.6 CORRELATION STUDIES

The correlation between vegetative and some of the floral characters were presented in table 4.6.1 and the correlation among vegetative, floral and meteorological parameters is given in table 4.6.2

4.6.1 Correlation between vegetative and floral characters

With regard to correlation among different vegetative characters, leaf area was positively and significantly correlated with number of primary branches (0.840), stem girth (0.740), number of leaves (0.808) and plant height (0.788). There was a significant positive correlation of plant spread with number of primary branches (0.910), stem girth (0.868), number of leaves (0.932) and plant height (0.937). A positive significant correlation of number of primary branches could be observed with stem girth (0.867), number of leaves (0.949) and plant height (0.908). Stem girth was positively and significantly correlated with number of leaves (0.939) and plant height (0.908). A significant positive correlation could be observed between number of leaves (0.939) and plant height (0.908). The number of leaves had a positive and significant correlation with plant height (0.953).

Regarding correlation among floral characters a positive significant correlation of flower yield could be observed with flower weight (0.933), flower diameter (0.894) and number of ray florets per head (0.866). There was a positive significant correlation of flower weight with flower diameter (0.858) and ray florets per head (0.804). Flower diameter and ray florets per head (0.848) were positively and significantly correlated to each other.

Table 4.6.1 Correlation between vegetative and floral characters of China aster varieties

	LA	PS	NPB	SG	NL	PH	NFL	FY	FW	FD	DF	RF
LA	1											
PS	.643*	1										
NPB	.840**	.910**	1									
SG	.740*	.868**	.867**	1								
NL	.808*	.932**	.949**	.939**	1							
PH	.788**	.937**	.908**	.908**	.953**	1						
NFL	.619	.396	.447	.243	.446	.538	1					
FY	.796**	.894**	.978**	.843**	.941**	.882**	.392	1				
FW	.700*	.847**	.922**	.843**	.918**	.832**	.151	.933**	1			
FD	.802**	.828**	.956**	.780**	.836**	.815**	.391	.894**	.858**	1		
DF	.538	-0.55	.243	.209	.182	.060	.139	.171	.263	.340	1	
RF	.576	.894**	.875**	.796**	.805**	.839**	.271	.866**	.804**	.848**	-.131	1

LA- Leaf area, PS- Plant spread, NPB- Number of primary branches, SG- Stem girth, NL- Number of leaves, PH- Plant height, NFL- Number of flowers/plant, FY- Flower yield/plant, FW- Flower weight, FD- Flower diameter, DF- Disc florets/head, RF- Ray florets/head

Table 4.6.2 Correlation between vegetative, floral and meteorological parameters

	Max. temp. (°C)	Min. temp. (°C)	Mean RH (%)	Mean sunshine hours
Plant height (cm)	-0.646**	0.648**	0.291	-0.048
Leaf area (cm ²)	0.296	-0.181	-0.648**	0.626**
Stem girth (cm)	0.279	-0.171	-0.602**	0.570**
No. of leaves	0.322	-0.180	-0.778**	0.768**
No. of flowers/plant	-0.477**	0.226	0.147	-0.390*
Flower yield (g)	-0.514**	0.095	0.020	0.514

4.6.2 Correlation among vegetative, floral and meteorological characters

Plant height had a negative, significant correlation with maximum temperature (-0.646) and a positive, significant correlation with minimum temperature (0.648). Leaf area showed significant, negative correlation with mean relative humidity (-0.648) and a positive, significant correlation with mean sun shine hours (0.626). There was a negative significant correlation between stem girth and relative humidity (-0.602) and positive significant correlation with mean sun shine hours (0.570). Number of leaves was negatively and significantly correlated with mean relative humidity (-0.778) whereas positively correlated with mean sun shine hours (0.768). A negative significant correlation was exhibited between number of flowers and maximum temperature (-0.477) and between number of flowers and mean sun shine hours (-0.390). Flower yield also showed negative significant correlation with maximum temperature (-0.540).

4.7 PATH ANALYSIS

4.7.1 Direct effects of flower yield per plant

The direct and indirect effects of various characters on flower yield per plant in China aster are depicted in Table 4.7.1. High direct effect on flower yield per plant was exhibited by flower weight (0.498) whereas moderate direct effect was exhibited by leaf area (0.281). Low positive direct effect was revealed by number of primary branches (0.150) and plant spread (0.199). Stem girth showed negative direct effect on flower yield (-0.135).

4.7.2 Indirect effects on flower yield per plant

4.7.2.1 Plant height

Plant height had a low positive indirect effect (0.176, 0.124, 0.173) on flower yield through moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and plant spread (0.199). High positive indirect effect (0.357) was expressed through the high direct effect of flower weight (0.498). Plant height had low negative indirect effect (-0.119) on flower yield per plant *via* the low negative direct effect of stem girth (-0.135).

4.7.2.2 Stem girth

Stem girth exhibited low positive indirect effect on flower yield (0.164, 0.122 and 0.170) through the moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and plant spread (0.199). High positive indirect effect (0.431) was revealed through high direct effect of flower weight (0.498).

4.7.2.3 Number of leaves

The number of leaves had a low positive indirect effect on flower yield per plant (0.191, 0.130 and 0.177) *via* moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and plant spread (0.190). High positive indirect effect (0.436) was exhibited through the high direct effect of flower weight (0.498).

4.7.2.4 Leaf area

Leaf area showed low positive indirect effect on flower yield per plant (0.109 and 0.111) through low positive direct effect of number of primary

branches (0.150) and plant spread (0.190). Moderate indirect effect (0.295) was also exhibited through the high direct effect of flower weight (0.498).

4.7.2.5 Number of primary branches

Number of primary branches had a moderate positive indirect effect (0.204) on flower yield per plant *via* moderate direct effect of leaf area (0.281). Low indirect effect (0.172) and high positive indirect effect (0.420) through the low direct effect of plant spread (0.199) and high direct effect of flower weight (0.498).

4.7.2.6 Plant spread

Plant spread exhibited low indirect positive effect (0.157 and 0.129) on flower yield per plant through moderate direct effect of leaf area (0.281) and low direct effect of number of primary branches (0.150). High positive indirect effect was exhibited through the high direct effect of flower weight (0.498).

4.7.2.7 Flower diameter

Flower diameter expressed a low positive indirect effect (0.149, 0.121 and 0.169) on flower yield per plant through moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and plant spread (0.199). High positive indirect effect (0.373) was revealed through the high direct effect of flower weight (0.498).

4.7.2.8 Number of disc florets

Number of disc florets had a low positive indirect effect (0.190, 0.123 and 0.153) on flower yield per plant through moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and plant spread

Table 4.7.1 Path analysis with direct and indirect effect on flower yield per plant in China aster

	Plant height	Stem girth	No. of leaves	Leaf area	No. of primary branches	Plant spread	Flower diameter	No of disc florets	Flower weight
Plant height	0.064	-0.119	-0.054	0.176	0.124	0.173	-0.025	0.060	0.377
Stem girth	0.056	-0.135	-0.055	0.164	0.122	0.170	-0.025	0.062	0.431
No. of leaves	0.055	-0.120	-0.062	0.191	0.130	0.177	-0.025	0.064	0.436
Leaf area	0.040	-0.078	-0.042	0.281	0.109	0.111	-0.018	0.058	0.295
No. of primary branches	0.052	-0.109	-0.054	0.204	0.150	0.172	-0.028	0.071	0.420
Plant spread	0.055	-0.115	-0.055	0.157	0.129	0.199	-0.029	0.067	0.401
Flower diameter	0.045	-0.096	-0.045	0.149	0.121	0.169	-0.035	0.066	0.373
No of disc florets	0.044	-0.096	-0.046	0.190	0.123	0.153	-0.027	0.086	0.405
Flower weight	0.048	-0.116	-0.054	0.166	0.126	0.160	-0.026	0.070	0.498

Residual effect are 0.12348

(0.199). High positive indirect effect (0.405) *via* the high direct effect of flower weight (0.498).

4.7.2.9 Flower weight

Flower weight exhibited a low indirect positive effect (0.166, 0.126 and 0.160) on flower yield per plant through the moderate direct effect of leaf area (0.281), low direct effect of number of primary branches (0.150) and of plant spread (0.199).

Discussion

5. DISCUSSION

China aster is an annual flowering crop grown for cut flowers as well as loose flowers. It is commercially cultivated for use in flower decoration, preparation of bouquets and garlands. It is widely cultivated in India due to its easy cultural practices, array of colours and varied uses. Commercial cultivation of China aster is mainly taken up by marginal and small farmers. The cultivation of the crop is mainly confined to the South Indian states of Karnataka, Andhra Pradesh and Tamil Nadu.

The experiment entitled 'Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation in tropical plains' was conducted in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara to evaluate the performance of China aster for cultivation in tropical plains.

The results of the study are discussed under the following main headlines incorporating other supporting works and literature available.

5.1. Vegetative characters

5.2. Floral characters

5.3. Incidence of pests and diseases

5.4. Post harvest characters

5.1 VEGETATIVE CHARACTERS

5.1.1 *Qualitative vegetative characters*

The leaf shapes generally found in China aster are linear, ovate and elliptic (DUS guidelines). Among the ten varieties evaluated for different qualitative characters, leaf shape was linear in variety Arka Shashank and all the other varieties were with ovate leaves. Leaf dentation was present in all the ten varieties evaluated. Leaf shape variation may be due to the genetic makeup of varieties. Presence of colouring pigments *viz.* anthocyanins impart a purplish colour to the

