SCREENING OF GENOTYPES AND F_2 SEGREGATING POPULATION OF CHINA ASTER (*Callistephus chinensis* [L.] Nees.) FOR ALTERNARIA LEAF SPOT

NISHCHITHA N.

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,
ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES,
BAGALKOT- 587 102

JUNE, 2016

SCREENING OF GENOTYPES AND F_2 SEGREGATING POPULATION OF CHINA ASTER (*Callistephus chinensis* [L.] Nees.) FOR ALTERNARIA LEAF SPOT

Thesis submitted to the

University of Horticultural Sciences, Bagalkot
in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE (HORTICULTURE)

In

FLORICULTURE AND LANDSCAPE ARCHITECTURE

By
NISHCHITHA N.
UHS14PGM423

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,
ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES,
BAGALKOT- 587 102

JUNE, 2016

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE, ARABHAVI- 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT - 587 102

CERTIFICATE

This is to certify that the thesis entitled **"SCREENING OF GENOTYPES AND F_2 SEGREGATING POPULATION OF CHINA ASTER (*Callistephus Chinensis* [L.] Nees.) FOR ALTERNARIA LEAF SPOT."** submitted by **NISHCHITHA N. ID No. UHS14PGM423** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FLORICULTURE AND LANDSCAPE ARCHITECTURE,** of the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by her during the period of her study in this university, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Arabhavi
Date: JUNE, 2016

(MUKUND SHIRAGUR)
CHAIRMAN
Assistant Professor
Dept. Floriculture and
Landscape Architecture,
K.R.C.C.H., Arabhavi

Approved by:
***Chairman*:** ____________________________
(MUKUND SHIRAGUR)

***Members*:** **1.** ________________________
(BALAJI S. KULKARNI)

2. ________________________
(SUMANGALA KOULAGI)

3. ________________________
(B.C. PATIL)

4. ________________________
(BASAVARAJAPPA, H.R.)

ACKNOWLEDGEMENT

*It was my fortune that made me work under ever inspiring **Dr. MUKUND SHIRAGUR**, Assistant Professor, Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi and the chairman of my advisory committee. His untiring knowledgeable guidance and constant encouragement were much more than deserved. They provide all the facilities during my investigation and it was helpful for me to successful completion of my investigation. I only can confess that it had been a privilege for me to be associated with him during my master's degree programme.*

*It is indeed an immense pleasure to express my deep sense of gratitude and indebtedness to **Dr. Balaji S. Kulkarni**, Professor and Head, Dept. of Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, for his inspiring encouragement and critical comments in the course of investigation.*

*I acknowledge with great pleasure the manifold assistance rendered to me by the members of my advisory committee, **Dr. Sumangala Koulagi,** Assistant Professor, Department of Horticulture Plant Pathology, Kittur Rani Channamma College of Horticulture, Arabhavi, **Dr. B.C. Patil** Associate Professor, AICRP(Vegetables) RHREC, Kumbapur, Dharwad, **Mr. Basavarajappa, H.R**. Assistant Professor, PPMC, UHS Bagalkot, their sensible criticism in ameliorating the manuscript and valuable guidance throughout the course of my study.*

*I avail myself of this opportunity to express my deep sense of gratitude to **Mr. B. S. Kamble**, Assistant professor, **Mr. R. T. Patil,** Assistant Professor, for their moral support, valuable suggestions and needful help during my research period.*

I express my deep sense of gratitude and affection to my parents Sri. Nijalingappa N T. and Smt.Geetha L and my ever encouraging brother Nandan N for their boundless love, unflagging interest and constant encouragement put confidence in me to reach this level.

Candid thanks to all my seniors, especially Anjali akka, Anu akka, Bhagya akka, Shwetha akka, Kusuma akka, Veda akka who encouraged and helped me a lot. No words can describe the unending love, care and moral support by my friends, Poornima, Sandhya, Naveena Kumari, Shilpa, Lakshmi, Anitha, Bindiya, Shruthi, Harish who deserve a special mention for being always there during difficult time and all my class mates during my course of study without whom this degree is unimaginable. I would also like to thanks my juniors Ayesha, Deepti, Jyothi, Maithri, Kaveri for their help.

My department staff Mr. Suresh Kashappagol, Mr. Ravi Pawate and department labours for supporting and encouraging me throughout my research.

End is inevitable for any kind of work. Though acknowledging is an endless task, I end by saying infinite thanks to all those whom I am able to recall here and also to those whom I might have left unknowingly.

Arabhavi

JUNE 2016 **(NISHCHITHA N.)**

Affectionately Dedicated to

My Parents and
My favourite god

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

1. INTRODUCTION

Flowers symbolize purity, beauty, love, peace and passion. They have significant role in beautifying the places. Diseased or disturbed flower plants will not serve the purpose. Hence, they have to be protected from diseases or such plants need to be replaced. This involves considerable labour and finance.

China aster (*Callistephus chinensis* [L.] Nees) is a semi - hardy free blooming annual and commercial flower crop belonging to the family Asteraceae. The plant is a diploid (2n = 18). The crop is native of China and spread to Europe and other tropical countries during 1731 AD (Desai, 1967). The genus *Callistephus* derived from two Greek words *Kalistos* meaning 'most beautiful' and *Stephos,* 'a crown' referring to the flower head.

It is preferred owing to its vast range of colours, long vase life, diversity of height and growth habit of the plant, exceptionally hardy nature, relative ease to grow all the year round and versatility of use. It is one of the most important traditional flowers of India, mainly used as a potted plant, loose flower, cut flower and as a border plant in the garden. Erect growth and spreading growth habits are common in China aster. In erect growing types, many cultivars are available with colour ranges like violet, pink, white, purple and red. In spreading growth habit, the colours available are violet, pink, white and purple. In case of powder puff types, bicolour cultivars are common. It is grown successfully in open conditions for year round production in *kharif, rabi* and summer for continuous supply of flowers to the market. It is used for the preparation of garlands, in bouquets as fillers and in flower arrangements and exhibitions. It is popular as a bedding plant and also used in herbaceous borders in gardens. It is grown as a potted plant and its dwarf cultivars are suitable for edges.

In India, it is grown on commercial scale in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra (Pune and Nashik) and West Bengal. In Karnataka, it is widely grown around Bengaluru, Tumkur, Kolar and Belgaum districts. The increasing popularity of the China aster in recent years is very much evident from the statistics that in Pune alone it is being grown in an area of 400 hectares. In Karnataka, it is cultivated on an area of 2, 083 ha, with a production of 1, 920 mt and productivity of 9.4 t/ha (Anon, 2012).

Increased flower production, quality of flowers and perfection in the forms of plants are important objectives to be reckoned in commercial flower production. Even though the crop has great significance in the market, there are some bottlenecks associated with its cultivation, such as non availability of planting material, lack of improved varieties and high market fluctuation. Now a days, research in the field of crop improvement has lead to the introduction of different cultivars having different forms and colours by public sector institutions. Recently cultivars like Poornima, Kamini, Shashank and Violet Cushion (IIHR, Bengaluru) and Phule Ganesh White, Phule Ganesh Pink, Phule Ganesh Violet and Phule Ganesh Purple (MPKV, Rahuri) were released.

China aster is affected by various diseases caused by fungi and bacteria. Leaf spot [*Alternaria alternata* (Fr. Keissler)] is a common disease in field condition. The fungal pathogen, alternaria affects mostly the foliar parts causing light brown to dark brown, roundish-oval to irregular spots of 1 to 2 mm in diameter in initial stage, while later expanded, often coalesced and produced 'Shot hole' during severe infection. The disease severity on foliage was more common during humid weather and symptoms were most pronounced on nutrient deficient leaves (Nagrale, 2007 and Nagrale *et al.*, 2012). Therefore, there is a need to develop varieties resistant to diseases to stabilize the yield potentials of China aster varieties. The manipulation of inherent potentials of plants in the form of resistant varieties is a cheap, viable and environment friendly alternative to reduce losses from biotic stress.

Development of China aster as cut flower and also as loose flower needs improvement in quality traits like flower colours, stalk length, shape and size of flower to improve its vase life and resistace to pest and disease. Considering the potentiality of this crop, there is need to screen different genotypes and F_2 segregating population of China aster for resistance to alternaria leaf spot disease. Keeping this in view the present study was undertaken to screen the available germplasm for resistance against this disease.

Objectives of research

1. To screen the China aster genotypes and F_2 segregating population for alternaria leaf spot incidence.
2. To study the segregation pattern for alternaria leaf spot in F_2 segregating population of China aster.
3. To study the genotypes and F_2 population for growth and yield parameters.

2. REVIEW OF LITERATURE

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

Alternaria leaf blight [*Alternaria alternata* (Fr.) Keissler] is a major foliar disease of China aster occurs in all parts the world, wherever China aster is grown. The studies with respect to "Screening of genotypes and F_2 segregating population of China aster (*Callistephus chinensis* [L.] Nees.) for alternaria leaf spot" to find the resistance source includes occurrence and symptoms of the disease, host pathogen relationship, growth and yield parameters are taken into consideration while reviewing the literature. Accordingly, the literature pertaining to the above aspects is presented here.

2.1 Occurrence and symptoms of the disease

Schmidt (1965) for the first time reported a fungal leaf spot of *Chrysanthemum maximum* L. caused by *A. chrysanthemi*. He noticed disease on green parts of the plants. Initially, round, pale grey spots appeared which enlarged rapidly to their final diameter of one cm when fully developed. They became grey to brownish black, often with pale fleck at the centre and more or less distinct light and dark zonations. Where the spots were sufficiently numerous entire leaves withered. Sobers (1965) reported *A. chrysanthemi* from florida.

Srinath and Sarwar (1965) for the first time reported alternaria blight of *Chrysanthemum cinerarifolium* (Trev.) var. Pyrethrum caused by *A. tenuissima* from Bengaluru. They described the symptoms as brown patches of 2-4 mm diameter near the apical part of the leaves. These patches of enlarged irregularly, turning blackish brown in colour. Eventually, the necrosis covered the entire leaf area and proved fatal to the plant.

Hegde (1988) reported the leaf blight of *C. morifolium* Ramat. caused by *A. tenuissima* (Fries) Wiltshire from Dharwad in Karnataka. He described that initially, yellowish green spots of 3-4 mm diameter appeared on older uninjured leaves. Whereas, on injured leaves symptoms appeared after five days. These spots are circular in the beginning, enlarged later and became irregular and turned to blackish brown or dark brown in colour. Eventually such spots covered entire leaf and coalescing of spots was seen which caused blighting of leaves, such blighted leaves were found to defoliate. On upper leaves also similar symptoms appeared but flowers remained free from infection.

Mallikarjun (1996) described the symptoms of leaf blight of turmeric caused by *Alternaria alternata*. The symptoms were noticed initially on lower set of leaves and later blighting extended to top leaves. The spots were light brown in colour with a clear yellow hallow, sub-circular to irregular, measuring 0.5mm to 10mm wide. Under favorable conditions, the plant exhibited a burnt appearance which could be very easily detected from a distance.

Alternaria leaf spot of chilli produced small, circular, necrotic brown spots initially on the lower leaves. As the disease progressed, these spots became irregular, sunken with concentric circles surrounded by a dark brown margin. Many of these spots coalesced and led to blightening appearance. The disease slowly progressed to upper leaves. Defoliation occurred on severely affected plants. Green fruits and seed also showed disease symptoms. Initially small, circular, dark brown sunken spots appeared on the outer surface of the rind. Later, the size of these spots increased and became irregular resulting in rotting of the fruits. Severely affected fruits dropped off from the plants. Seeds in the affectd fruits showed blackish discoloration. (Mangala *et al*, 2006).

Alternaria alternata produced small, circular to oval dark brown necrotic sunken spots on the leaves of *Aloe vera* (Bajwa *et al.*, 2010)

Symptoms were observed before early blight, from 50-60 days after emergence of potato plants. Typical leaf symptoms were small, circular, brown lesions, first visible on the abaxial sides of leaves. Lesions resembled those of early blight, but were smaller and did not show concentric rings. During favourable environmental conditions, severe infections were seen as coalesced when high humidity, leaf wetness, and warm temperatures were present (Waals *et al.*, 2011).

Small, circular and brown necrotic spots appeared all over the foliage. The spots gradually enlarged in size and later became irregular in shape or remained circular with concentric rings or zones. In the later stages of infection, these spots coalesced, resulting in withering, extensive drying and shedding of leaves of chilli (Li *et al.*, 2011).

Nagrale *et al*. (2012) reported that gerbera is infected by many pathogens in the protected cultivation. The severe infection of fungal blight caused by *Alternaria alternata* (Fr.) Keissler was observed in the polyhouse condition. The fungus *A. alternata* produced profuse mycelium on Potato Dextrose Agar (PDA) with an average width of 4.42 µm in diameter, conidiophores, conidia and intercalary chlamydospores measured as 42.26 x 4.29 µm, 47.16 x 13.49 µm and 7.22 µm in diameter, respectively.

Bhat *et al.* (2013) reported that alternaria leaf blight is one of the most important diseases of gerbera (*Gerbera jamesonii*) worldwide. The pathogen associated with the disease was identified as *Alternaria alternata* (Fr. Keissler). In early stages of disease development, spots were circular and brown with somewhat irregular margins the lesion later turned dark brown. Maximum disease development in the field was observed during June when spots attained a maximum size of 23 to 26 mm.

2.2 Isolation and identification of the pathogen

Rao (1965) reported *Alternaria tenuis* Auct. (*Alernaria alternata* (Fr.) Keissler causing leaf blight and blossom blight of *Chrysanthemum indicum* L. from Maharashtra. He described that the spots were oval to irregular or angular, dark brown to black, inciting leaf blight, blossom blight and defoliation.

The alternaria leaf blight of sunflower caused by *Alternaria helianthi* (Hansf) was known to infect all aerial parts of plant *viz*. leaf, petiole, stem, floral parts and seeds. Initially, the disease appeared in the form of small scattered brown spots on the leaf lamina. Later, these spots increase in size and coalesce covering larger leaf area (1 to 2.5 cm in diameter) with dark brown margin and yellow halo, linear necrotic lesions also appear on stem, petioles and sepals. In severe cases, the head and seeds also get infected (Tabuki and Nishihara, 1969; Narain and Saksena, 1973; Kolte and Mukhopadhyay, 1973 and Anilkumar *et al*., 1976)

Severe infection of alternaria blight on leaf, stem, petiole and inflorescence including petals in sunflower was described by many workers (Mukewar *et al.*, 1974; Balasubramanyam and Kolte, 1980a and b; Nargund and Nazeer, 1994).

Hiremath *et al. (*1990) observed cracking of stem and petioles along with other symptoms severely infected sunflower plants.

Ishiba *et al*. (1982) reported a new disease of *Stevia rebaudiana* caused by a hitherto undesribed alternaria which was found in Kagawa in August 1978. It was characterized by small black spots surrounded by a chlorotic zone, on leaves, stems, petioles and involucres scales. The pathogen was named *Alternaria stevia*, a new sp., and the disease reproduced experimentally. *Alternaria steviae* was also pathogenic on wounded leaves of related plants (*Eupatorium chinensis* and *E. fortune*) but not on *Chrysanthemum spp*., *Erigeron annus* or *Tagetes patula*. Culture filtrates of the fungus induced necrotic lesions on leaves of susceptible plants at a dilution of 1: 8 and on resistant plants when undiluted.

Karlatti and Hiremath (1989) collected marigold flowers heavily infected by *Alternaria zinniae* from a garden in Dharwad district of Karnataka. Seeds were separated, dried and plated on potato dextrose agar (PDA) medium. Some of the seeds were surface sterilized. Spore suspensions were prepared and inoculated on the seedlings of 10 plants belonging to the Asteraceae. *Alternaria zinnia* was successfully isolated from apparently healthy and discoloured seeds and from those that had been surface sterilized. The isolated fungus infected the ageratum, aster, chrysanthemum, cosmos and sunflower seedlings, safflower, tridax, niger and parthenium.

Mallikarjun (1996) described the symptoms of leaf blight of turmeric caused by *Alternaria alernata*. The symptoms noticed initially on lower set of leaves later blighting extended to top leaves. The spots were light brown in colour with a clear yellow halo, sub-circular to irregular, measuring 0.5 mm to 10 mm wide. Under favorable conditions the plant exhibited a burnt appearance which could be very easily detected from a distance.

David (1998) had provided description for leaf spot disease of zinnia caused by *Alternaria zinniae*. The fungus attacked the leaves, stems of its host and can cause damping off of seedlings where both the root and the stems of the plant may be affected. In older plants the fungus attacked the older leaves and then spread to the younger leaves, and when the attack was severe the spots may became confluent.

Ellis (1998) described the leaf blight disease of chrysanthemum caused by *Alternaria chrysanthemi*. The symptoms appeared on leaves, stems, flowers and seeds of *Chrysanthemum maximum*. On the leaves, spots were round, at first pale grey and up to one cm diameter, later grey or brownish black, often with a whitish spot in the centre surrounded by pale and dark concentric rings.

Kopaoki and Wagner (2003) evaluated 10 garden mums (*Dendranthema grandiflora)* cultivars *viz.*, Barbara, Bravo, Debonair, Frolic, Holly, Linda, Sunny Linda, Nicole, Sarah and Volterra for their winter hardiness and plant pathogens. All cultivars showed good hardiness. However, in the second year of investigations, disease symptoms appeared on the tested plants. Apart from typical disease symptoms, changes in shape and size of plants were observed.

Shahi and Shyam (1993) isolated *A. solani* and *A. alternata* f. sp. *lycopersici* from tomato plants in Himachal Pradesh, India. In laboratory test, *A. alternata* f. sp *lycopersici* produced symptoms on leaflets, stems and branches following artificial inoculation, while, *A. solani* produced only on leaf.

Dhal *et al.* (1997) observed the association of *A. alternata* with blossom end rot of tomatoes for the first time in Odisha, India.

Diseased okra leaf samples were isolated and purified using single spore or hyphal tip techniques. Developed fungus was identified as *Alternaria alternata* based on cultural characterstics and light microscope examination (Atia and Tohamy, 2004).

The causal agent of leaf spot disease of egg plant was successfully isolated and identified as *Alternaria tenuissima* (Raja *et al.*, 2005).

The fungus isolated from chilli leaves grew luxuriously on PDA medium at 25 ± 10^{0}C. Based on the morphological characters, the fungus was identified as *Alternaria alternissler* which is the causal agent of leaf spot, which became the major cate (Fr.) Keisler (Mangala *et al.*, 2006). *Alternaria alternata* (Fr.) Keissler is the causal agent of leaf spot, which became the major constraint in economic production of okra (Phapale *et al*., 2010).

Leaves of onion showing typical symptoms were isolated on PDA medium. Based on the morphological and cultural characters isolates are identified as *A. alternata* (Ramjegathesh and Ebenezar, 2012).

2.3 Host pathogen relationship

2.3.1 Chlorophyll

Bhaskaran and Kandaswamy (1978) observed reduction of photosynthetic pigment in the necrotic halo and dead tissues of sunflower leaves infected by alternaria leaf blight. It was observed that the reduction of chlorophyll content might be due to reduction in synthesis of pigment or loss of chlorophyll.

Rajivkumar and Singh (1996) observed that there was decrease in chlorophyll \`a\` and chlorophyll \`b\` content in infected tissue due to alternaria leaf blight in sunflower as compared to healthy tissue.

Chlorophyll \`a\`, \`b\` and chlorophyll a/b ratio were also low in infected leaves as compared to healthy leaves in mosaic disease of sunflower (Bhavani *et al*., 1998).

Benagi (1995) noticed that reduction of chlorophyll was less in resistant varieties due to infection of late leaf spot in groundnut. Chlorophyll \`a\`, Chlorophyll \`b\` were reduced as the disease progressed in leaf tissue of susceptible varieties.

Amaresh (2000) noticed that higher amount of Chlorophyll \`a\`, Chlorophyll \`b\` and total chlorophyll in resistant varieties for alternaria blight and rust of sunflower. He also reported that there was decrease in all the above three biochemical constituents in severely infected leaves of sunflower.

2.3.2 Sugars

Benagi (1995) observed the decrease in total sugar content in resistant genotypes of groundnut cultivars against late leaf spot, but increased in susceptible genotypes as the infection advanced. Higher amount of reducing sugars was observed in susceptible genotypes at later stages of disease development.

Rajivkumar and Singh (1996) noticed the decrease in reducing sugar and non-reducing sugars in the *Alternaria* sp. inoculated leaves when compared to un inoculated leaves of sunflower.

Amaresh (2000) observed decrease in reducing and non-reducing sugar content in both resistant and susceptible genotypes of sunflower.

Ranganatha *et al*. (2003) reported that there is increase in sugar content in wild sunflower (*H. occidentalis*) after 24 hours of infection of *A. helianthi.*

2.3.3 Phenols

Phenols are known to impart resistance against pathogens because of their anti microbial activity and it is often assumed that their main role in plants is to act as protective compounds against disease causing agents such as fungi, bacteria, and viruses (Rohringer and Samborski, 1967).

Concentration of phenolic compounds was usually higher in resistant than in susceptible genotypes of different crop plants (Arora and Wagle, 1985 and Saini *et al.*, 1988)

Rajivkumar and Singh (1996) observed drastic increase in polyphenols content after 40 days of inoculation by *Alternaria sp.* in sunflower and reduced progressively after 70 days of inoculation, while least amount of polyphenols were observed in un-inoculated healthy plants.

Theerthaprasad and Shambulingappa (1986) noticed that the rust resistant sunflower cultivars contained higher amount of total phenols (13.5 ± 1.65 mg/g) compared to susceptible (10.5 + 1.3 mg/g) cultivars. There was increase in phenol content in *H. occidentalis* (a wild variety of sunflower resistant to leaf spot) in 24 hours after inoculation of *A. helianthi* (Ranganatha *et al*., 2003).