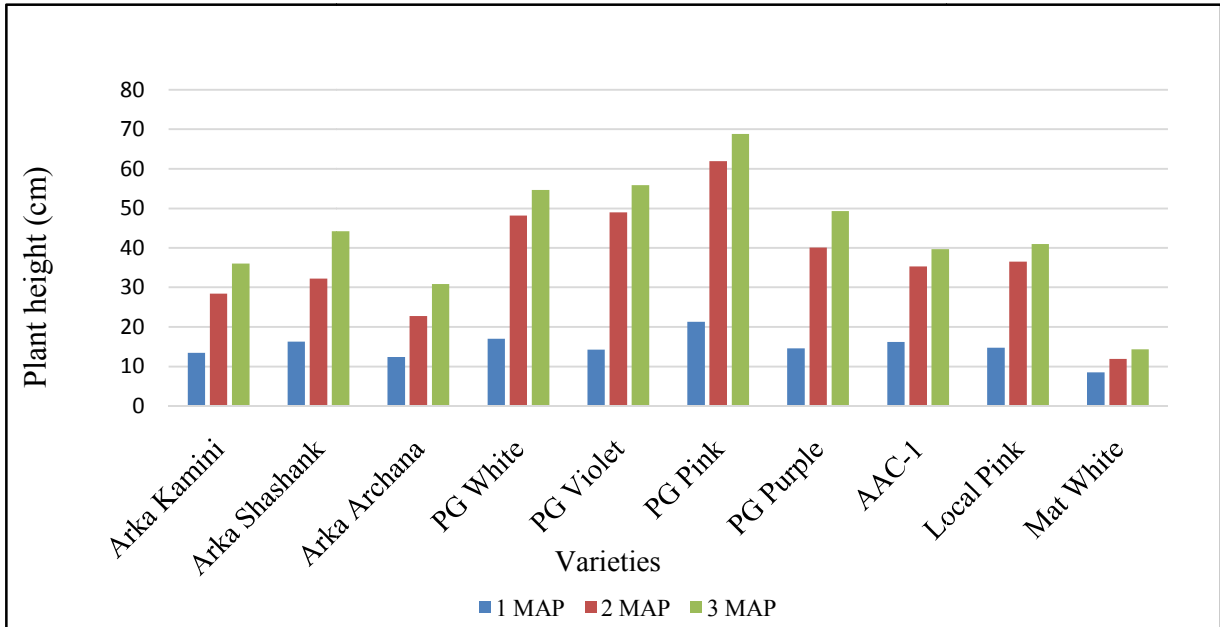


Fig. 1. Variation in plant height in China aster varieties

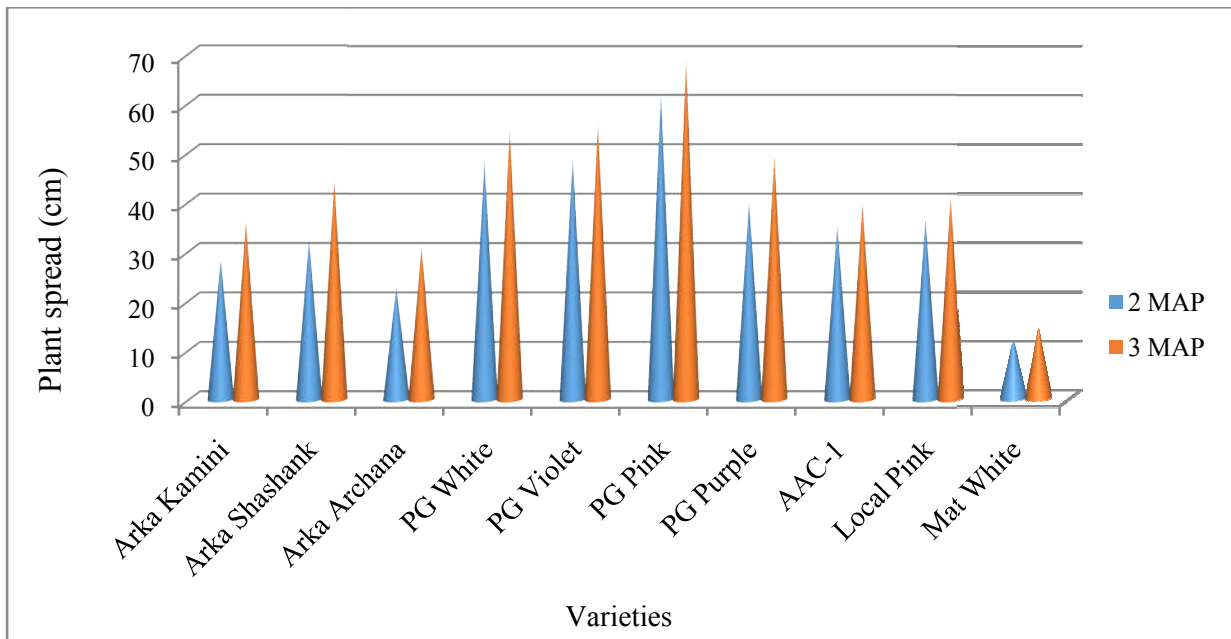


Fig. 2. Variation in plant spread in China aster varieties

stem. They contribute leaf mid rib colouration also. The stem colouration recorded in varieties that had flower colour and the colouration was absent in varieties having white coloured flowers. The variation in stem colouration is due to the presence of colouring pigments and genetic makeup of varieties.

5.1.2 Quantitative vegetative characters

All the vegetative characters are genetically controlled and sometimes express differently to growing environment (Bichoo *et al.*, 2002). The quantitative vegetative characters under observation are plant height, plant spread, number of primary branches, stem girth, number of leaves and leaf area. The plants of China aster are reported to attain a height of 60-80 cm depending upon the genotypes (Pandey and Rao, 2014). In the present study, plant height was observed maximum in the variety Phule Ganesh Pink 21.32 cm, 61.93 cm, 68.86 cm at one, two and three MAP respectively, whereas minimum plant height was exhibited by variety Mat White at all stages of observations (Fig. 1). The character plant height differed significantly within the varieties and being a varietal character, variation in the genetic makeup and better adaptability of the variety might be the reason for variation in plant height. Similar variations among the varieties were observed by Kulkarni and Reddy (2006) and by Chavan *et al.* (2010) in China aster. The vigorous growth of Phule Ganesh series of China aster in terms of plant height was also reported by Zosiamliana *et al.* (2013). Leaf characteristics such as length, orientation and arrangement have direct influence on plant spread, which is controlled by genotypic constitution. The plant spread was observed highest in variety Phule Ganesh Pink (41.17 cm and 50.08 cm) at two and three MAP (Fig.2) whereas minimum plant spread was recorded in variety Mat White (6.25 cm and 7.69 cm). Bhargav *et al.* (2019) reported highest plant spread of 42.15 cm for Phule Ganesh Pink at flowering stage and similar results were observed by Rai and Choudhary (2016). The number of primary branches of plant influence the plant spread, number of leaves and number of flowers per plant. The maximum number of primary branches was recorded in variety Phule Ganesh Pink (11.53 and 14.25) at all stages of observation recorded (Fig. 3). The primary branches

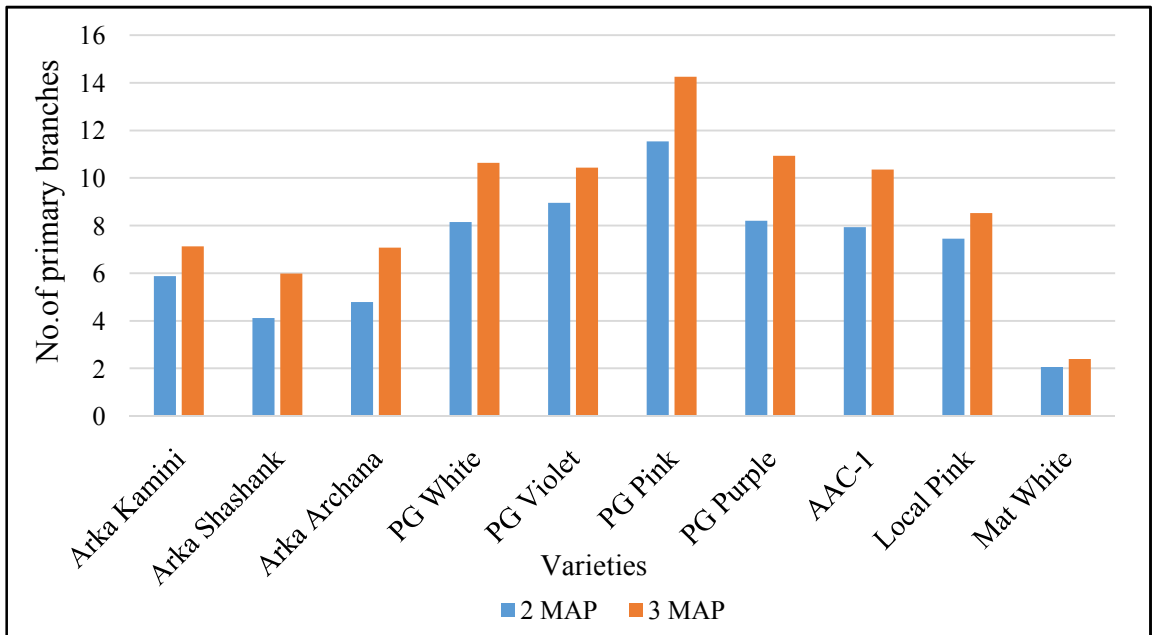


Fig. 3. Variation in number of primary branches in China aster varieties

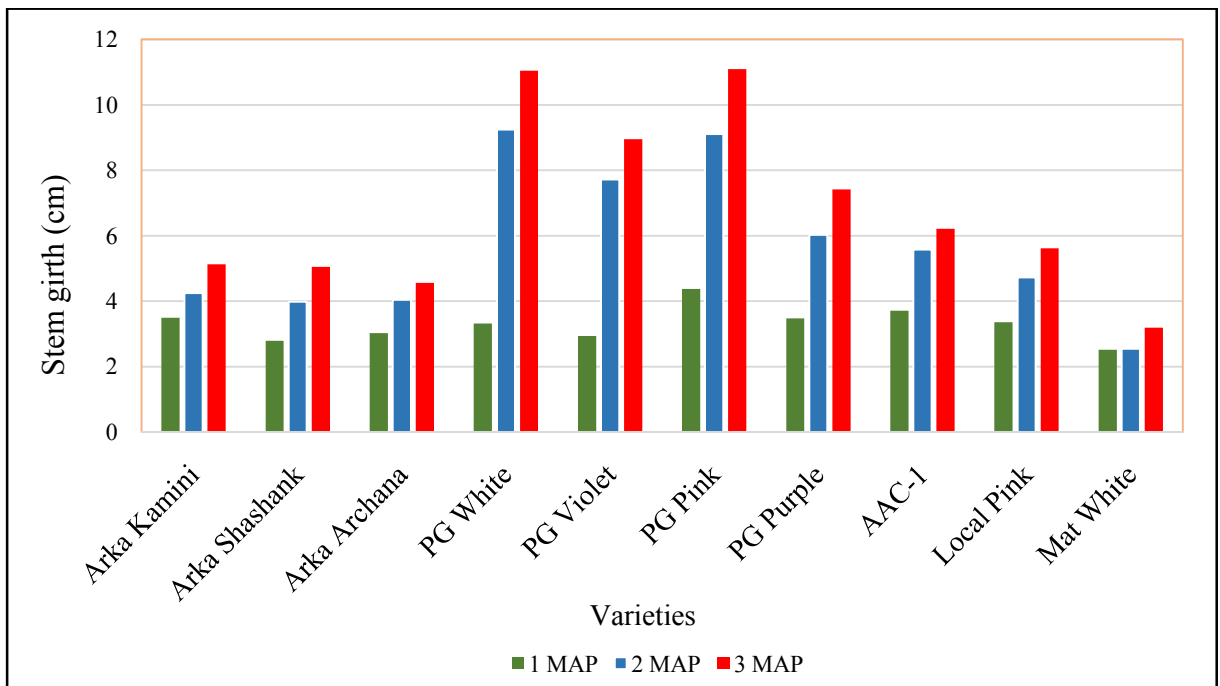


Fig. 4. Variation in stem girth in China aster varieties

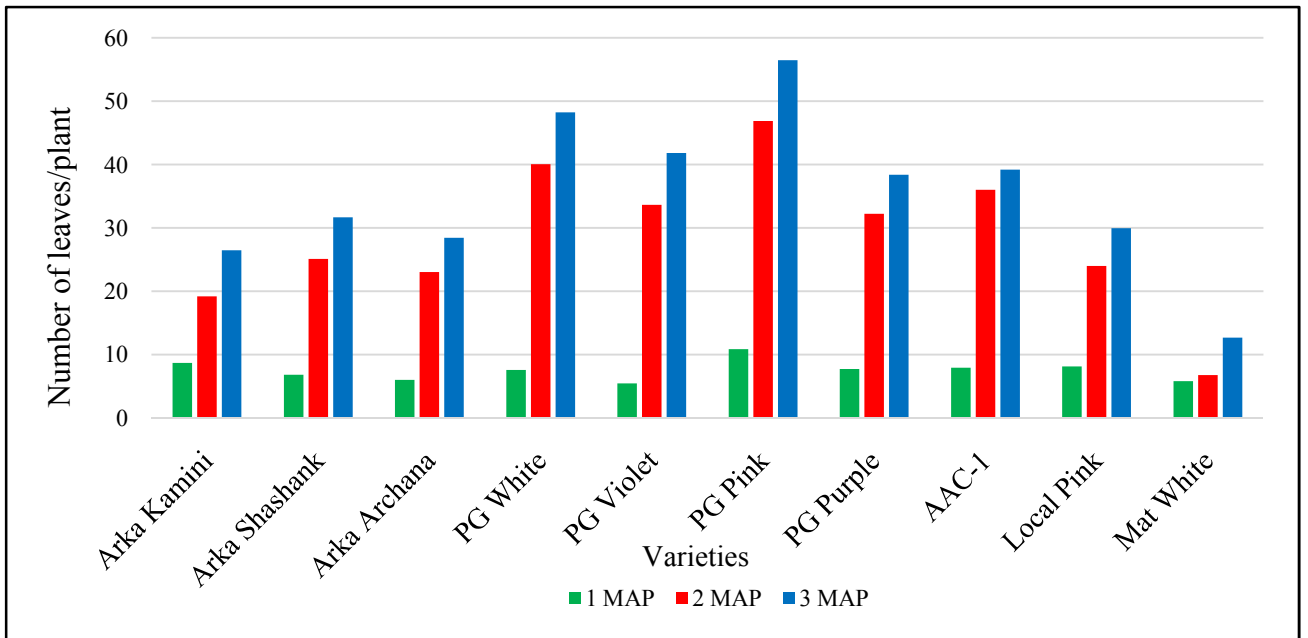


Fig. 5. Variation in number of leaves per plant in China aster varieties

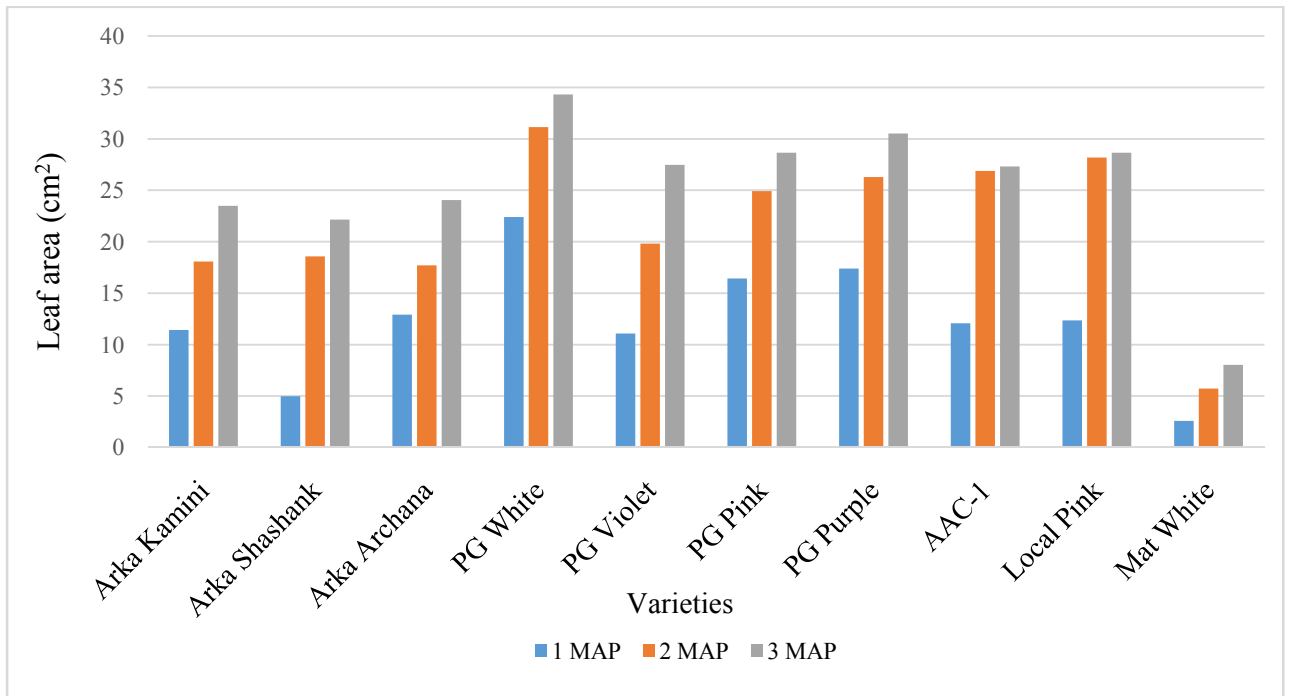


Fig. 6. Variation in leaf area in China aster varieties

were minimum in variety Mat White. The superiority of the variety Phule Ganesh Pink over other varieties may be due to the genetic makeup of the variety. Similar inference was found by Poornima *et al.* (2006) and by Chavan *et al.* (2010). Stem girth was highest in variety Phule Ganesh Pink (4.37 cm) at one month after planting while two month after planting, Phule Ganesh White (9.24 cm) had greatest stem girth. At three month after planting the varieties Phule Ganesh Pink (11.09 cm) and Phule Ganesh White (11.04 cm) were on par with one another. At all stages of observations recorded minimum stem girth was registered in variety Mat White (Fig. 4). The variation in stem diameter with respect to growing condition was documented by Budiarto and Marwoto (2009) in chrysanthemum and Nimisha (2016) in Marigold.

The maximum number of leaves was produced by variety Phule Ganesh Pink (46.87 and 56.48) at 2nd and 3rd month of planting while lowest number of leaves was produced by variety Mat White (Fig. 5). The superiority of Phule Ganesh Pink in terms of number of leaves might be due to genetic makeup and also because of the height of the plant (Dharmendra *et al.*, 2019). Variations in number of leaves were observed by Poornima *et al.* (2006) in China aster. At all the months of observations, the variety Phule Ganesh White (22.39 cm², 31.12 cm² and 34.31 cm²) was documented with highest leaf area whereas Mat White (2.59 cm², 5.72 cm² and 8.02 cm² at one, two and three MAP respectively) recorded the lowest leaf area (Fig. 6). The variation in leaf area could be due to genetic makeup of the varieties and similar variation among varieties were observed and reported in China aster by Poornima *et al.* (2006), Munikrishnappa and Chandrashekhar (2015) and Dharmendra *et al.* (2019).

5.2. FLORAL CHARACTERS

5.2.1 Qualitative floral characters

Colour is the most attractive trait of a flower and the choice of consumer varies widely with colour. The flowers were observed with various colours such as pure white, shades of pink, primrose, pale blue, mauve, purple, dark blue and

scarlet (Mukhopadhyay and Randhawa, 1986). The colour of the flowers were analysed using RHSCC. The variety Arka Kamini was having Vivid reddish purple A colour (Red purple group N74). Arka Shashank, Arka Archana, Phule Ganesh White and Mat White were under White group C colour (White group NN 155). The variety Phule Ganesh Violet came under Strong violet B colour (Violet blue group 93). Phule Ganesh Pink was under colour group having Deep purplish pink A colour (Red purple group 73). Phule Ganesh Purple was under Strong purple B colour (Purple violet group N 82) while varieties AAC-1 and Local Pink were with Vivid purplish Pink A colour (Red purple group NN 66). The variation in flower colour is due to the varietal characters mainly variation in colouring pigment anthocyanin present in the varieties. The results were in agreement with findings of Jagtap (2013) and Rai and Choudhary (2016).

In China aster generally two flower types are noticed, powderpuff and semidouble. The variety Arka Shashank was having powderpuff type flowers while all other varieties were semi double type. The variation in flower type is also due to the varietal character. Similar results were reported by Kumari *et al.* (2017).

5.2.2 Quantitative floral characters

The earliness of flower bud initiation is a desirable character as it helps in early flowering and thereby increases the profit of farmers (Singh *et al.* 2014). The earliness for bud initiation was documented in variety Arka Shashank (44.40 DAP) and bud initiation was late in variety Phule Ganesh White (73.67 DAP). Once the flower bud formation has initiated, the time for development is reliant upon the temperature and genetic constitution (Lopez and Runkle, 2005). Rai and Choudhary (2016) observed that minimum days to first flower opening was recorded in Arka Shashank (77.25 days) while Phule Ganesh White (106.25 days) took maximum days to first flower opening. The results were confounded with the findings of Poornima *et al.* (2006) and of Kaushal *et al.* (2014). The variety Arka Shashank was earliest in complete flower opening (59.60 DAP) and Phule Ganesh

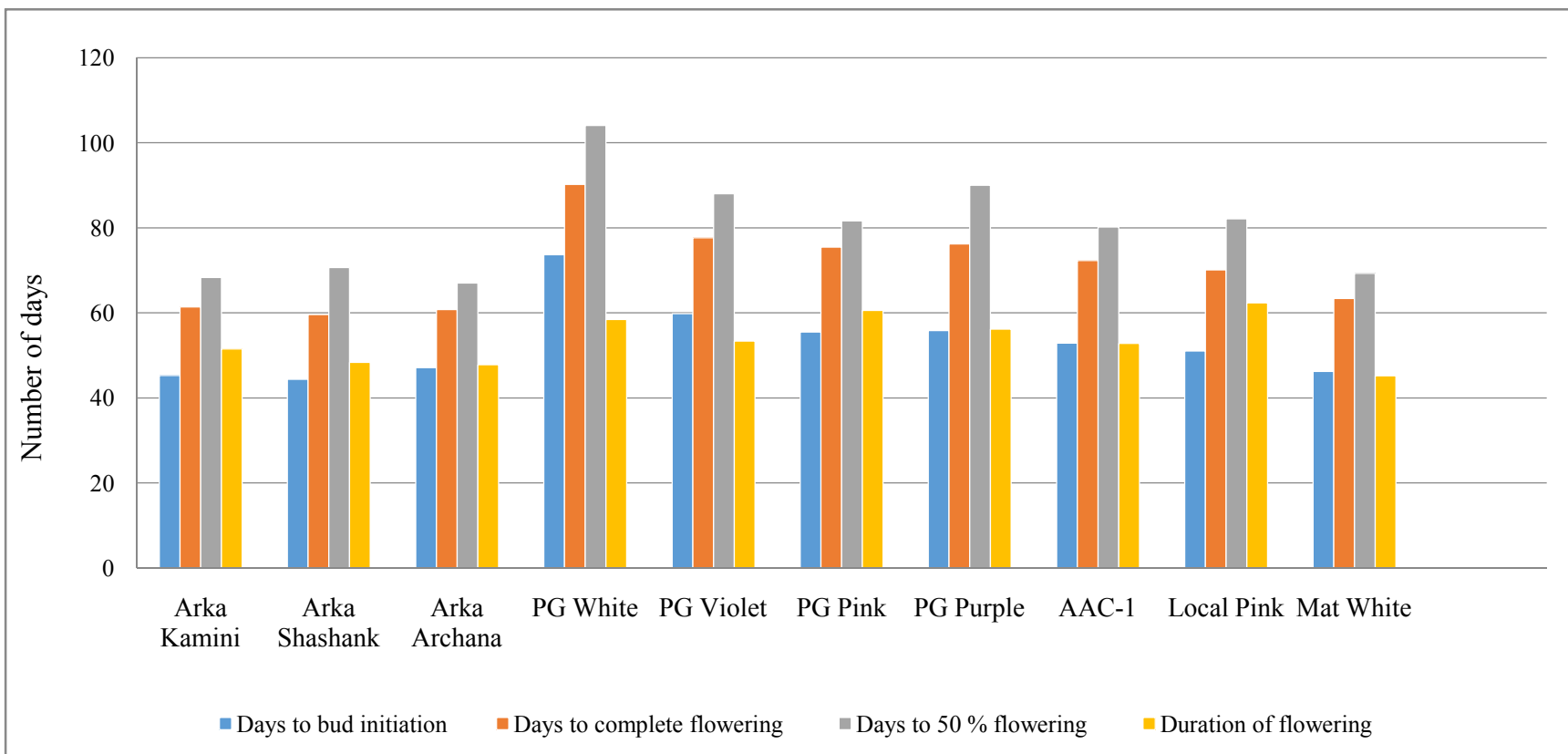


Fig. 7. Variation in flowering phenology of China aster varieties

White took more number of days (90.20 DAP) for complete opening of flowers. Dhiman (2003) opined that during favourable climatic conditions the accumulation of dry matter increases which induce earliness in flower opening. The results were in accordance with the findings of Chowdhuri *et al.* (2016), Rai and Chaudhary (2016) and Kaushal *et al.* (2014). The variety Arka Archana (67.00 DAP) took minimum number of days for 50% flowering whereas Phule Ganesh White (104.06 DAP) took maximum number of days for 50% flowering. The results were in agreement with the data of Rai and Chaudhary (2016). The maximum flowering duration indicates the availability of flowers for the market and it also highlights the usefulness of the plant for bedding purpose in landscape. Duration of flowering was highest in variety Local Pink (62.40 days) and was on par with Local Pink (60.60 days). The lowest duration of flowering was recorded in variety Mat White (45.20 days). The results were in accordance with the findings of Pandey and Rao (2014) (Fig. 7).