2.4 Screening of genotypes and F_2 segregating population for resistant to diseases

Anilkumar *et al.* (1976) reported that although a large number of germplasm and wild species are available, there are not many efforts to evaluate all the germplasm to identify stable resistant sources. Among the wild species, *Helianthus debilis* was reported to be highly susceptible and *H. argophyllus* as highly resistant. However, the resistant species of *H. argophyllus* showed infection under prolonged warm humid conditions.

Acimovic (1976) evaluated 1420 inbred lines for resistance to leaf blight. He observed differential reaction of these genotypes to disease. Ten per cent of lines showed some degree of resistance. Similarly, Mathur *et al.* (1978) observed variation in loss of yield among genotypes suggesting differential reaction of genotypes to the disease.

Agarwal *et al*. (1979) reported that out of 115 varieties tested under artificial ephiphytotic conditions only five varieties were found moderately resistant to leaf spot disease.

Sackston (1998) reported that although differences exist in reaction to *A. helianthi* infection among genotypes, no stable resistant varieties or hybrids have been released so far in any part of the world. The levels of resistance available were very low and usefulness of such resistance in reducing the yield loss was uncertain. All the 27 entries of National Oil Seed Nursery in Minnesota were susceptible to *A. helianthi* (Shane *et al.*, 1981).

Morris *et al.* (1983) concluded that no absolute resistant was available among the 21 annual and 37 perennial *Helianthus* sp. for resistant to *A. helianthi*. However, moderate level of resistant was observed in three perennial species *viz. Helianthus hirsutus, H. rigidus* sub sp.*subrhomboides* and *H. tuberosus*.

There were significant differences in alternaria leaf blight reactions among 24 inbred lines of sunflower evaluated by Carson (1985).

Lipps and Herr (1986) reported that *Helianthus tuberosus* accessions had significantly low disease incidence than a commercial hybrid indicating that *H. tuberosus* was a good source of resistant to *A. helianthi*. However, Ravikumar *et al*. (1995) did not observe any resistant in *H. tuberosus* derived lines when evaluated under natural epiphytotic conditions.

One hundred ninety six germplasm entries along with nine varieties and hybrids were screened for *A. helianthi* resistance in sunflower under natural conditions. Only one entry GP-324 exhibited resistance, while three entries showed moderate level of resistance. However, under artificial conditions, none of the entries were resistant to alternaria leaf spot. Only three entries, K-2, MSFH - 1 and GP-324 proved to be moderately resistant and 15 entries showed moderate susceptibility while the rest were susceptible (Velanzhahan *et al*., 1991).

Nagaraju *et al*. (1994) reported that susceptible checks Morden and L- 101 showed 22.78 and 23.89 percent severity, respectively in sunflower.

Velanzhahan and Narayanaswamy (1994) evaluated 31 sunflower genotypes for leaf blight under natural field conditions. Four genotypes were resistant, 11 were moderately resistant and remaining all were found susceptible. However, only one entry GP-145 was found resistant and 6 genotypes expressed moderate resistance to the disease under artificial epiphytotic conditions.

Ravikumar *et al.* (1995) reported that germplasm lines Acc No-180, 1229 and hybrid ISFH-306 recorded moderately resistant reaction, among the 23 genotypes evaluated under natural epiphytotic conditions at Dharwad. However, none of them showed high level of resistance.

Mesta *et al*. (2005) reported that the Accessions 194, 336, 347, 367, 446, 1039, 1142, 1210 and 1483 as resistant entries against alternaria leaf blight of sunflower under natural conditions.

Smita *et al.* (1998) found that ten varieties/lines of sunflower (*Helianthus annus*) were evaluated against leaf blight caused by *Alternaria alternata* in pot experiments. Of these, Sungene 90, Peredovik and Sunbred -221 were susceptible to the pathogen while

Morden showed a highly susceptible reaction against alternaria leaf blight. The fungus was also observed as pathogenic on chrysanthemum and zinnia.

Sreenivasulu *et al.* (2004) screened six genotypes of China aster against alternaria leaf spot under field condition by following 0-5 scale. Results revealed least score by Phule Ganesh Pink (18.26) for leaf area infection, whereas it was maximum in Kamini (28.63) for the same.

In an experiment of screening the chrysanthemum cultivars for alternaria leaf spot disease under natural condition (Thammaiah *et al.,* 2004). Among the twelve cultivars, Chandini recorded the highest alternaria leaf spot index (39.12%), followed by Raja (38.67%), Bangalore (28.34%), Sarval (26.29%), No-9 (26.23%), Golden Red (22.57%), Dundi (22.88%). Cultivar Indira (2.33%) recorded the lowest leaf spot index followed by Co-2 (3.06%) and Co-1 (6.49%).

Reddy *et al.* (2006) screened sunflower genotypes in field and lab environments to evaluate genotype for resistance to *A. helianthi*. The disease intensity for hybrids ranged from 3.73 to 52.33 per cent. The variety RHA 587 and ARG*RHA 587 were found to be resistant to alternaria blight both under field and laboratory condition.

Shivakumar (2008) revealed that screening studies under artificial condition shows that one progeny line from cross JS 335 × EC 241780 and five progeny lines from cross JS 93-05 × EC 241780 exhibited resistant reaction to soyabean rust.

Seventeen marigold cultivars were screened under natural epiphytotic conditions against leaf spot and flower blight disease. Cultivars *viz.* Pusa Narangi Gainda (87.60%), Pusa Basanti Gainda (84.50%) and Crackerjack (81.30%) of African marigold were found to be highly susceptible to disease, while as in French marigold, ten cultivars exhibited resistant reaction towards the disease (Akoijam and Chandel, 2010).

Yadav *et al.* (2014) screened different advanced lines and genotypes against early blight of tomato caused by *Alternaria solani.* Nineteen advanced lines were found resistant against *A. solani*.

Kale and Ajjappalavara (2014) screened Forty four genotypes of onion for purple blotch disease. None of them was found resistance or immune, while five genotypes *viz.* OG-4, OG-7, OG-14, OG-34 and OG-44 were found to be moderately resistant (Grade 2) and 31 genotypes were moderately susceptible (Grade 3), five were susceptible (Grade 4) and the remaining two genotypes were highly susceptible with grade 5.

Thirty varieties of chrysanthemum were screened against alternaria leaf spot disease. Accession No-1 was found to be resistant to leaf spot disease. Of the 30 varieties screened none of them found to be immune or completely free from disease. The genotype Accession No.1 recorded resistant reaction (12.72%). The variety Dundi recorded highly susceptible reaction (79.33%) screened under natural disease pressure condition (Madalagi, 2014).

Rachappa (2014) reported in field screening for alternaria leaf spot disease, minimum score was obtained in genotype AAC-1. Whereas, the high score obtained genotypes were susceptible (Poornima). The degree of variation occurred with respect to the response of genotypes to alternaria leaf spot disease, any resistance or susceptibility of the cultivar to the disease is controlled by the genetic constituent of genotype.

2.5 Segregation ratio for alternaria leaf spot in F_2 population.

The resistant reaction of muskmelon line MR-1 to alternaria leaf blight is characterized by the production of small necrotic lesions in response to infection by the pathogen. The F_1 and F_2 from crosses of the alternaria leaf blight resistant inbred line MR-1 and the susceptible cultivars Perlita and PMR 6 were used to determine inheritance of resistance to *Alternaria cucumerina*. All plants in the F_1 population were resistant. F_2 phenotypic ratios were 3 resistant: 1 susceptible. The reactions of parental lines and progenies to conidial inoculation with *A. cucumerina* support the hypothesis that the resistance of line MR-1 is conferred by a single dominant gene (Thomas *et al*., 1990).

Eswarappa *et al*. (2011) studied that alternaria blight of sesame leads to considerable yield loss. The resistance mechanism in sesame is obscure. RT-273 was identified as a resistance line to alternaria blight through field screening and in advanced to F_2 generation the inheritance for resistance was controlled by a single dominant allele and segregated as 3:1 (chi-square is NS) ratio.

Tryphone *et al*. (2012) reported that the Chi-square values were computed to determine whether the observed ratios for disease reactions deviated from expected Mendelian ratios for a single dominant gene controlling resistance to angular leaf spot in common bean. Based on the resistance of the F_2 and the backcross generation to the resistant parent, 3 resistant: 1 susceptible segregation ratio in the F_2 and a 1 resistant: 1 susceptible segregation ratio in the backcross generation to the susceptible parent was obtained implying that resistance to the isolate of *Phaeoisariopsis griseola* is governed by a single dominant gene.

2.6 Performance of genotypes and F_2 population

Negi and Raghava (1982) evaluated many germplasm collections of China aster at the Indian Institute of Horticultural Research, Bengaluru. Many of the collected germplasm were heterozygous in nature. Therefore, single plant selections were made on the basis of desirable attributes and these were maintained to evaluate. Two lines AST-1 and AST-2 were consistently superior in their performance over other lines.

Medium to high heritability was observed in China aster by Rao (1982). High heritability coupled with high genetic advance was observed for weight of flowers and number of ray florets per head. High heritability values with medium genetic advance were noticed for height of plant, spread of plants, length and girth of stalks. Medium heritability with low genetic gain was exhibited by number of main branches.

Negi *et al.* (1983) evaluated many selections of China aster. The line IIHR-35 (Violet Cushion) was found the best for both cut flower and loose flower purpose. While another improved line IIHR-19 was found better for individual cut flower purpose. Two violet F_1 hybrids from crosses IIHR-3 x IIHR-19 and IIHR-35 x IIHR-19 performed better than Local Violet.

Negi and Raghava (1985) carried out a large number of crosses involving many pure lines having desirable and complimentary characters at IIHR, Bengaluru in China aster. Selections were made in the subsequent generations. Five lines namely IIHR-3, IIHR-18, IIHR-26, IIHR-31 and IIHR-35 were found to be highly promising with regard to flower colour, shape, size and stalk length. Among the five lines, IIHR-26 and IIHR-35 performed better compared to other varieties and have been named as Poornima and Violet Cushion.

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

A study on 12 diverse genotypes of China aster revealed narrow sense heritability for number of ray florets per flower followed by size of flowers and weight of flowers per plant (Raghava and Negi, 1994). Estimates of heritability and co-heritability for 12 varieties of China aster revealed additive gene effects for all the characteristics under study (Aswath and Parthasarathy, 1993).

Heritability information on nine genotypes of China aster showed narrow sense heritability estimates for all the 12 characteristics studied. Among them, height of plant, rows of ray florets per flower were highest (Patil and Rane, 1995).

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

Bindumathi and Gulabrao (1997) studied the performance of three cultivars of China aster *viz.* Sel-No-4 (Red), Sel-No-6 (White) and Sel-No-11 (Blue). The plants of white cultivars produced more flowers with better stalk length. The weight of white flowers was also better than red and blue flowers.