Number of flowers per plant is a yield contributing character and it varied significantly among the varieties. The maximum number of flowers was produced by variety Arka Shashank (20.20) while minimum number of flowers was recorded in variety Mat White (5.20) (Fig.8). The genetic makeup and the environmental factors are found to be deciding the yield contributing characters. The results were in agreement with the data of Kishanswaroop *et al.* (2004), Poornima *et al.* (2006) and Chowdhuri *et al.* (2016). Flower yield was highest in variety Phule Ganesh Pink (55.99 g) and was lowest in variety Mat White (4.16 g) (Fig.9). The increase in flower yield may be due to large sized flowers. The results are in agreement with the findings of Kulkarni and Reddy (2006).

The flower stalk length is regarded as the character preferred for cut flowers. The highest flower stalk length was recorded in variety Phule Ganesh Pink (21.13 cm) whereas least flower stalk length was observed in variety Mat White (3.02 cm) (Fig.10). The results were in conformity with the findings of Sreenivasulu *et al.* (2004) who reported that late flowering genotypes *viz.* Phule Ganesh White, Phule Ganesh Pink and Phule Ganesh Violet had bigger sized

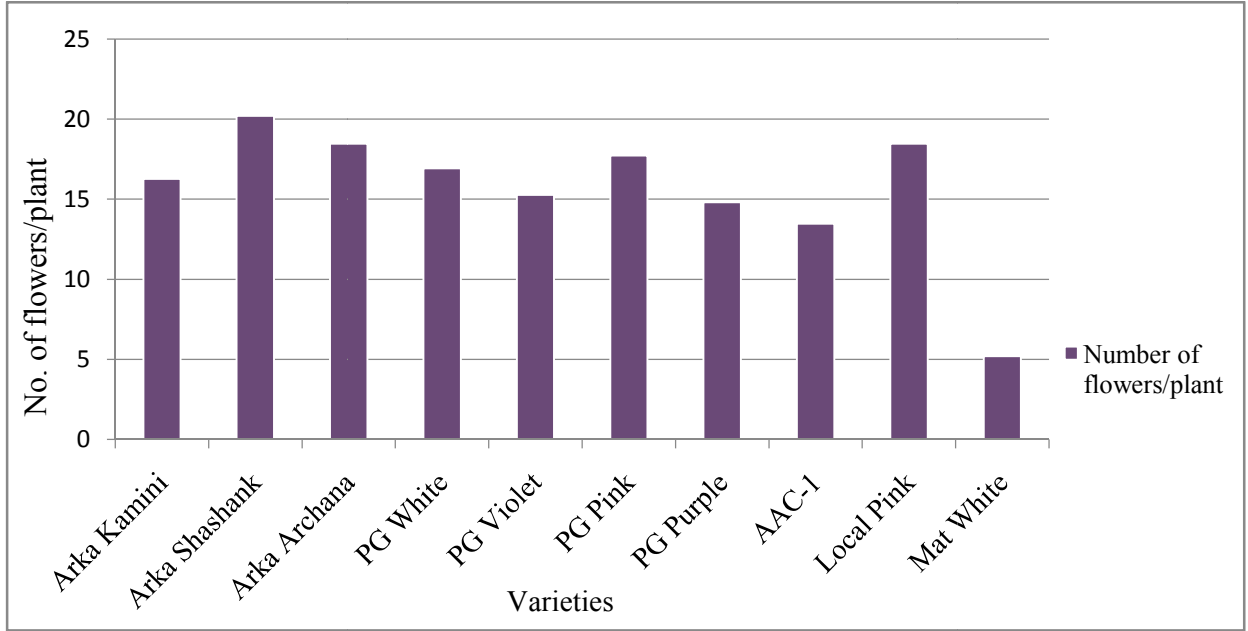


Fig. 8. Variation in number of flowers per plant in China aster varieties

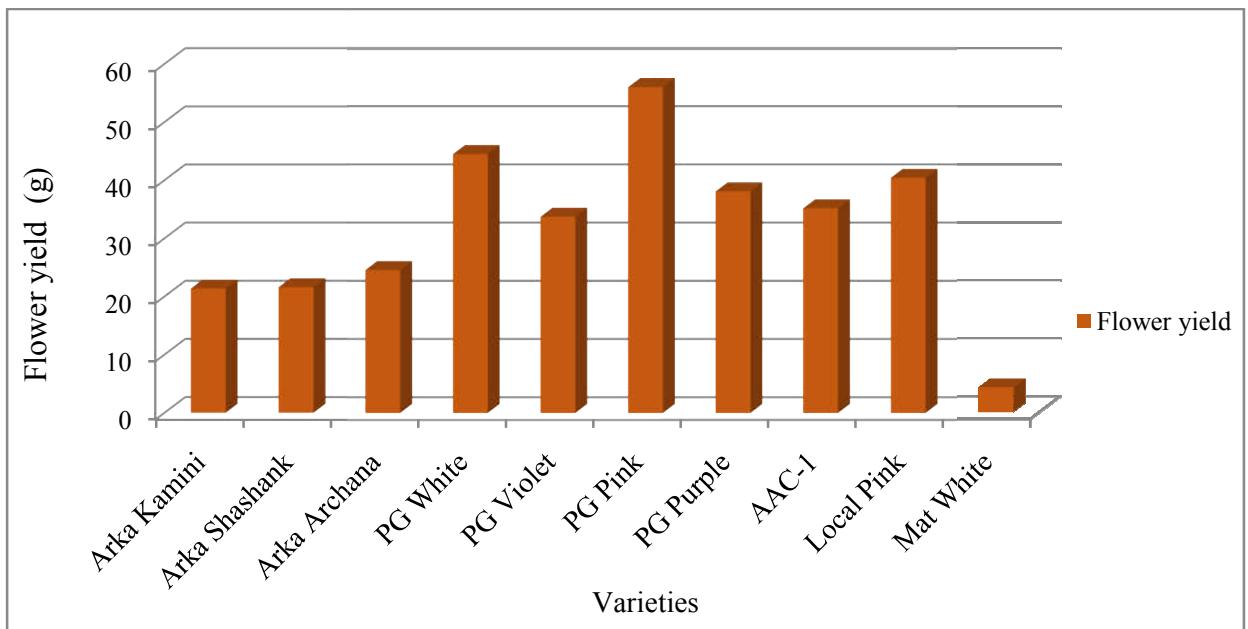


Fig. 9. Variation of flower yield in China aster varieties

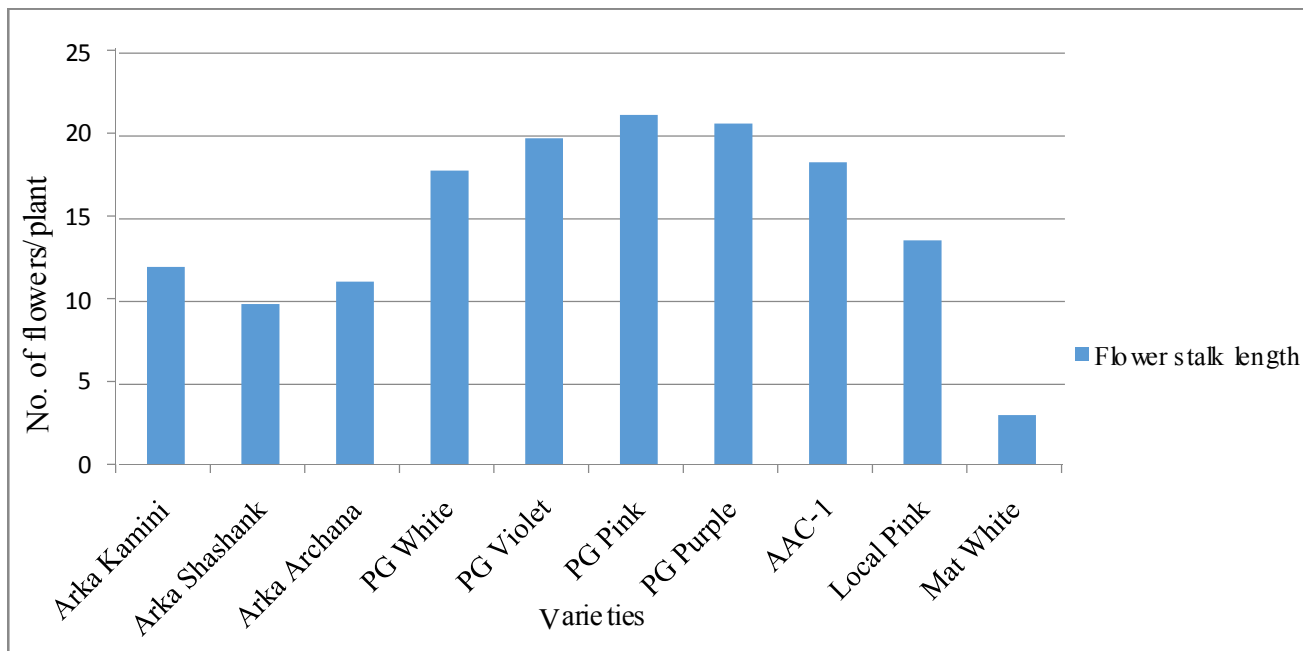


Fig. 10. Variation in flower stalk length in China aster

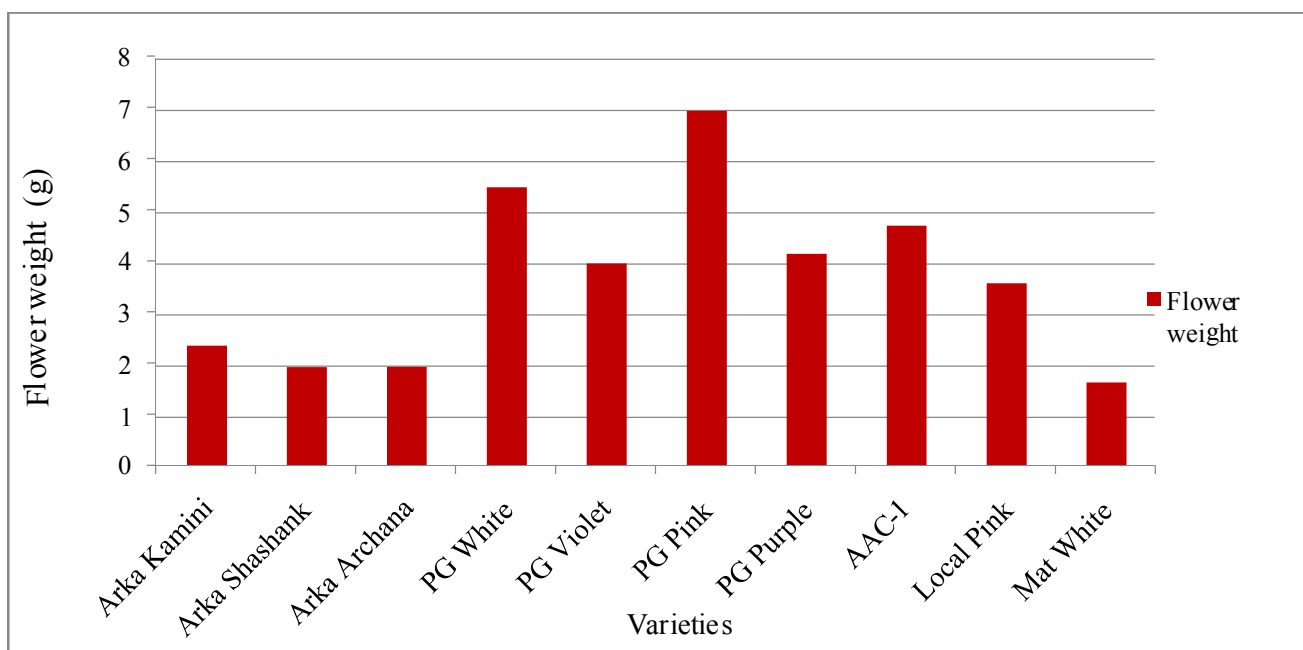


Fig. 11. Variation in flower weight of China aster varieties

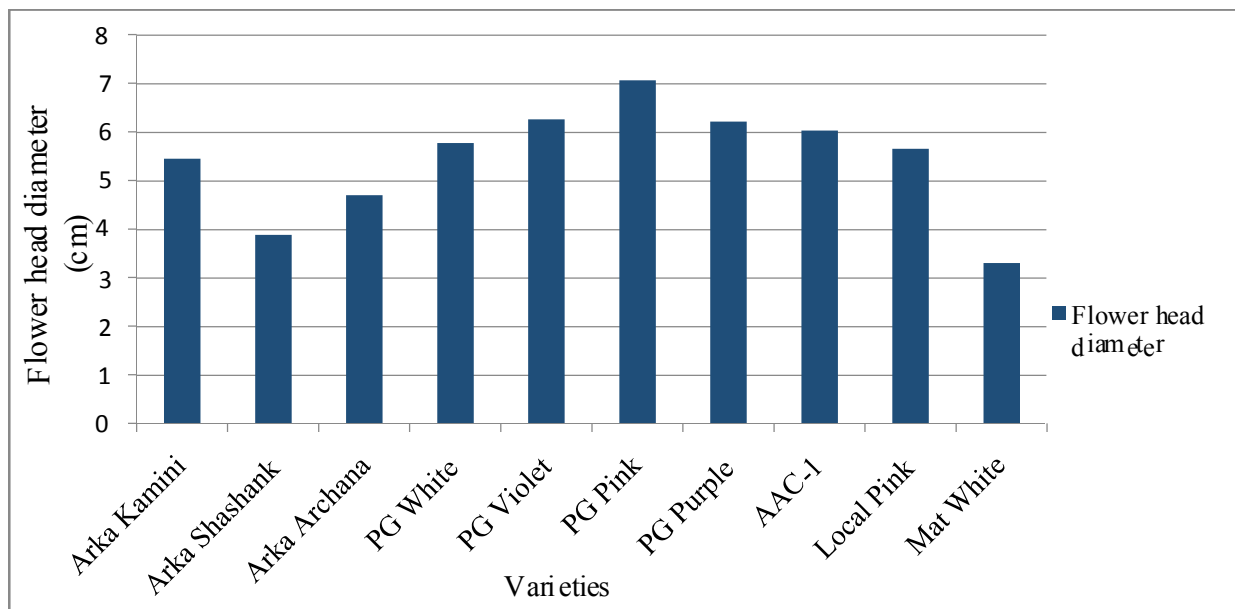


Fig.12. Variation in flower head diameter in China aster varieties

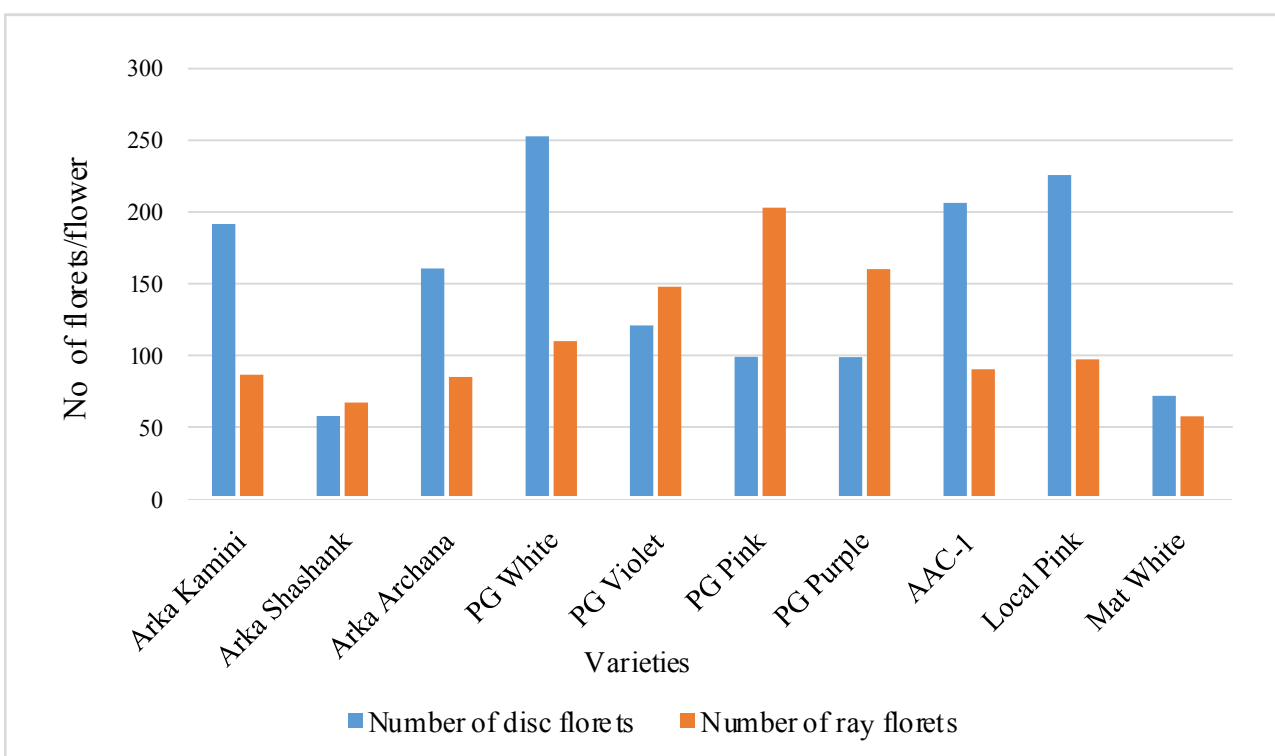


Fig. 13. Floret characters of China aster varieties

flower with larger stalks. Flower weight is an important character that contributes to the flower yield. Flower weight was recorded highest in variety Phule Ganesh Pink (6.94 g). Flower weight was observed lowest in variety Mat White (1.63 g) (Fig. 11) and the results were in accordance with the findings of Dharmendra *et al.* (2019). The character flower head diameter was also registered highest in variety Phule Ganesh Pink (7.07 cm) while lowest flower diameter was observed in variety Mat White (3.31 cm) (Fig.12) Sreenivasulu *et al.*, (2004) reported that Phule Ganesh White produced maximum flower diameter (7.15 cm) followed by Phule Ganesh Pink (6.46 cm) while comparing different genotypes of China aster. The result was confounded with the findings of Bharghav *et al.* (2019).

The flower of China aster is referred to as head or capitulum which consists of central disc florets (hermaphrodite) and outer ray florets (pistillate). The proportion of ray and disc florets determines the flower type also (Kumari *et al.*, 2018). According to Novotona (1989) tubular flower produce more seeds than ligulate flowers. Number of disc florets was highest in variety Phule Ganesh White (251.00) whereas lowest number of disc florets was recorded in variety Arka Shashank (55.87). Number of ray florets was maximum in variety Phule Ganesh Pink (201.20) and was least in Mat White (55.67). The number of ray florets influences the flower weight and thereby increases the flower yield (Fig. 13). The variation in the number of ray florets and disc florets may be due to the environmental condition prevailing during growing period Nagaraju *et al.* (2004).

The seed yield per flower was maximum in variety Phule Ganesh White (1.27 g) and minimum in variety Mat White (0.44 g). The seed setting is generally reliant on the ratio of disc and ray florets present in flower head and the season. Similar results were observed by Arunkumar (2012), Munikrishnappa *et al.* (2013), and Tirakannanvar *et al.* (2015) in China aster. Seed germination was highest in variety Phule Ganesh White (65.28 %) and lowest in variety Arka Archana and Arka Shashank (6.25 %). The good germination of seeds of Phule Ganesh White was also supported by the research findings of Arunkumar (2012) and Tirakannanvar (2015). China aster seeds lose viability very fast and climatic

condition accelerate seed deterioration and cause loss of viability of seeds (Vimala *et al.*, 2014). The high temperature occurred during the harvesting period (February–March) might have caused loss of viability and resulted in poor germination of seeds.

5.3 INCIDENCE OF PESTS AND DISEASES

The incidence of pest and disease was less in China aster and this might be due to the hardy nature of the crop. At nursery level, the attack of leaf eating caterpillar was observed and minor attack of serpentine leaf miner (*Liriyomyza brassicae*) was also noticed. Damping off (*Phythium sp.*) was observed at nursery level. In the main field level, attack of leaf eating caterpillar and flower eating caterpillar was noticed.

5.4 POST HARVEST CHARACTERS

Vase and shelf life are the important post harvest parameters which decide the longevity of flower in vase and shelf respectively. Longest shelf life was observed in the variety Phule Ganesh Pink (3.67 days) and was least in varieties viz. Mat White, Arka Kamini, AAC-1 (1.67 days). The reason for longer shelf life might be due to the higher fresh weight of flowers. The flowers for shelf life were kept in ambient temperature and variation in shelf life may be due to the genetic makeup of the variety. Similar results have been reported by Kishanswaroop *et al.* (2004), Pandey and Rao (2014) and Rai and Choudhary (2016). The reduction in flower weight due to respiration, transpiration and loss of resistance to microbial activity are the cause of physiological loss of weight (Madan *et al.* 2014). Physiological loss of weight was greatest in variety Phule Ganesh White (35.70 per cent) and lowest in variety Mat White (20.42 per cent). Physiological loss of weight was observed highest in variety with lowest fresh weight. Similar variation in physiological loss of weight was reported by Priyanka *et al.* (2017) in crossandra.