Among the various cultivars, the most promising cultivars for cut flower production under Ghataprabha Command Area were Violet Cushion, Shashank, Poornima and Kamini while the Phule Ganesh Series were suitable for loose flower production (Angadi, 2000).

Eleven genotypes of China aster were evaluated for fourteen quantitative characters by Kumar and Patil (2003). Genotypic coefficient of variation was high for spread of plant, leaf area per plant, average weight of fresh flower and flower yield per plant. Heritability estimates for these characters were also relatively high which indicated that there was a scope for selection of these characters to improve flower yield. There was strong correlation and high expected genetic advance. The correlation studies revealed that flower yield was positively and significantly correlated with diameter of flower and number of flowers per plant during selection of genotypes for improvement in yield.

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

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

Tryphone *et al*. (2012) reported that the genetic resistance to angular leaf spot (ALS) caused by *Phaeoisariopsis griseola* in the common bean cultivar Mexico 54 was investigated on disease reactions in parental, F_1, F_2 and backcross generations derived from crosses between a resistant cultivar Mexico 54 and a susceptible cultivar Kablanketi under screen house conditions. The heritability (h^2) estimate was as high as 0.719 indicating a successful transfer of ALS resistance among progenies and thus selection can be performed in early generation. High heritability coupled with high expected genetic advance of 39.50 per cent is considered to be more useful in predicting the outcome of selecting the best individuals.

Ranganatha *et al.* (2012) reported that the genetic variability, heritability and genetic advance study for seed cotton yield and its components in segregating F_2 generation of cotton (*Gossypium hirsutum* L.). Genetic potential of segregating F_2 generation for different parameters revealed plant height, bolls plant per plant, boll weight and seed cotton yield per plant. Genetic variances were found almost greater than the environmental variances for all the traits. High broad sense heritability and genetic gain were recorded for plant height, bolls plant per plant, boll weight and seed cotton yield per plant respectively. These results suggest that rigorous plant selection is required to identify desirable plants from F_2 generation.

2.6.1 Vegetative parameters

Rao and Negi (1990) evaluated 38 genotypes of China aster for variability and heritability with respect to 12 biometric characters. They found highly significant differences among all the genotypes for vegetative characters. The range of plant height was 25.23 cm to 61.37 cm. The heritability was medium for number of flowers, number of laterals and number of main branches per plant.

Kulkarni and Reddy (2006) noticed that China aster cultivar Phule Ganesh White performed better in terms of vegetative growth followed by cultivars Phule Ganesh Violet and Phule Ganesh Purple. All the Phule Ganesh cultivars proved better than the cultivars Kamini and Violet Cushion.

Poornima *et al.* (2006) evaluated five genotypes of China aster under hill zone of Karnataka. It was observed that maximum number of leaves was recorded in the genotype Violet Cushion (248.95) whereas, minimum was recorded in the genotype Kamini (127.71).

Munikrishnappa *et al.* (2011) evaluated ten genotypes, among them variety Phule Ganesh Violet recorded the highest plant height. The plant spread was maximum in varieties Phule Ganesh Violet at 45 days after transplanting and Phule Ganesh Purple at 75,105 days after transplanting and at harvest. The variety Phule Ganesh Violet was found superior which recorded maximum number of primary branches per plant, leaf area per plant and leaf area index. The variety Phule Ganesh Purple recorded maximum number of secondary branches per plant.

Zosiamliana *et al.* (2012) studied the growth, flowering and yield characters of some cultivars of China aster. The studies revealed that the maximum number of leaves per plant were recorded in cultivar Phule Ganesh Violet (192.73), whereas, minimum were recorded in cultivar Local (146.67).

2.6.2 Flowering, yield and quality parameters

In China aster, number of flowers per plant had significant positive correlation with height of plants, number of laterals per plant and weight of flowers. Whereas, plant spread was negatively correlated with plant height (Aswath and Parthasarathy, 1993).

The association between number and weight of flowers was positive and perfect. Both the characters were positively correlated with days to flowering, days to harvest, plant height, plant spread and stalk length at genotypic and phenotypic levels. Days to flowering exhibited highest positive direct effect with number of flowers per plant followed by duration of flowering, weight of flowers and number of branches per plant (Patil and Rane, 1995).

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

Kumar and Patil (2003) revealed that flower yield was positively and significantly correlated with diameter of flower and number of flowers per plant

Tirakannanavar *et al.* (2004) reported that significant difference among the genotypes of China aster for 1000 seed weight, germination percentage, root length, shoot length, seedling length, root to shoot ratio and seedling dry weight. While non significant difference was observed for vigour index. The maximum germination percentage was recorded in genotype Phule Ganesh White and lowest in genotype Kamini. The genotype Phule Ganesh Pink showed maximum 1000 seed weight, root length, shoot length, seedling length and seedling dry weight. The genotype Kamini showed lowest 1000 seed weight, root length, shoot length, seedling length, and seedling dry weight.

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

China aster genotypes *viz.,* Poornima, Shashank, Kamini, Violet Cushion and Local were selected for evaluation. The maximum number of flowers and more flower yield was obtained in cultivar Shashank (50.22 and 9.51 t/ha, respectively). Whereas, the cultivar Poornima produced least number of flowers (45.30) and flower yield (5.03 t/ha) followed by cultivar Local Type (Poornima *et al.,* 2006).

Ten China aster genotypes were selected for evaluation. Among them the genotype Mixed Variety Local differed significantly and took least number of days to commence flowering, exhibited the earliness in reaching 50 per cent flowering. The weight of 100 flowers, flower diameter and flower yield per hectare was recorded maximum in genotype Phule Ganesh White (Munikrishnappa *et al.,* 2011).

2.6.3 Other flower crops of the Asteraceae family

2.6.3.1 Chrysanthemum

Chaugule (1985) working on chrysanthemum observed high variability for weight of flowers per plant followed by number of flowers per plant and also noticed highest genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV) for number of flowers per plant.

Chezhiyan *et al.* (1985) determined genetic variability in chrysanthemum. A high heritability estimates were recorded for number of flowers per plant (49.83%). Despite the high heritability, the genetic advance was low for all the characters except earliness to flower (68.06%). Such a high heritability and a low genetic advance are attributed to the non-additive gene effect.

Genotypic variances in 27 cultivars of chrysanthemum were lower than phenotypic variance. High GCV and PCV were observed for earliness in flowering, number of flower per plant and yield of flowers (Ponnuswami *et al.,* 1985).

Variability studies on 57 genotypes of chrysanthemum revealed higher values in PCV than GCV. Higher GCV and PCV values were found for number of flowers per plant followed by number of branches per plant and diameter of disc (Sirohi and Behera, 2000).

Gaikwad and Patil (2001) evaluated nine chrysanthemum varieties to assess growth, flowering and yield parameters under open and polyhouse conditions. The variety Indira recorded medium height and spread with more number of sprays per plant and per plot followed by Mutant No. 9 having larger size and maximum spray length.

Dhiman (2003) studied the performance of eleven different cultivars of chrysanthemum (Thaichung, Fiji, Tata, Century, Ajay, Snow Ball, Sonarbangla, Pink Prince, Mountaineer, Flirt, Johnwebber). Among them, Ajay, Flirt and Fiji showed higher flower yield in terms of number and weight basis with medium size flowers and these are suitable for loose flower production. Large flowering types, namely Pink Prince, Tata Century, Thaichung and Snow Ball are suited for garden display or exhibition purposes

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

Baskaran *et al.* (2004) studied the performance of ten chrysanthemum cultivars best suited for commercial purpose under open field condition at Bengaluru. The result showed that the variety which recorded higher yield was Red Gold (365.00 g) followed by Nilima (324.00 g) and Yellow Star (287.00 g). Maximum flower diameter (8.14 cm) was observed in variety Ravikiran, while minimum (2.07 cm) was recorded in variety Button Type Local. Based on the studies it was observed that varieties Red Gold, Nilima, Yellow Star and Ravikiran can be exploited commercially for different purpose under Karnataka condition.

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

Kulkarni and Reddy (2004) evaluated seventeen chrysanthemum genotypes. Among them genotypes Harvest Home, Mutant No. 9, Selection-5, Karnool, Saraval and Chandrika were superior for their vegetative growth in terms of plant spread, number of branches, leaf area and flower yield as compared to other genotypes.

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

Among chrysanthemum cultivars evaluated, days taken for first flowering was minimum in cv. Co-1. However, it is statistically on par with cultivars Punjab Anuradha and Silper, whereas the cv. Raichur recorded late flowering. Maximum number of flowers per plant were recorded with cultivar Raichur followed by cv. Silper (Laxmi *et al.*, 2008).

The accessions B-7, B-14, B-16 and B-28 of chrysanthemum were suitable for growing in the garden largely due to better plant spread together with more number of flowers, synchronous flowering and comparatively longer flowering duration. ACC-115 and B-4 were found to be suitable for cut flower, as they were observed to be tall with long sprays and uniform opening of flowers (Singh *et al.,* 2008).

In chrysanthemum, the variety Mayur recorded minimum days for first bud initiation and days taken for first flowering. The maximum number of flowers per plant and size of flower was found in varieties Red Gold and Shyamal, respectively. Variety Nilima recorded maximum weight of flowers per plant and flower yield (Joshi *et al.*, 2009).

2.6.3.2 Marigold

Tsukamoto *et al.* (1971) assessed different *Tagetes* cultivars in different temperature range and obtained flowering in French marigold cv. Butter Ball at 30^0 C under 10 hours day length. They further evaluated various cultivars of African marigold and reported that cv. Pot O Gold was not affected by either day length or temperature.

Among the African group, cultivars Giant Double African Orange, Climax and Bangalore Selection were suitable for commercial cultivation. In French group cultivars Rusty Red, Butter Scotch, Red Brocade, Valencia Sussana and Tetraploids were excellent for bedding purposes under Ludhiana conditions (Arora and Singh, 1980)

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

An evaluation trial of different *Tagetes* cultivars under short and long duration of light was conducted and it was observed that cultivars Orange Winner and Tanger responded well to long duration in summer, whereas, cv. Tiger Eyes responded well to long duration in winter (Zimmer, 1989).

In an evaluation study, 24 marigold cultivars for budding. Howe and Waters (1990) indicated that cultivars Torch, Yellow Jacket, Spin Wheel, Tiger Eyes, Gypsy Sunshine, Boy O Boy, Harvest Moon Improved, Yellow Boy, Janie Flame as superior ones.

High phenotypic and genotypic coefficient of variations were observed in 11 varieties of African marigold by (Janakiram and Rao, 1991) for characters like number of laterals branches (17.63% and 39.21% respectively), flower size (15.72% and 15.61%), flower weight (18.00% and 27.53%) and total flower yield per plant (29.46% and 28.61%).

Studies on variability in chrysanthemum by Barigidad *et al.* (1992) revealed significant variation among the 15 genotypes tested for all the characters. PCV and GCV were high only for diameter of flower disc.

A study on 12 cultivars of African and French marigold depicted significant differences in all characteristics studied. High GCV values were observed for dry weight of flowers, yield of flowers per plot and weight of fresh flowers in African marigold. In French marigold, they noticed high GCV for yield of flowers per plant, number of flowers per plant and spread of flowers. They noticed more variability for all the traits in French marigold than in African marigold (Singh and Sen, 2000).

Mathad *et al.* (2003) assessed the genetic variability in 31 accessions of African marigold for yield parameters. Analysis of variance revealed significant differences among accessions for all the 23 characters studied. The phenotypic and genotypic coefficient of variations were recorded higher for the traits like flower yield per plant, flower yield per plot and flower yield per hectare, indicating existence of wide range of genetic variability in the germplasm.

Rao *et al.* (2005) evaluated ten cultivars, among them better plant growth found in cultivar Orange Double with the highest plant height, leaf area, fresh biomass and dry matter yield.

Singh and Singh (2005) evaluated French marigold and wild marigold under tarai conditions. Among these germplasm, TP_7 germplasm of French marigold exhibited better performance in terms of diameter of flower and yield of flowers per plant.

Genetic variability was estimated for various vegetative and floral characters in 30 genotypes of French marigold (*Tagetes patula*). The studies showed high range for total yield per plant (59.08–559.35g), weight per flower (0.96–8.59g) and number of flowers per plant (35.33–206.0). The coefficient of variation (PCV and GCV) was maximum for weight per flower (PCV=59.75%, GCV=59.49%) and minimum for duration of flowering (PCV=11.08%, GCV=10.84%). The phenotypic coefficients of variations were higher than those of genotypic coefficient of variation, which indicate greater GxE interaction (Kanwar and Saha, 2006).

Singh and Saha (2006) studied the heritability and genetic advance in 30 genotypes in African marigold. High estimates of heritability (broad sense) were obtained for all the characters studied.

Singh and Singh (2006) studied the performance of 29 genotypes of African marigold under Uttaranchal conditions. Among these germplasm TEG-16 exhibited best performance for number of primary branches per plant, number of flowers per plant and dry weight of leaf.

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

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

Pal and Kumar (2010) studied the genetic variability, heritability and genetic advance in seventeen genotypes of African marigold (*Tagetes erecta* L.) under Meerut region. The genotype Pusa Basanti Gainda exhibited maximum mean performance for plant height at peak flowering period (80.00 cm), while minimum was exhibited by genotype Indam Orange (30.90 cm).

Kavitha and Anburani (2010) evaluation on genotypic variability in thirty genotypes and found that the coefficients of variation both at genotypic and phenotypic levels were maximum for number of flowers per plant, while minimum for dry matter production.

Raghuvanshi and Sharma (2011) studied varietal evaluation of French marigold under hill zone of Himachal Pradesh. Among cultivars Safari Queen recorded maximum plant height, flower yield and seed yield per plant.

Genetic variability and heritability studies involving 30 genotypes of French marigold indicated that there were highly significant differences between the genotypes for flower yield and seven other characters. Comparison of genotypic and phenotypic co-efficient of variation for different traits indicated that the values of PCV were higher as compared to GCV due to the influence of environment. High genotypic co-efficient of variation was observed for stem girth, flower head weight and flower yield per plant. Heritability estimate in general were high for most of the characters studied. High heritability coupled with high genetic advance (as per cent of mean) was observed for number of flowers per plant, flower yield per plant, stem girth and plant height. Hence, these characters need to be given more importance in selection as these are expected to be controlled additive genes (Anuja and Jahnavi, 2012).

Shivakumar (2014) evaluated fifteen African marigold genotypes to identify suitable genotypes under hill zone of Karnataka. Among the fifteen genotypes studied, the results showed a highly significant variation for various growth and yield parameters among the cultivars. The genotype Nilakkotai Local Orange recorded the maximum flowering duration (86.53), number of flowers per plant (59.4) and flower yield per plant (529.33 g), whereas minimum flowering duration (38.56), number of flowers per plant (20.60) and flower yield per plant (120.93 g) was recorded in the genotype Dwarf Yellow.

2.6.3.3 Gerbera

Performance of each gerbera variety varied with respect to number of flowers per plant, stalk length and flower diameter due to several factors like genomic constitution, environmental factors, growing conditions, soil and inputs (Horn *et al.*, 1974).

Vergora *et al*. (1984) concluded that among 18 cultivars of gerbera in polyethylene cladded greenhouse, Terrafarava, Terranutow, Arabella and Fredking cultivars found to be high yielder than the other cultivars during winter season.

Kannan and Ramdas (1990) conducted variability studies in gerbera. Genotypic co-efficient of variation were lower than phenotypic co-efficient of variation indicating the environmental effect. High genotypic co-efficient of variation were noticed for number of suckers per plant and number of leaves per plant, while low GCV were noticed for length and girth of flower stalk.

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

Borate (2002) indicated that the gerbera cultivar Twiggy was found to be the early flowering (72.66 days) having maximum flower diameter (8.85 cm) and stalk length (57.47 cm) with highest yield of 12.60 flowers per plant per year under shade net.

Lhoste (2002) observed that cultivars like Alberino, Amaderes, Bonnie, Duela, Evalou, Gigliola, Orange Dino, Red Dino, Suzanne, Pia, Tambre, Testarossa, Tucam, Ulysse, Virginia and Vyanah were the best performing standard gerberas under Mediterranean condition which were selected based on the number of stems per plant and percentage of flowering stems.

Performance of 11 gerbera cultivars under polyhouse conditions was studied by Dalal *et al.* (2005) and reported that the cultivars Kozak, Yellow, Venus, Masai and Xenia were found most promising.

Naik *et al.* (2006) studied performance of gerbera cultivars under naturally ventilated polyhouse and reported maximum number of leaves per plant in the cultivar Gescom (38.65).

Paraneetha (2006) studied the promising seven bedding type of accessions and ten named cultivars of gerbera at Shervaroy hills of Tamil Nadu, the longest stalk length (58.73 cm) was measured by the accession GJ-5. The maximum of 0.55 cm was measured as diameter of the flower stalk, flower diameter (10.17 cm) and more number of suckers per plant per year (11.27) in the accession GJ-23. Among the ten cut flower genotypes, genotype Rosalin performed well for the characters like plant height (27.75 cm), flower yield per plant per year (23.35), flower diameter (11.65 cm) and number of suckers per plant per year (10.32).

Singh and Srivastava (2008) revealed that low cost polyhouse planting recorded significantly better growth and yield to shade net planting. Flower stalk length, diameter of flower, stalk diameter and yield of flower per square meter were more under low cost polyhouse conditions as compared to shade net conditions. The duration of flower, days taken to first floret opening and vase life were also more under low cost polyhouse conditions as compared to shade net conditions. Among the varieties evaluated cultivars Ruby Red, Dalma, Essance and Dune were found promising for commercial cultivation under protected conditions.

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

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

Taj (2012) assessed the performance of ten gerbera genotypes under protected cultivation. The genotype Naike (38.01) produced maximum number of quality cut flowers and was statistically on par with Kyllian (36.94) and significantly superior over other genotypes. The genotype Amlet produced the longest stalk length, bigger sized flowers were produced by genotypes Kyllian and Vilassar and the genotype Elite produced maximum number of ray florets compare to other genotypes.

2.6.3.4 Dahlia

Mishra *et al.* (1987) noticed the phenotypic performance of 23 varieties of dahlia and revealed that largest variation in terms of maximum range were plant height (72.6 to 148.4 cm), flower weight (3.6 to 49 g), number of flowers per plant (12.3 to 147.1), days to first flowering (102.6 to 129.7 days) and diameter of flower (4.6 to 21.8 cm).

Choudhary (1989) reported that all the characters showed a considerable range of variation. Maximum variation range was observed for plant height (72.5 to 133.633 cm), number of flowers per plant. (13.36 to 51.55), diameter of flower (4.9 to 22.7 cm) and weight of tubers (191.6 to 1278.3 g) in Dahlia.

High heritability with high genetic advance was noticed for number of branches per plant, leaf area and total number of flowers per plant in dahlia (Shashikala *et al.*, 1995)

Fifteen genotypes of dahlia were assessed for genetic variability and character association by Beura *et al.* (1995) for total flower production per plant and its nine yield attributing traits. Genotypic differences were significant for total flower production and its components, thereby indicating the possibility of improving flower production through varietal selection in the existing collection.

All the characteristics under study in dahlia, showed high heritability. Inter nodal length, number of disc florets per head, leaf area and number of ray florets per head showed high heritability together with high genetic advance. Selection based on these traits would be useful in breeding (Srinivas and Narayanagowda, 1995).

Mishra *et al.* (1987) from their studies on genetic variability in dahlia reported high heritability for all the characteristics, high heritability together with high genetic advance was noticed for number of ray florets per flower, height of plants and number of flowers, number of leaflets per flower and length of petiole exhibited high heritability with low genetic advance.

Mishra and Saini (1997) found the genetic variability for related parameters in twenty varieties of dahlia obtained from different sources. There was a wide range of variability for all the characters. High heritability was found for all the characters**.**

Singh (2003) obtained higher phenotypic and genotypic coefficient of variations for characters like number of flowers per plant (55.42% and 35.48%) followed by number of branches per plant (41.46% and 29.53%), fresh weight of flower (37.84% and 33.97%) and number of seeds per flower (33.57% and 24.75%). Narrow differences between phenotypic and genotypic coefficient of variation were noticed for days to 50 per cent flowering (1.65% and 0.80%) and fresh flower weight (37.84% and 33.97%) indicating less environmental interference on the expression of these characters.

Twenty five dahlia accessions were evaluated to ascertain genetic parameters of variability. Phenotypic coefficients of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the characters studied. However higher PCV and GCV estimates were found for stalk length of the flower, duration of flowering, number of ray florets per flower and individual flower weight. High heritability with high genetic advance was observed for vase life, diameter of flower, stalk length of the flower and individual flower weight (Vikas *et al.*, 2011)

2.7 Vase life studies

The difference vase life of flowers of different species is inherently influenced and it varies among different cultivars of same species. Hence, several workers judgment is given below.

2.7.1 China aster

Guruprasad (1999) studied the longevity of cut China aster cv. Kamini. He reported that cobalt sulphate and aluminium sulphate at 1.0 mM along with four per cent sucrose was best combination to promote the vase life and quality of China aster cut flowers.

The maximum vase life was recorded in cultivar Phule Ganesh White followed by cultivars Kamini and Poornima. Whereas, least longevity was recorded in cultivar Phule Ganesh Violet (Angadi, 2000).

Among different genotypes Phule Ganesh Pink, Phule Ganesh Violet and Phule Ganesh White had significantly higher vase life. Whereas, genotypes Giant Branching

Comet, Shashank, Ostrich Plume Mix and Rainbow Mix had the lower vase life (Ravikumar, 2002).