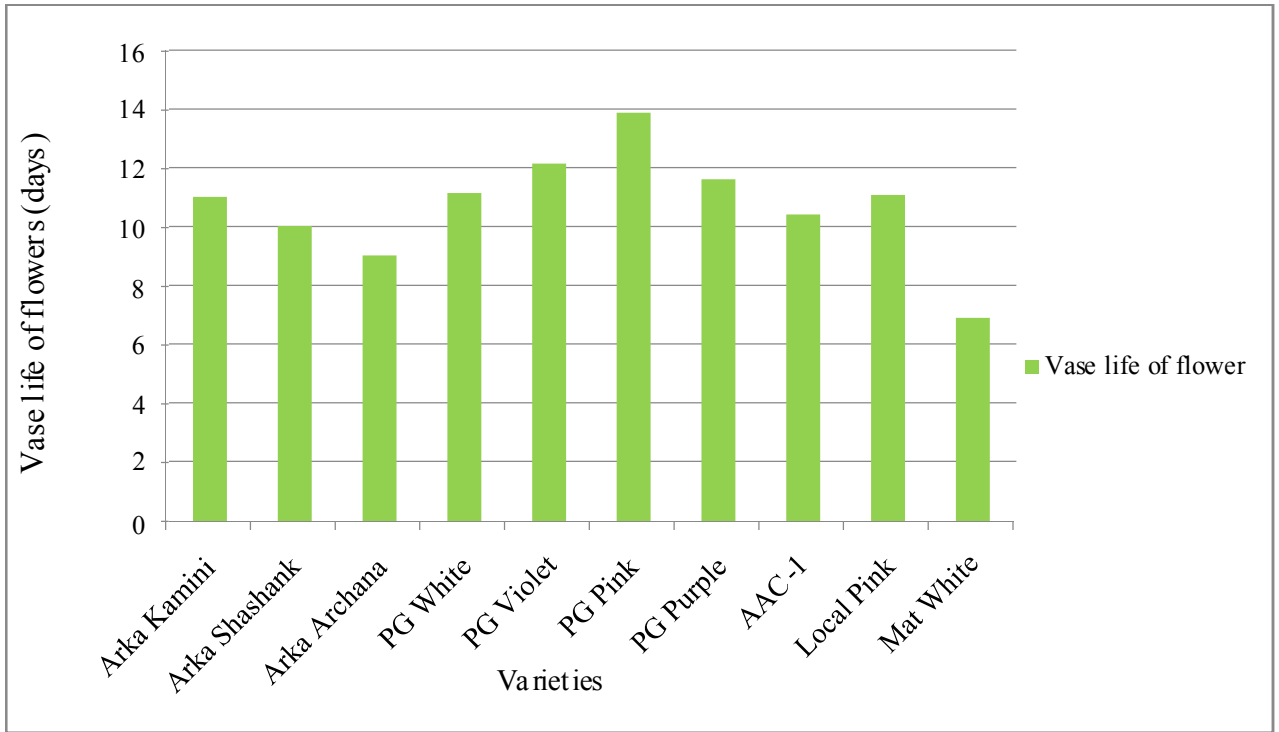


Fig. 14. Variation in vase life of China aster varieties

Vase life of China aster varieties varied significantly among the different varieties. Ravikumar (2002) observed that varieties Phule Ganesh Pink, Phule Ganesh Violet and Phule Ganesh White showed significantly higher vase life. The vase life was highest in variety Phule Ganesh Pink (13.93 days) which was on par with Phule Ganesh Violet (12.20 days) and lowest vase life was recorded in variety Mat White (6.95 days) (Fig. 14). The highest water uptake recorded by Phule Ganesh Pink might have resulted in the better vase life shown by the variety. The vase solution for all the varieties was the same (distilled water) and the variations observed in vase life may be due to the genetic makeup of varieties. Similar variations in vase life was observed by Zosiamliana *et al.* (2013) and Rai and Choudhary (2016). The total water uptake was maximum in Phule Ganesh Pink (20.27 ml) which was on par with Arka Kamini (17.67 ml) and least water uptake was recorded in Mat White (12.43 ml). The variety with longest vase life had greatest amount of water uptake. The result is similar to the findings of Vedamitra (2017) in gerbera.

Anthocyanins are group of intensely coloured water soluble colouring pigments responsible for pink, scarlet, red mauve, violet and blue colours in the petals and leaves (Harborne, 1998). They are the permitted pigments which can be utilized as food colourants (Janna *et al.*, 2005). Anthocyanin content of China aster flowers was estimated by UV- Vis photometry. Anthocyanin content was recorded greatest in variety Phule Ganesh Violet (51.87 mg/g) and lowest in variety Arka Kamini (48.62 mg/g). In white coloured flowers anthocyanin content was not detected. The variation in anthocyanin content may be due to the genetical make up or varietal character. Similar variations were observed by Gantait and Pal (2010) in chrysanthemum and Joshi (2012) in gerbera.

5.5 GENETIC DIVERGENCE IN CHINA ASTER VARIETIES

Before designing a breeding programme, the extent of diversity among genotypes has to be analysed and selection will be effective if parents are selected from a diverse group. Genetic divergence was done by cluster analysis.

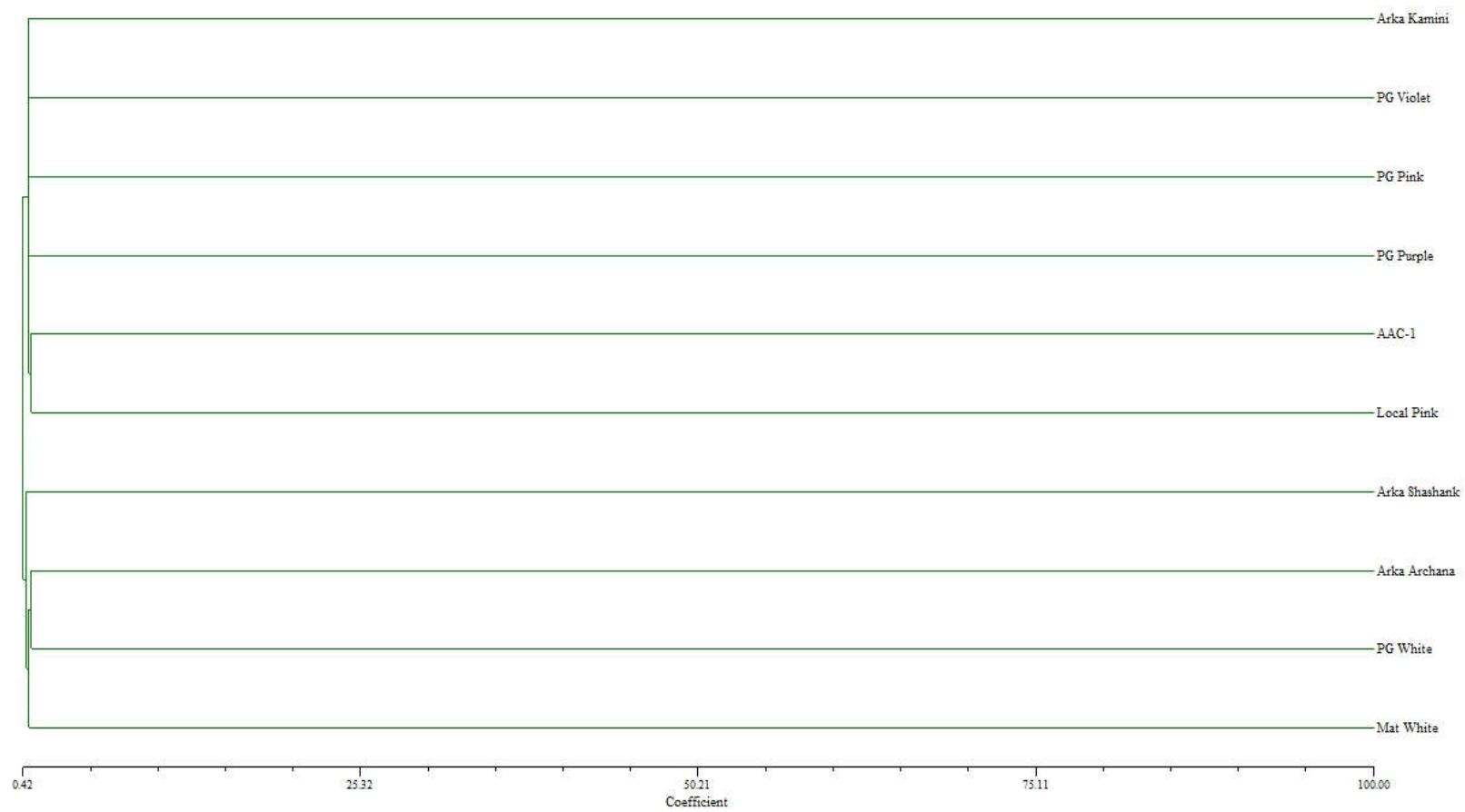


Fig. 15. Dendrogram for qualitative characters of China aster varieties

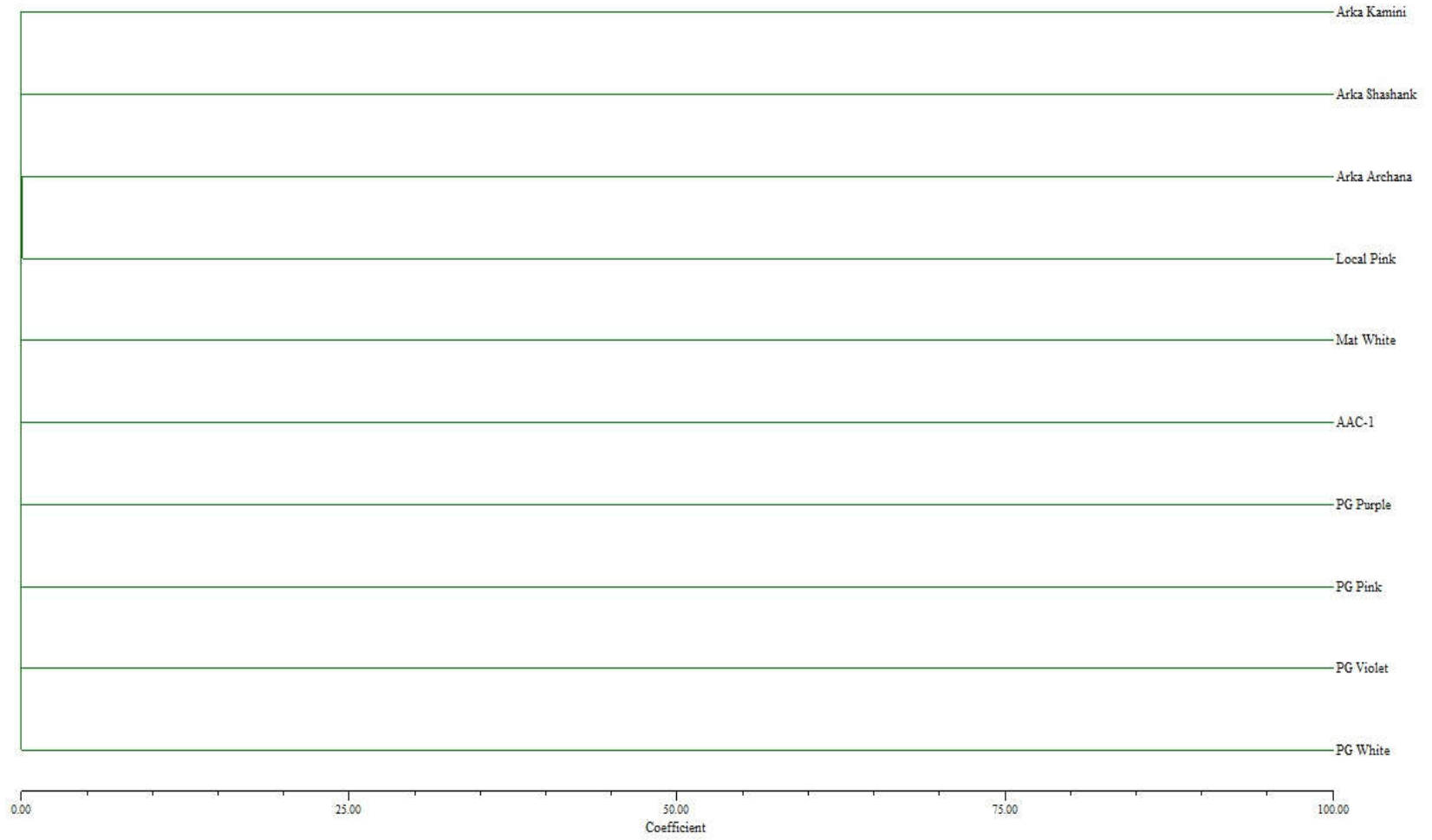


Fig. 16. Dendrogram for quantitative characters of China aster varieties

5.5.1 Cluster analysis based on qualitative characters

The varieties sharing similar characters were clustered into same group (Fig. 15). At 40 per cent similarity coefficient two clusters were formed which indicates high amount of variability present among the ten varieties.

The varieties Arka Kamini, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1 and Local Pink were grouped in Cluster 1. The genotypes with purple or pink colour were grouped together to form cluster 1 and these genotypes show presence of stem colouration and leaf mid rib colouration. The Cluster 2 included varieties *viz.* Arka Shashank, Arka Archana, Phule Ganesh White and Mat White sharing similarity in flower colour, stem colouration and mid rib colouration. The results were in pact with the findings of Chang *et al.* (2018) who clustered 88 chrysanthemum varieties based on the type of petal present on each varieties.

5.5.2 Cluster analysis based on quantitative data

All quantitative characters were considered for clustering and the result showed that they are highly variable and each genotype falls into distinct class (Fig. 16).