2.7.2 Marigold

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

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

2.7.3 Gerbera

Nalawadi *et al.* (1980) studied vase life in some varieties of gerbera. They reported that varieties Firefly, Minshlory, Kasjuglory and Sabama were having good vase life. Varieties Dr. H. C. Mukerjee, General Choudry, Sahitya, Sunset, Summer Yellow, Zakir Hussain, Delight and Minerva were having medium vase life and varieties Bhim Bhadur, Swadeshi, Niranjan and Vermilion Colour were having poor vase life.

Eberhardt (1982) studied vase life in some newly released gerbera varieties. The varieties Enzett Bootes, Enzett Orion, Enzett Persus, Enzett Auriga Violettrosa and Enzett Dorado were having vase life of 11, 10, 11.3, 15.3 and 17.7 days, respectively.

A study on vase life of 21 accessions of gerbera observed that the accessions GJ-8, GJ-10, GJ-16, GJ-18, GJ-23 and GJ-44 were free from the post-harvest disorders after 24 hours of cutting and were suitable for using as cut flowers (Thangaraj *et al.*, 1990).

Shin *et al.* (1994) reported peak cut flower production in gerbera during March and May and varieties recorded maximum vase life during spring than in summer.

A study on post-harvest life different genotypes observed that flower stems of cultivars GJ-6, GJ-7, GJ-8, GJ-13 and GJ-16 possessed good structural strength with stress caused during transit (Anuradha and Gowda, 1999).

Borate (2002) mentioned that, out of eight cultivars of gerbera cv. Testarossa produced attractive red colour flowers having long vase life of 10.40 days in distilled water.

Singh and Sangama (2002) studied the influence of cultivars and flower stalk length on vase life of gerbera and they observed that longer stems had a longer vase life compared with shorter stems. The cv. Lyonella recorded the longest vase life (5.06-9.13 days), followed by cv. Tiramisu (4.96-8.76 days), while cv. Thalassa had the shortest (3.93-7.03 days).

Dhane (2003) recorded that, variety Thalassa produced flowers with maximum vase life (9.33 days) in plain while variety Tonneke produced flowers with minimum 6.66 days vase life was at par with variety Yarna (7.00 days).

Parthasarathy and Nagaraju (2003) observed that, the highest longevity of gerbera cultivars (16.60 days) was found during October- November under mid-hills of Meghalaya.

Paraneetha (2006) mentioned that out of seven bedding type accessions of gerbera, the longest vase life (10.92 days) was recorded in Accession GJ-23. However, gerbera cv. Rosalin produced the longest vase life flower (16.33 days) as compared to other ten gerbera cultivars under Shervaroy hills of Tamil Nadu.

3. MATERIAL AND METHODS

The present investigations on "Screening of genotypes and F_2 segregating population of China aster (*Callistephus chinensis* [L.] Nees.) for alternaria leaf spot." was carried out in the Department of Floriculture and Landscape Architecture, Gokak taluk, Belagavi district of Karnataka during the period of 2015 - 2016 in medium black soil under irrigated conditions in order to find out the sources of resistance.

Each genotype was replicated thrice. Crop cultivation practices were followed as per package of practice but plant protection measures not taken. Observations were recorded by screening sixteen genotypes under natural disease pressure and artificial inoculated conditions. The disease intensity was recorded by using disease score (0-5 scale). The details of the materials used and the methods adopted during the course of the investigation are presented in this chapter.

3.1 Experimental site

The experiment was carried out in the research field of Department of Floriculture and Landscape Architecture, Kittur Rani Chennamma College of Horticulture, Arabhavi (University of Horticultural Sciences, Bagalkot), Belagavi district, Karnataka.

3.2 Geographical location of experimental site and climate

Arabhavi is situated in northern dry zone of Karnataka state at 16º15´ north latitude, 74º45´ east longitude and at an altitude of 612.03 meter above the mean sea level.

Arabhavi which comes under Zone-3 of Region-2 of agro-climatic zones of Karnataka, has the benefit of both South-West and North-East monsoons. The average rainfall of this area is 530 mm which is distributed over the period of seven months (May to October) with prominent peak during August to October.

Plate 1(a): General view of experimental plot with different genotypes

Plate 1(b): Experimental plot of F_2 population.

The command area receives water from Ghataprabha Left Bank Canal from mid July to mid March. During the experimental period, the mean minimum temperature varied from 18.05ºC to 22.70ºC whereas the mean maximum temperature varied from 28.00ºC to 38.00 ºC. The total rainfall of this area is about 409.80 mm, distributed over a period of seven to eight months (March to October) with peak during June to July. The meteorological data for the period of experimentation was recorded at the meteorological observatory of the Agricultural Research Station, Arabhavi and is presented in the Appendix I.

3.3 Experimental Details

3.3.1 Planting materials

For the experiment, sixteen genotypes of China aster and F_2 segregating lines from two crosses for assessing resistance to alternaria leaf spot were used**,** which includes four released varieties from Indian Institute of Horticultural Research, Hessarghatta, Bengaluru, four varieties released from M.P.K.V. Rahuri and remaining varieties collections made at the Department of Floriculture and Landscape Architecture, K.R.C. College of Horticulture, Arabhavi.

3.3.2 F_2 segregating population

The material under investigation comprises of F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, these two population shown resistance against alternaria leaf spot in F_1 generation were selfed and seeds are collected and used for F_2 analysis. Two hundred plants from each F_2 population were observed for growth, yield and disease reaction. The characteristic features of parents used are presented in table 1 and genotypes used are presented in table 2.

Table 1. Salient features of the parents of F_2 population

Sl. No.	Codes used	Features
1.	AAC-1	This is locally cultivated genotype, flowers are pink in colour, flower diameter is 6 cm and flower weigh 4 g, plant height is 60 cm, stalk length of 30 cm and takes about 138 days to flower. The plants produces 50 flowers/plant.
2.	Arka Kamini	This variety was released from IIHR, Bengaluru and commercially cultivated throughout Karnataka state. The variety produces attractive pink coloured flowers. It grows to about 60 cm. It has stalk length of 30 cm and vase life of 8 days. Flowers are 6 cm in diameter and weight 5 g each. The plant produce about 50 flowers.
3.	Phule Ganesh Purple	It is semi-erect plant with bright purple color flowers which is preferred in the artistic floral managements. It produces 46.82 lakh flower/ha.

Table 2. Details of genotypes used in an experiment

Sl. No	Genotypes	Type	Flower colour	Stem colour	Source
1	Arka Kamini	Double	Bright pink	Slight pink	IIHR, Bengaluru
2	Arka Poornima	Double	Creamy White	Slight green	IIHR, Bengaluru
3	Arka Shashank	Double	Milky White	Dark green	IIHR, Bengaluru
4	Arka Violet Cushion	Double	Violet	Slight brown	IIHR, Bengaluru
5	Arka Archana	Double	White	Slight green	IIHR, Bengaluru
6	Arka Aadya	Double	Pink	Slightly pink	IIHR, Bengaluru
7	Phule Ganesh Violet	Double	Violet	Slight brown	MPKV, Rahuri
8	Phule Ganesh White	Double	Milky white	Dark green	MPKV, Rahuri
9	Phule Ganesh Pink	Double	Bright pink	Dark pink	MPKV, Rahuri
10	Phule Ganesh Purple	Double	Purple	Dark pink	MPKV, Rahuri
11	AAC-1	Double	Bright dark red	Slight pink	Collection made at Dept. of FLA, KRCCH, Arabhavi
12	AAC-5	Single	Light Pink	Slight pink	Collection made at Dept. of FLA, KRCCH, Arabhavi
13	AAC-7	Single	Milky White	Slight green	Collection made at Dept. of FLA, KRCCH, Arabhavi
14	AAC-8	Double	Bright Pink	Slight pink	Collection made at Dept. of FLA, KRCCH, Arabhavi
15	AAC-10	Double	Pink	Slight green	Collection made at Dept. of FLA, KRCCH, Arabhavi
16	Miraj Local	Double	Bright Pink	Slight pink	Collection made at Dept. of FLA, KRCCH, Arabhavi

3.3.3 Design and experimental layout

Experimental design	: Randomized Complete Block Design /Un-replicated trial
Number of genotypes	: Sixteen and two F_2 population
Spacing	: 30 cm × 30 cm
Planting method	: Ridge and Furrow method

3.4 Cultural operations

The details regarding the various cultural operations carried out in the course of investigations are furnished here under.

3.4.1 Seed treatment

The genotypes and F_2 seeds were treated with captan @ 0.2 per cent to avoid fungal damage by soaking the seeds for 30 minutes and then shade dried, kept in refrigerator till the sowing.

3.4.2 Preparation of experimental site

Land was thoroughly ploughed to a depth of 30 cm and brought to fine tilth. All the weeds, stubbles, stones were removed and well decomposed farm yard manure @ 10 t/ha was applied and mixed well. The details regarding the various cultural operations carried out in the course of investigation are furnished here under.

3.4.3 Nursery operations

Raised nursery beds of size 2.0 m x 1.0 m were first prepared. The treated seeds of different genotypes were sown in nursery bed, then drench the beds with Bavistin (0.2%). The nursery beds were watered daily twice. Hand weeding was to remove all unwanted weeds at regular intervals. Urea spray was done at 0.2 per cent 15 days after sowing. The seedlings were ready for transplanting at 45 days after sowing.

AAC-1

Phule Ganesh White

Phule Ganesh Purple

Phule Ganesh Pink

Phule Ganesh Violet

Arka Poornima

Arka Kamini

Arka Violet Cushion

Plate 2(a): China aster genotypes used in the experiment

Arka Shashank

Arka Aadya

Arka Archana

AAC-5

AAC-7

AAC-8

AAC-10

Miraj Local

Plate 2(b): China aster genotypes used in the experiment

3.4.4 Transplanting

Forty five days old healthy and uniform seedlings were used for transplanting. The seedlings were transplanted in the month of October 2015 at a spacing of 30 cm X 30 cm.

3.4.5 Fertilizer application

Nitrogen, Phosphorus and Potassium fertilizers were applied at the recommended dose of 180:120:60 kg/ha of N: P: K (Anon, 2008) in the form of urea, single super phosphate and murate of potash, respectively. At the time of transplanting, half dose of N and full dose of P and K were applied in a circular band of about 3-4 cm around each plant and the crop was top dressed with remaining half dose of nitrogen after 30 days of transplanting.

3.4.6 Weeding and irrigation

The plots were kept weed free by periodic hand weeding. Irrigation was given at an interval of 5-6 days throughout the period of experimentation, depending on the soil moisture status and climatic conditions.

3.4.7 Gap filling

The gap filling was done seven days after transplanting with fresh seedlings, in order to maintain cent per cent population in all the treatments.

3.4.8 Plant protection

Timely and suitable plant protection measures were taken up to protect the experimental plants from the attack of pests.

3.4.9 Harvesting

Harvesting the flowers for the purpose of observation on flower and yield components was commenced after when flower attained maturity stage. The flowers were harvested from each genotype when they attained full size. Harvesting of crop for seed production was done after complete capitulum drying.