5.6 CORRELATION AND PATH ANALYSIS

Genetic relationship among the genotypes is vital for classification and utilization of germplasm (Kumar *et al.*, 2013). The correlation study helps in selection through other characters affecting the desirable character. The positive correlation indicates that both traits can be improved simultaneously as the improvement in one may bring improvement in the correlated trait (Sreenivasulu *et al.*, 2007). The path coefficient analysis suggested by Dewy and Lu (1959) splits the correlation into direct and indirect effects. This partitioning of total correlation provides, the information on contribution of the characters, forming the basis for selection of suitable characters to improve the yield.

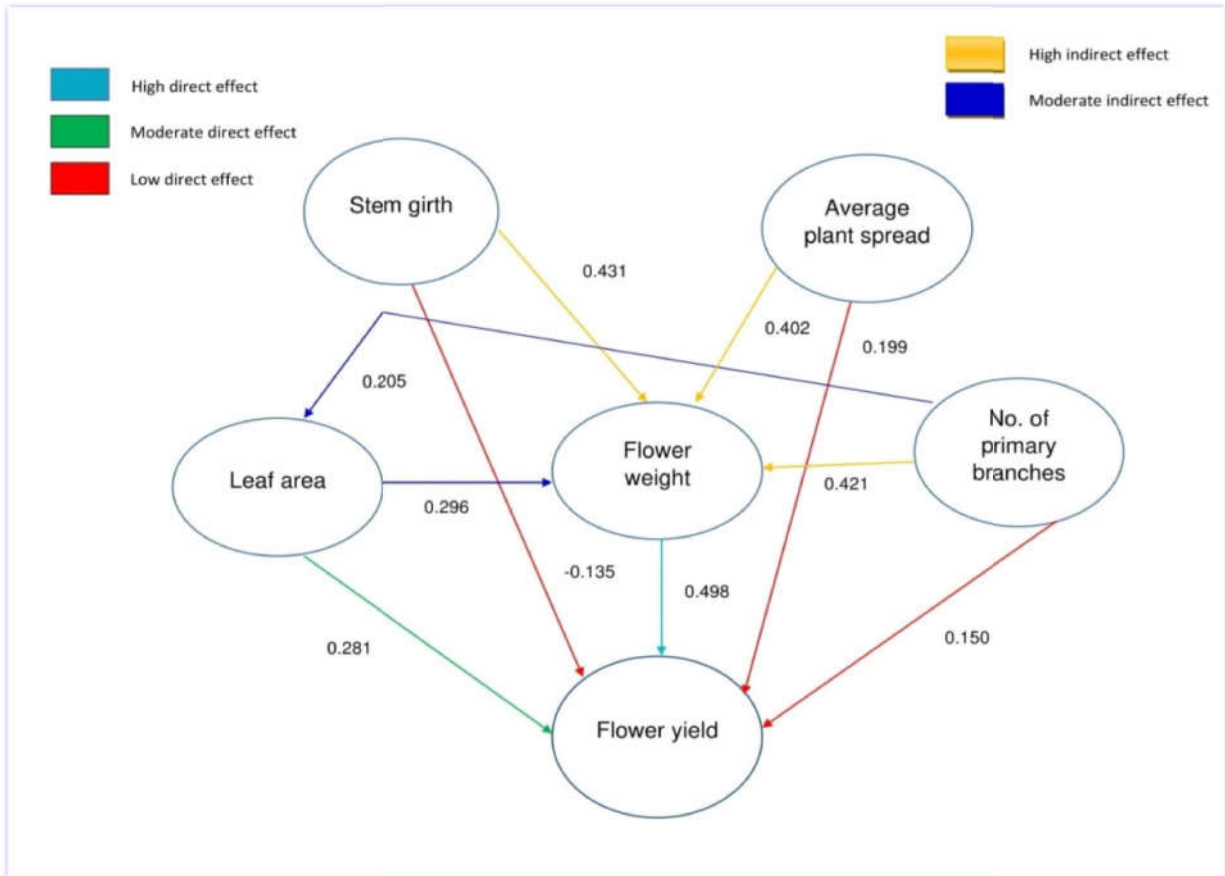


Fig. 17. Path diagram for selected characters in China aster varieties

The flower yield per plant was selected as the dependent variable. The path diagram for direct and indirect effect on flower yield by selected characters is illustrated in Fig. 17.

Tirakannanavar *et al.* (2015) reported that in China aster flower yield per hectare was positively and significantly correlated with plant height, plant spread, number of secondary branches and leaf area at genotypic level. The results of present study indicated that the character flower weight (0.933) exhibited strong positive correlation also exhibited high direct effect on flower yield per plant (0.498). Leaf area revealed strong positive correlation also showed moderate direct effect on flower yield per plant (0.281). The characters plant spread and number of primary branches had a positive correlation with flower yield (0.894 and 0.978) also showed a low direct positive effect (0.199 and 0.150) respectively. These characters are of great importance for improvement in flower yield per plant. The results were confounded with the findings of Khangjarakpam *et al.* (2015) and of Rai and Choudhary (2016).

5.6.2 Correlation among vegetative floral and meteorological characters

Plant height had a negative, significant correlation with maximum temperature (-0.646) and a positive, significant correlation with minimum temperature (0.648). Leaf area showed significant, negative correlation (-0.648) between mean relative humidity and a positive, significant correlation (0.626) with mean sun shine hours. There was a negative significant correlation between stem girth and relative humidity (-0.602) and positive correlation with mean sun shine hours (0.570). Number of leaves was negatively and significantly correlated with mean relative humidity (-0.778) whereas positively correlated with mean sun shine hours (0.768). A negative significant correlation was exhibited between number of flowers (-0.477) and maximum temperature, mean sun shine hours (-0.390). Flower yield (-0.540) also showed negative significant correlation with maximum temperature.

Table 5.7.1 Ranking of China aster varieties for loose flower types

Varieties	Score obtained						Total score	Rank position
	No. of 1 ^o branches	No. of flowers	Flower weight (g)	Flower yield (g)	Duration of flowering (days)	Shelf life (days)		
Arka Kamini	3	1	4	5	5	3	21	VI
Arka Shashank	4	1	5	5	6	3	23	VII
Arka Archana	3	1	5	4	6	3	21	VI
PG White	2	1	2	2	2	1	10	II
PG Violet	2	2	3	3	4	2	16	V
PG Pink	1	1	1	1	1	1	6	I
PG Purple	2	2	3	2	3	3	15	IV
AAC-1	2	3	2	2	4	3	16	V
Local Pink	2	1	3	2	1	3	12	III
Mat White	5	4	5	6	6	3	29	VIII

Table 5.7.2 Ranking of China aster varieties for cut flower types

Varieties	Score obtained						Total score	Rank position
	No. of 1 ^o branches	Flower diameter (cm)	Flower yield (g)	Vase life flower (days)	Stalk length (cm)	Duration of flowering (days)		
Arka Kamini	3	2	5	2	2	5	19	IV
Arka Shashank	4	4	5	2	3	6	24	VI
Arka Archana	3	3	4	3	2	6	21	V
PG White	2	2	2	2	1	2	11	II
PG Violet	2	1	3	1	1	4	12	III
PG Pink	1	1	1	1	1	1	6	I
PG Purple	2	1	2	2	1	3	11	II
AAC-1	2	1	2	2	1	4	12	III
Local Pink	2	2	2	2	2	1	11	II
Mat White	5	5	6	4	4	6	30	VII

Table 5.7.3 Overall ranking of China aster varieties

Varieties	Total score obtained		Total score	Rank position
	Loose flower	Cut flower		
Arka Kamini	21	19	40	VI
Arka Shashank	23	24	47	VIII
Arka Archana	21	21	42	VII
PG White	10	11	21	II
PG Violet	16	12	28	V
PG Pink	6	6	12	I
PG Purple	15	11	26	IV
AAC-1	16	12	28	V
Local Pink	12	11	23	III
Mat White	29	30	59	IX

5.7 RANKING OF VARIETIES

5.7.1 Ranking for loose flower types

Ranking was done in order to identify superior varieties. The highest value was given score 1. The total scores were added and variety with minimum score is ranked first. Ranking for loose flower was done considering the characters such as number of primary branches which showed direct effect with yield along with number of flowers, flower weight, duration of flowering and shelf life were considered in addition to flower yield. For loose flower Phule Ganesh Pink obtained first rank followed by Phule Ganesh White and Local Pink. The performance of Mat White was poor.

5.7.2 Ranking for cut flower types

The ranking for cut flower was also done considering the specific characters for cut flowers such as flower diameter, vase life, stalk length, number of primary branches, flower yield and duration of flowering. The first position was secured by Phule Ganesh Pink and second position was shared by Phule Ganesh White, Phule Ganesh Purple and Local Pink. The performance of Mat White was inferior.

5.7.3 Overall ranking of China aster genotypes

An overall ranking was done to identify the best suited variety for cultivation under tropical plains. It was done by adding the scores for cut and loose flowers. The variety Phule Ganesh Pink was found most suitable and can be recommended for commercial cultivation in plains. Phule Ganesh White and Local Pink can also be cultivated successfully in the tropical plains.

Summary

6. SUMMARY

The experiment entitled “Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation in tropical plains” was conducted at Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara, during the year 2018-19. The objective of the study was to evaluate the performance of China aster for cultivation under tropical plains.

The study was done in October 2018 and ten varieties namely, Arka Kamini, Arka Shashank, Arka Archana, Phule Ganesh White, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1, Local Pink, Mat White were evaluated for vegetative, floral and post harvest characters. The experiment was laid out in randomized block design having three replications. The research work findings are summarized in this chapter.

6.1 Vegetative characters

- The China aster varieties varied significantly with respect to vegetative characters. Plant height was highest in variety Phule Ganesh Pink (21.32, 61.93, 68.86 cm at 1, 2 and 3 MAP) during the entire period of observation. The variety Mat White was observed with lowest plant height all over the experiment (8.49, 11.92, 14.32 cm at 1, 2 and 3 MAP).
- The plant spread was greatest in variety Phule Ganesh Pink (41.17 and 50.08 cm at 2 and 3 MAP) whereas lowest plant spread was observed in variety Mat White (6.25 and 7.69 at 2 and 3 MAP).
- The number of primary branches was highest in variety Phule Ganesh Pink (11.53 and 14.25 at 2 and 3 MAP) while lowest was registered in Mat White (2.06 and 2.39 at 2 and 3 MAP).
- Number of leaves was non-significant at one month after planting. The number of leaves varied significantly among the varieties and was highest in variety Phule Ganesh Pink (46.87 and 56.48 at 2 and 3 MAP). The

lowest number of leaves was observed in variety Mat White (6.76 and 12.69 at 2 and 3 MAP).

- Stem girth was observed highest in Phule Ganesh Pink at one month after planting (4.37 cm) whereas at one month after planting stem girth was highest in variety Phule Ganesh White (9.24 cm). At three month after planting, maximum stem girth was recorded in variety Phule Ganesh Pink (11.09 cm) which was on par with Phule Ganesh White (11.04 cm). The lowest stem girth was observed in Mat White at all the stages of observation (2.51, 2.54, 3.19 cm at 1, 2 and 3 MAP, respectively).
- Leaf area was highest in variety Phule Ganesh White (22.39, 31.12 and 34.31 cm² at 1, 2 and 3 MAP) and lowest in variety Mat White (2.59, 5.72 and 8.02 cm² at 1, 2 and 3 MAP) during the entire period of observation.
- Qualitative vegetative characters also differed significantly among the varieties. Leaf shape was ovate in all the varieties other than Arka Shashank and linear leaf shape was observed in this variety.
- Leaf dentation was observed in all the ten varieties evaluated.
- Stem colouration and leaf mid-rib colouration were absent in varieties *viz.* Arka Shashank, Arka Archana, Phule Ganesh White and Mat White. Stem and leaf mid-rib colouration were present in varieties *viz.* Arka Kamini, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1, Local Pink and Mat White.