3.5 Collection of experimental data

The data were collected on various parameter of vegetative and flowering from the five randomly tagged plants in each replication, individual plant observations were recorded in F_2 population.

3.5.1 Growth parameter

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

3.5.1.1 Plant height (cm)

The height was measured from the base of the plant to the tip of the plant with the help of measuring scale and average was worked out and expressed in centimeters**.** This was done at all the two stages of plant growth *i.e.*, at 30 and 60 days after transplanting.

3.5.1.2 Number of leaves per plant

Numbers of leaves were recorded at 30 and 60 days after transplanting from tagged plants and average number of leaves per plant was worked out.

3.5.1.3 Plant spread East - West direction (cm)

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

3.5.1.4 Plant spread North-South direction (cm)

Similarly, spread of the plant was measured from north to south direction of the plant with help of meter scale and expressed in centimeters.

3.5.1.5 Stem girth (cm)

Stem girth was measured by leaving 5 cm from the ground level with the help of vernier caliper at 30 and 60 days after planting from all the tagged plants and average was worked out. It was expressed in centimeters.

3.5.1.6 Number of branches per plant

The number of main branches arising from the main stem were counted and recorded as the primary branches and branches arising from the primaries were counted and recorded as the secondary branches. This was done at 30 and 60 days after transplanting.

3.5.1.7 Number of leaves per plant

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

3.5.1.8 Leaf area (cm^2)

Leaf area was estimated by using graphical method at grand growth stage of the plant. At the plant grand growth stage, five randomly selected plants leaves were taken and their entire foliage was drawn on graph paper and later counting of squares which were occupied by the leaf. The leaf coverage on graph was clearly observed and counting of full squares and more than half covered and half and less than half covered area by leaf was estimated using correction factor and computed the mean value for further analysis.

3.5.2 Floral characters

The important parameters like number of days taken for first bud initiation, number of days taken to the first flower opening, days taken for 50% flowering, duration of flowering, crop duration, number of flowers per plant, flower yield per plant (g), weight of individual flower (g), flower yield per ha (tons), flower diameter (cm), disc diameter (cm) and ray floret length (cm) were measured and analyzed statistically.

3.5.2.1 Days taken for first flower bud initiation

This was recorded by counting the number of days from the date of transplanting to the stage at which the first flower bud was formed in five randomly selected plants per replication among the different genotypes. The mean was computed and expressed in days.

3.5.2.2 Days taken for 50 per cent flowering

The number of days taken for 50 per cent of plants to produce flowers in different cultivars was recorded from each treatment by counting the days from the date of transplanting. The mean was computed and expressed in days.

3.5.2.3 Duration of flowering

Number of days taken from the first flowering to the last harvest of flowers from five randomly selected plants per replication was recorded as total duration of flowering in each treatment. The mean was computed and expressed in days.

3.5.3 Yield and other parameters

3.5.3.1 Number of flowers per plant

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

3.5.3.2 Individual flower weight (g)

From the tagged plants, randomly five flowers were selected in each replication for recording the fresh weight of flowers and the mean value was worked out and expressed in grams.

3.5.3.3 Flower yield per plant (g)

From tagged plants, flower yield per plant was worked out by recording the fresh weight of ten flowers per plant. The mean weight of individual flower was worked out and multiplied by number of flowers per plant from five randomly selected plants per replication. The mean was worked out and expressed in grams.

3.5.3.4 Flower yield per hectare (t/ha)

The flowers yield/ha was calculated by weight of flowers per plant and multiplied by number of plants/ha. Then expressed in tonnes/ha.

3.5.4 Quality parameters

3.5.4.1 Diameter of flower (cm)

The diameter of five randomly selected flowers per plant and five plants per replication was measured from the outer circumference of petal to the other end with the help of a meter scale. It was recorded at peak flowering stage. The mean value was computed and expressed in centimeters.

3.5.4.2 Disc diameter (cm)

The disc diameter of five randomly selected flowers per plant and five plants per replication was measured from the outer circumference of disc florets to the other end with the help of a measuring scale. The mean was computed and expressed in centimeters.

3.5.4.3 Ray floret length (cm)

The length of five randomly selected ray florets per plant and five plants per replication were measured from tip of the ray florets to the basal end with the help of measuring scale and the average was computed and expressed in centimeters.

3.5.4.4 Stalk length (cm)

Length of stalk was measured at peak flowering stage from the base of the flower stalk to the base of the flower head and expressed in centimeters.

3.5.4.5 Vase life (days)

The point of termination of vase life varies from the first sign of wilting or fading to the death of flower. For this purpose, flowers were harvested when one whorl of outer ray florets was opened. The stems were cut to a uniform length in all the lines and lower leaves were removed leaving only few upper leaves. Immediately after cutting, the stems were put into the bucket having clean water. Then the two cut stems were put in 250 ml of distilled water in conical flasks. Wilting of one or two petals was taken as the end of vase life.

3.6 General laboratory procedure

3.6.1 Glassware cleaning

For all laboratory experimental studies, corning and borosil glass wares were used. Petriplates of 10 cm diameter were used, before using, the glass wares were kept in cleaning solution containing 60 g of potassium dichromate ($K_2Cr_2O_7$) and 60 ml of concentrated sulphuric acid in one litre of water for a day. They were then washed with detergent powder followed by rinsing several times in tap water and finally in distilled water.

3.6.2 Sterilization

All the glasswares used in the studies were sterilized in an autoclave at 1.1 kg cm^{-2} pressure for 20 minutes and kept in hot air oven at 60^0 C for one hour. Both solid and liquid media were sterilized at 1.1kg cm^{-2} pressure for 15 minutes.

3.6.3 Collection and isolation of the pathogen

Collection of China aster leaves showing typical symptoms suspected to be caused by alternaria were collected from the experimental field. Standard tissue isolation procedure was followed to isolate the pathogen. The infected leaf bits along with healthy portions were surface sterilized with 1 : 1000 mercuric chloride solution for 30 seconds and washed repeatedly using sterilized distilled water. They were aseptically transferred to potato dextrose agar (PDA) slants and incubated at 28^0 C for seven days. The growth and sporulation of the fungus was monitored periodically. Further, sub-culture of this was again done in potato dextrose agar to obtain it in pure culture.

3.6.4 Identification of the pathogen

Identification of the fungus was made after examining conidia under microscope from mature pure culture of the fungus obtained from infected leaves of China aster.

3.6.5 Artificial inoculation

The China aster seedlings were planted in earthen pots (size 6' ×5') filled with media. When plants were 30 days old, they were inoculated with conidial suspension was prepared by scraping mycelia and spores from plates of actively growing fungal cultures into autoclaved water and filtering the suspension through cloth to remove most of the mycelia. The filtered spore suspension was used for artificial inoculation. Observations were made at regular intervals to know the symptom development on the inoculated leaves.

3.6.6 Screening for alternaria leaf spot disease

Leaf spot disease caused by *Alternaria alternata* was observed at both vegetative and flowering stage. Intensity of disease was recorded in percentage and then converted by using 0 to 5 point rating scale and remarks were given.

$$\text{PDI} = \frac{\text{Sum of numerical ratings}}{\text{Number of plants assessed X Maximum ratings}} \text{ X 100}$$

Grading of ratings	Reaction	Disease intensity
0	Immune	<1
1	Resistant	1-15
2	Moderately resistant	16-25
3	Moderately susceptible	26-50
4	Susceptible	51-75
5	Highly susceptible	Above 76

Five plants were selected randomly in each treatment and individual plants in F_2 population were selected and intensity of the disease was recorded by following 0-5 scale as mentioned earlier. Per cent disease index was calculated by using the formula given by Wheeler (1969).

3.7 Biochemical parameters

3.7.1 Estimation of chlorophyll using DMSO method in plants

Each 100 mg of freshly harvested healthy as well as infected leaf samples were cut into small pieces. These cut pieces were transferred to the test tube containing 5 or 7ml of Dimethyl sulfoxide (DMSO). The test tubes were boiled at 60 ± 1^{0}C for three hours in water bath. The extract was collected by discarding the leaf sample. Finally the volume was made up to 10ml with DMSO. Absorbance readings were taken at 440, 645 and 663nm wavelength using DMSO as a blank.

Calculations carried out by using these formulas:

$$\text{mg chlorophyll a/g tissue} = 12.7\,(A_{633}) - 2.69\,(A_{645}) \times \frac{V}{1000 \times w \times a}$$

$$\text{mg chlorophyll b/g tissue} = 22.9\,(A_{645}) - 4.68(A_{663}) \times \frac{V}{1000 \times w \times a}$$

$$\text{mg total chlorophyll /g tissue} = 20.2\,(A_{645}) + 8.02\,(A_{663}) \times \frac{V}{1000 \times w \times a}$$

A= Absorbance at specific wavelength (645 nm and 663nm)

B= Volume of the extract (10 ml)

C= Fresh weight of the sample (100 mg)

a= Path of light in cuvette (1 cm)

3.7.2 Estimation of free phenols by Folin - Ciocalteau method

Both healthy and infected samples (0.5 - 1.0 g) were weighed and ground with a pestle and mortar in 10 time volume of 80 per cent ethanol. Homogenate was centrifuged at 10000 rpm for 20 min. and supernatant was retained. The residue extract with five times the volume of 80 per cent ethanol and again supernatants centrifuged. The supernatant was evaporated. The residue was dissolved in known volume of distilled water (5 ml). Pipette out different aliquots in the test tube (0.1, 0.2, 0.5, and 1.0 ml) then the volume was made to 3ml with water. 0.5 ml of FCR was added to this after 3 min and then, 2 ml of 20 per cent Na_2CO_3 solution was added to each test tube. The solution was mixed thoroughly. The tubes were placed in boiling water bath for exactly one min, cooled and the absorbance was measured at 650 nm against a reagent blank.

3.7.3 Acid hydrolysis of non - reducing sugar present in the sample and its estimation as reducing sugar

Alcohol sample extract (0.5ml) was evaporated in a boiling water bath. The test tube was cooled after after complete evaporation of alcohol and was made up to a known volume. To 1ml of this evaporated extract, 1ml of 1N HCL was added and placed in a water bath maintained at 60^0C for exactly 20 minutes. The tube was cooled and a drop of indicator solution was added and mixed well. 1N NaOH was added drop wise till the solution turned pink. 0.1N HCl was added drop wise till the solution became colourless.

The content of the test tubes were made up to a known volume with distilled water. Suitable aliquots were used to estimate reducing sugars present in the hydrolysate by a method used earlier for the estimation of reducing sugars. The quantity of reducing sugar was subtracted from that of total sugar and multiplied by a conversion factor 0.95 to get non-reducing sugar.