6.2 Floral characters

- Days to bud initiation had significant variation among the varieties. The bud initiation was earliest in varieties Arka Shashank, Arka Kamini, Mat White and Arka Archana (44.40, 45.27, 46.27 and 47.13 DAP, respectively). The variety Phule Ganesh White (73.67 DAP) took maximum number of days for bud initiation.
- The lowest number of days for complete flower opening was recorded in variety Arka Shashank (59.60 DAP) were on par with Arka Archana, Arka

Kamini and Mat White (60.80, 61.40 and 63.40 DAP, respectively). Phule Ganesh White (90.20 DAP) took maximum number of days for complete flower opening.

- The variety Arka Archana (67.00 DAP) took less number of days for 50 per cent flowering and was on par with varieties, Arka Kamini, Mat White and Arka Shashank (68.33, 69.33 and 70.67 DAP). The variety Phule Ganesh White (104.06 DAP) recorded highest number of days to 50 per cent flowering.
- Maximum number of flowers was produced by variety Arka Shashank (20.20) and was on par with varieties Arka Archana, Local Pink, Phule Ganesh Pink, Phule Ganesh White and Arka Kamini (18.47, 18.47, 17.73, 16.93 and 16.27 respectively). Lowest number of flower per plant was recorded in Mat White (5.20).
- Flower stalk length was the highest in Phule Ganesh Pink (21.13 cm) which was on par with other varieties Phule Ganesh Purple (20.61 cm), Phule Ganesh Violet (19.73 cm), AAC-1 (18.27 cm) and Phule Ganesh White (17.77 cm). The lowest flower stalk length was observed in Mat White (3.02 cm).
- The flower weight was documented highest in variety Phule Ganesh Pink (6.94 g) and was lowest in Mat White (1.63 g).
- Flower head diameter varied significantly in all the varieties and maximum flower diameter was observed in variety Phule Ganesh Pink (7.07 cm) which were performing on par with the varieties Phule Ganesh Violet (6.27 cm), Phule Ganesh Purple (6.22 cm) and AAC-1 (6.04 cm). The lowest was exhibited by variety Mat White (3.31 cm).
- Number of disc florets per head was highest in the variety Phule Ganesh White (251.00) whereas lowest number of disc florets was registered in variety Arka Shashank (55.87) which was on par with variety Mat White (69.93).
- The highest number of ray florets per head were recorded in variety Phule Ganesh Pink (201.20) and was lowest in Mat White (55.67).

- Flower yield significantly varied among the varieties and the highest flower yield per plant was observed in variety Phule Ganesh Pink (55.99 g). The yield per plant was recorded lowest in Mat White (4.16 g).
- The variety Arka Shashank was having powderpuff type flower while all other varieties were of semi double type flower. The flower colour was Vivid reddish purple in variety Arka Kamini. The varieties Arka Shashank, Arka Archana, Phule Ganesh White and Mat white were under White group C. The variety Phule Ganesh Violet recorded colour Strong violet. Phule Ganesh Pink was under colour group Red purple 73 having Deep purplish pink A colour. Phule Ganesh Purple was under purple violet group N 82 having Strong purple B. The variety AAC-1 and Local Pink were under red purple group NN 66 with Vivid purplish pink A.
- The variety Local Pink was significantly superior among other varieties and was recorded with maximum duration of flowering (62.40 days) which was on par with Phule Ganesh Pink (60.60 days). The lowest flowering duration was documented in Mat White (45.20 days).
- Seed yield per flower was highest in variety Phule Ganesh White (1.27 g) whereas lowest seed yield was observed in variety Mat White (0.44 g).
- Maximum seed germination was observed in variety Phule Ganesh White (65.28 %) and lowest germination was recorded in varieties Arka Shashank (6.25 %) and Arka Archana (6.25%).
- Regarding the incidence of pests and diseases, infestation of leaf eating caterpillar was observed at nursery and field level. Leaf miner attack and damping off was observed at nursery level. Flower eating caterpillar was an important pest recorded in field.
- Significant variation was observed with respect to post harvest characters also. The longest shelf life was observed in the variety Phule Ganesh Pink (3.67 days) which was on par with Phule Ganesh White (3.33 days) and the lowest was observed in variety Mat White (1.67 days).
- The variety Phule Ganesh White was recorded with maximum physiological loss of weight (35.70 per cent) and was on par with variety

Phule Ganesh Purple, Arka Shashank, Phule Ganesh Violet and AAC-1 (35.47, 35.31, 33.22 and 28.79 per cent respectively). The lowest physiological loss of weight was observed in Mat White (20.42 per cent).

- The vase life was recorded highest in variety Phule Ganesh Pink (13.93 days) which was on par with varieties Phule Ganesh Violet (12.20 days). The lowest vase life was observed in variety Mat White (6.95 days).
- Total water uptake was highest in variety Phule Ganesh Pink (20.27 ml) which was on par with Arka Kamini (17.67 ml) and lowest water uptake was recorded in Mat White (12.43 ml).
- Anthocyanin content of flowers was recorded highest in variety Phule Ganesh Violet (51.87 mg/g). Lowest anthocyanin content was recorded in variety Phule Ganesh Purple (40.36 mg/g). In white coloured flower varieties anthocyanin content was not detected.
- Diversity analysis was done using dendrogram based on D^2 statistics for both quantitative and qualitative characters and the results showed that there is wide variability among the genotypes.
- Based on qualitative characters, two main clusters were formed among the 10 varieties and cluster analysis based on quantitative characters showed that all the varieties are variable and each genotype falls into distinct class.
- With regard to correlation among different vegetative characters, leaf area was positively and significantly correlated with number of primary branches (0.840), stem girth (0.740), number of leaves (0.808) and plant height (0.788). There was a significant positive correlation of plant spread with number of primary branches (0.910), stem girth (0.868), number of leaves (0.932) and plant height (0.937). A positive significant correlation of number of primary branches could be observed with stem girth (0.867), number of leaves (0.949) and plant height (0.908). Stem girth was positively and significantly correlated with number of leaves (0.939) and plant height (0.908). A significant positive correlation could be observed between number of leaves (0.939) and plant height (0.908). The number of leaves had a positive and significant correlation with plant height (0.953).

- Regarding correlation among floral characters a positive significant correlation of flower yield could be observed with flower weight (0.933), flower diameter (0.894) and number of ray florets (0.866). There was a positive significant correlation of flower weight with flower diameter (0.858) and ray florets per head (0.804). Flower diameter and ray florets per head (0.848) were positively and significantly correlated to each other.
- Plant height had a negative significant correlation with maximum temperature (-0.646) and a positive significant correlation with minimum temperature (0.648). A negative significance was exhibited between maximum temperature with number of flowers (-0.477) and mean sunshine hours (-0.390). Flower yield (-0.540) also showed significant negative correlation with maximum temperature.
- The results indicated that the character flower weight (0.933) exhibited strong positive correlation having high direct effect on flower yield per plant (0.498). Leaf area revealed strong positive correlation showing moderate direct effect on flower yield per plant (0.281). The characters plant spread and number of primary branches had a positive correlation with flower yield (0.894 and 0.978) which showed a low direct positive effect on flower yield (0.199 and 0.150) respectively.
- Ranking of varieties was done individually for loose flower and cut flower types. In ranking for loose flower types, variety Phule Ganesh Pink scored first position which was followed by Phule Ganesh White and Local Pink. When varieties were ranked for cut flower types, first position was scored by Phule Ganesh Pink while second position was shared by Phule Ganesh White, Phule Ganesh Purple and Local Pink.
- In overall ranking, the variety Phule Ganesh Pink occupied first position followed by Phule Ganesh White and Local Pink and these varieties can be recommended for commercial cultivation in tropical plains of Kerala during winter season.

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Appendices

EVALUATION OF CHINA ASTER
[*Callistephus chinensis* (L.) Nees.] FOR CULTIVATION
IN TROPICAL PLAINS

by

ALFIN SANTHOSH
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ABSTRACT OF THE THESIS

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ABSTRACT

China aster [*Callistephus chinensis* (L.) Nees.] is one of the most important annual flower crops grown in India for cut flower as well as loose flower purposes. It ranks third next to chrysanthemum and marigold among the annual flowers and has gained popularity due to ease of cultivation, diversity of colours and good vase life. It is also used for bedding purpose in landscapes and as pot plants. In Kerala, the demand for annual flower crops is on the rise, however the cultivation is limited. China aster due to its hardy nature can be grown as a pure crop as well as intercrop in coconut gardens.

The investigation entitled 'Evaluation of China aster [*Callistephus chinensis* (L.) Nees.] for cultivation in tropical plains' was conducted at the Department of Floriculture and Landscaping during 2018-2019 with an objective to evaluate the performance of China aster for cultivation in tropical plains. Ten varieties of China aster *viz.* Arka Kamini, Arka Shashank, Arka Archana, Phule Ganesh White, Phule Ganesh Violet, Phule Ganesh Pink, Phule Ganesh Purple, AAC-1, Local Pink and Mat White were evaluated for vegetative, floral and post harvest characters.

The varieties showed significant variation for vegetative characters. In all the varieties, leaf dentation was present and leaf shape was ovate for all varieties except Arka Shashank which had linear leaf shape. Stem colouration and leaf mid rib colouration were absent in varieties such as Arka Shashank, Arka Archana, Phule Ganesh White and Mat White and the rest of the six varieties showed the presence of purplish stem and mid rib colouration. The variety Phule Ganesh Pink was superior in plant height (68.86 cm) at 3 months after planting. The characters like plant spread (50.08 cm), number of leaves (56.48), number of primary branches (14.25) and stem girth (11.09 cm) were also highest in variety Phule Ganesh Pink. Leaf area was the highest in variety Phule Ganesh White (34.31 cm²). The variety Mat White was significantly inferior for all the vegetative characters observed.

Floral characters showed significant variation among the varieties. Powderpuff flower type was observed in Arka Shashank and all the other varieties had semi-double type flower. Days to bud initiation was minimum in variety Arka Shashank (44.40 days) and maximum in Phule Ganesh White (73.67 days). The same trend was observed for days to complete flower opening and days to 50 per cent flowering. The variety Local Pink had the highest duration of flowering (62.40 days) and variety Mat White (45.20 days) had the lowest duration of flowering. The variety Arka Shashank produced highest number of flowers per plant (20.20). The flower stalk length (21.13 cm), flower weight (6.94 g) and flower diameter (7.07 cm) were the highest in the variety Phule Ganesh Pink. The variety Phule Ganesh White was superior in terms of number of disc florets per head (251.00) whereas Phule Ganesh Pink had the highest number of ray florets per head (201.20). The flower yield per plant was highest in variety Phule Ganesh Pink (55.99 g). The variety Phule Ganesh White recorded the highest seed yield per flower (1.27 g) and seed germination (65.27 %).

Longest shelf life was observed in variety Phule Ganesh Pink (3.67 days) which was on par with Phule Ganesh White (3.33 days) and physiological loss of weight was recorded highest in Phule Ganesh White (35.70 %). The variety Phule Ganesh Pink had the longest vase life (13.93 days) and total water uptake was also maximum in variety Phule Ganesh Pink (20.27 ml). Anthocyanin content of flowers was recorded highest in the variety Phule Ganesh Violet (51.87 mg/g) followed by Arka Kamini (48.62 mg/g).

Dendrogram based on D^2 statistics considering qualitative and quantitative characters indicated that high amount of variability is present among the varieties. Correlation and path analysis revealed that the characters such as number of primary branches (0.978), plant spread (0.894), leaf area (0.796) and flower weight (0.933) were having significant positive correlation with flower yield per plant with a direct effect of 0.150, 0.199, 0.281 and 0.498 respectively.

Ranking of varieties was done individually for loose flower and cut flower types. In ranking for loose flower types, variety Phule Ganesh Pink scored first position which was followed by Phule Ganesh White and Local Pink. When varieties were ranked for cut flower types, first position was scored by Phule Ganesh Pink while second position was shared by Phule Ganesh White, Phule Ganesh Purple and Local Pink. In overall ranking the variety Phule Ganesh Pink occupied first position followed by Phule Ganesh White and Local Pink and these can be recommended for commercial cultivation in tropical plains of Kerala during winter season.