3.7.4 Estimation of reducing sugar by dinitro salicylic acid (DNSA) method

Both healthy and infected samples (100 mg) were weighed and extracted sugars with hot 80 per cent alchohol twice. (5ml each time) Collected the supernatant and evaporated on water bath. 10 ml of water was added and dissolved the sugars. 0.1, 0.2, and 0.5 ml of alcohol free extracts was pipetted into test tubes and the volume made to 5 ml in all the test tubes. 1.0, 2.0, 3.0, 4.0, and 5.0, ml of working standard solution was pipette in a series of test tubes and the volume made to 5 ml in all the test tubes. 5 ml as blank was taken. 3ml of DNSA reagent added to each test tube and mixed thoroughly. The test tubes were heated for 5 min in a boiling water bath. After that cooled the test tube until colour has developed, to this 1ml of 40 per cent Rochelle salt solution was added (when the contents are still warm) and mixed vigorously. The volume made to 15 ml with distilled water in each test tubes. The test tubes were cooled under running tap water and measured the absorbence at 540 nm using reagent blank adjusted to zero absorbence. The amount of reducing sugar was calculated in the samples using standard graph.

3.8 Statistical analysis

3.8.1 Mean and range

i) General mean (X) = Sum of observations of all the genotypes / Number of genotypes

ii) Range = The minimum and maximum values for each trait among the genotypes.

3.8.2 Estimation of genetic parameters

In order to assess and quantify the genetic variability among the genotypes for quantitative characters under study, the following parameters were estimated.

a) Estimation of variance components

Phenotypic and genotypic variance were estimated using the following formula

Phenotypic variance (σ^2_p) = Var F_2

Genotypic variance (σ^2_g) = Phenotypic variance (σ^2_g) - Environmental variance (σ^2_e)

b) Coefficients of variation

Both genotypic and phenotypic coefficients of variability were computed as per the method suggested by Burton and Dewane (1953).

a. Genotypic coefficient of variation (GCV) = $\frac{\sigma_g}{\bar{X}} \times 100$

b. Phenotypic coefficient of variation (PCV) = $\frac{\sigma_p}{\bar{X}} \times 100$

Where,

σ_g = Genotypic standard deviation

σ_p = Phenotypic standard deviation

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

GCV and PCV values were categorized as low, moderate and high by Shivasubramanian and Menon (1973) as given below.

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

c) Heritability (h^2)

Heritability in broad sense was estimated as the ratio of genotypic variance to the total phenotypic variance as suggested by Hanson (1963) and expressed as percentage.

Heritability (h^2) = $\sigma^2_g / \sigma^2_p \times 100$

Where,

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance.

The heritability percentage was categorized as low, moderate and high as given by Robinson *et al.* (1949).

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

d) Genetic advance (GA)

Genetic advance was estimated by using the formula given by Johnson *et al.* (1955).

$$GA = h^2 k\ \sigma_p$$

Where,

h^2 = Heritability in broad sense

k = Selection differential which is equal to 2.06 at 5% intensity of selection

σ_p = Phenotypic standard deviation.

e) Genetic advance as per cent of mean (GAM)

$$GAM = \frac{GA}{\overline{X}} \times 100$$

Where,

GA = Genetic advance

$\overline{X}$ = General mean of the character.

Genetic advance as per cent mean was categorized as low, moderate and high by Johnson *et al.* (1955).

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

3.8.3 Segregation analysis

Chi square test was used to determine goodness of fit of observed to hypothetical segregation ratios in the F_2 population.

$$X^2 = \frac{\Sigma (O-E)^2}{E}$$

O- Observed frequency E- Expected frequency

4. EXPERIMENTAL RESULTS

The results of the experiment conducted during 2015-16 at the Department of Floriculture and Landscape Architecture, K. R. C. College of Horticulture, Arabhavi on "Screening of genotypes and F_2 segregating population of China aster (*Callistephus chinensis* [L.] Nees.) for alternaria leaf spot." are presented below.

4.1 Screening for alternaria leaf spot

4.2 Host pathogen relationship

4.3 Segregating pattern for alternaria leaf spot

4.4 Growth parameters

4.5 Flowering parameters

4.6 Flower quality parameters

4.7 Yield parameters

4.8 Vase life

4.1 Screening of different genotypes and F_2 segregating population against alternaria leaf spot of China aster

Screening of promising China aster genotypes and F_2 segregating population against alternaria leaf spot caused by *Alternaria alternata* was conducted in order to find out the resistance sources. Crop cultivation practices were followed according to package of practice but plant protection measures not taken. Observations were recorded by screening genotypes and F_2 population. The disease intensity was recorded at every 15 days interval.

Sixteen China aster genotypes and two F_2 population were screened against alternaria leaf spot in order to identify the resistant sources.

The genotypes and F_2 population were evaluated using 0-5 scale. Further, these entries were grouped into six categories based on their reaction to the disease as described in “Material and Methods” and disease reactions of the genotypes are presented in Table 3.

4.1.1 Per cent disease intensity for alternaria leaf spot under natural disease pressure condition

Sixteen China aster genotypes and two F_2 population were screened under natural disease pressure condition against alternaria leaf spot. Of the sixteen genotypes screened, none of them was found to be immune or completely free from disease.

The per cent disease intensity was recorded at 15 days after transplanting. The genotype AAC-1 recorded less PDI (0.17%), followed by PG Violet (1.55%) and PG Pink (1.68%) whereas, the genotype Arka Poornima recorded maximum PDI (5.52%) followed by Arka Violet Cushion (4.47%), Arka Kamini (3.65%) and PG Purple (3.24%).

One month after transplanting the per cent disease intensity was recorded with a minimum score by the genotype AAC-1 (1.09%), followed by PG Violet (3.45%), PG Pink (4.30%) and AAC-8 (5.89%) however, the genotype Arka Poornima reported highest PDI of 9.80 per cent, which was followed by the genotype Arka Kamini (7.64%), AAC-7 (7.60%) and PG Purple (7.53%).

The per cent disease intensity was recorded at 45 days after transplanting. The genotype AAC-1 recorded continuous less PDI (6.43%), followed by PG Violet (9.86%) and P G Pink (10.71%) whereas, the genotype Arka Poornima recorded maximum PDI of (22.33%) followed by AAC-7 (19.80%), Arka Kamini (18.67%) and PG Purple (16.93%).

Among the sixteen genotypes screened, the genotype AAC-1 recorded minimum PDI (10.20%) at 60 days after transplanting, followed by PG Violet (15.70%) and PG Pink (16.40%) whereas, the genotype Arka Poornima continued recording maximum PDI (43.13%) followed by PG Purple (38.40%), AAC-8 (36.37%) and Arka Kamini (35.12%).

At grand growth stage, the genotype AAC-1 recorded resistant reaction (12.53%), followed by PG Pink (20.87%), PG Violet (27.47%) and AAC-5 (23.41%)

whereas, Miraj local type (49.18%), AAC-10 (54.83%), AAC-7 (62.67%), Arka Shashank (55.67%) and PG Purple (57.25%) have recorded moderately susceptible reaction. The genotype Arka Poornima (76.60%) recorded susceptible reaction when screened under natural disease pressure condition (Table 3, 4 and Fig 1).

The experiment comprising F_2 population of two crosses AAC-1 x Arka Kamini and PG Purple x AAC-1, which were shown resistant during F_1 generation, are selected for screening against alternaria leaf spot under natural disease pressure condition to find resistance source.

In each population, 200 plants are chosen to record the observations. Screening was done by using 0-5 scale. Scoring was done at grand growth stage of the crop to get accurate results.

Screening studies of F_2 population of cross between AAC-1 x Arka Kamini under natural disease pressure condition revealed that out of 200 plants nine plants reports resistance reaction with lesser PDI viz., P7 (9.28%), P22 (14.27%), P48 (12.30%), P100 (11.28%), P130 (14.20%), P144 (11.27%), P151 (13.20%), P167 (14.35%) and P 198 (13.20%). However, 137 plants recorded moderate resistant reaction with a disease score range of (16-25%) and 39 plants showed moderately susceptible reaction with a disease score of (26-50%), 15 plants recorded susceptible reaction with a PDI of 51-75 per cent (Appendix II).

The F_2 population of cross between PG Purple x AAC-1 was screened under natural disease pressure condition against alternaria leaf spot revealed that out of 200 plants eleven plants reported resistance reaction with lesser PDI viz., P8 (12.6%), P18 (14.20%), P32 (13.20%), P48 (11.40%), P71 (14.80%), P93 (13.50%), P118 (9.20%), P151 (13.20%) , P167(14.35%), P172 (10.20%) and P181 (11.80%). However, 135 plants recorded moderate resistance reaction with a disease score range (16-25%) and 35 plants shows moderately susceptible reaction with a disease score of (26-50%), 19 plants recorded susceptible reaction with a PDI of 51-75 per cent (Appendix III).

Highest mean value for per cent disease intensity (26.71%) with a range of (9.20-64.30%) recorded in F_2 population of the hybrid PG Purple x AAC-1 followed by

Table 3: Per cent disease intensity of *Alternaria alternata* under natural disease pressure condition

Genotypes	Per cent disease intensity (%)				
	15DAT	**30DAT**	**45DAT**	**60DAT**	**75DAT**
AAC-1	0.17	1.09	6.43	10.20	12.53
PG White	3.10	6.29	12.47	19.38	43.40
PG Purple	3.24	7.53	16.93	38.04	57.25
PG Pink	1.68	4.30	10.71	16.40	20.87
PG Violet	1.55	3.45	9.86	15.70	27.47
Arka Poornima	5.52	9.80	22.33	43.13	76.60
Arka Kamini	3.65	7.64	18.67	35.12	65.57
Arka Violet Cushion	4.47	6.40	13.73	34.53	44.13
Arka Shashank	2.80	7.40	16.59	31.61	55.67
Arka Aadya	2.66	7.06	15.24	21.30	49.97
Arka Archana	2.90	6.31	14.77	23.63	43.23
AAC-5	3.13	6.70	13.30	16.80	23.41
AAC-7	2.88	7.60	19.80	32.57	62.67
AAC-8	3.22	5.89	11.50	36.37	42.07
AAC-10	2.88	7.14	15.47	28.67	54.83
Miraj Local	3.23	6.79	14.73	21.07	49.18
S.Em ±	**0.11**	**0.33**	**0.54**	**0.82**	**1.43**
C.D.@ 5%	**0.31**	**0.96**	**1.56**	**2.37**	**4.14**

PG: Phule Ganesh AAC: Arabhavi Aster Collection DAT: Days after transplanting

Table 4: Grading of China aster varieties in different disease reaction under natural disease pressure condition

SL. No.	Grade of rating	Reaction	Disease intensity	Genotypes
1	0	Immune (I)	<1	-Nil-
2	1	Resistant (R)	1-15	AAC-1
3	2	Moderately resistant (MR)	16-25	PG Pink, AAC-5
4	3	Moderately susceptible (MS)	26-50	PG Violet, Miraj local, PG White, Arka Violet Cushion, AAC-8, Arka Aadya, Arka Archana
5	4	Susceptible (S)	51-75	PG Purple, AAC-10, AAC-7, Arka Shashank,. Arka Kamini
6	5	Highly susceptible (HS)	>76	Arka Poornima,

PG: Phule Ganesh   AAC: Arabhavi Aster Collection

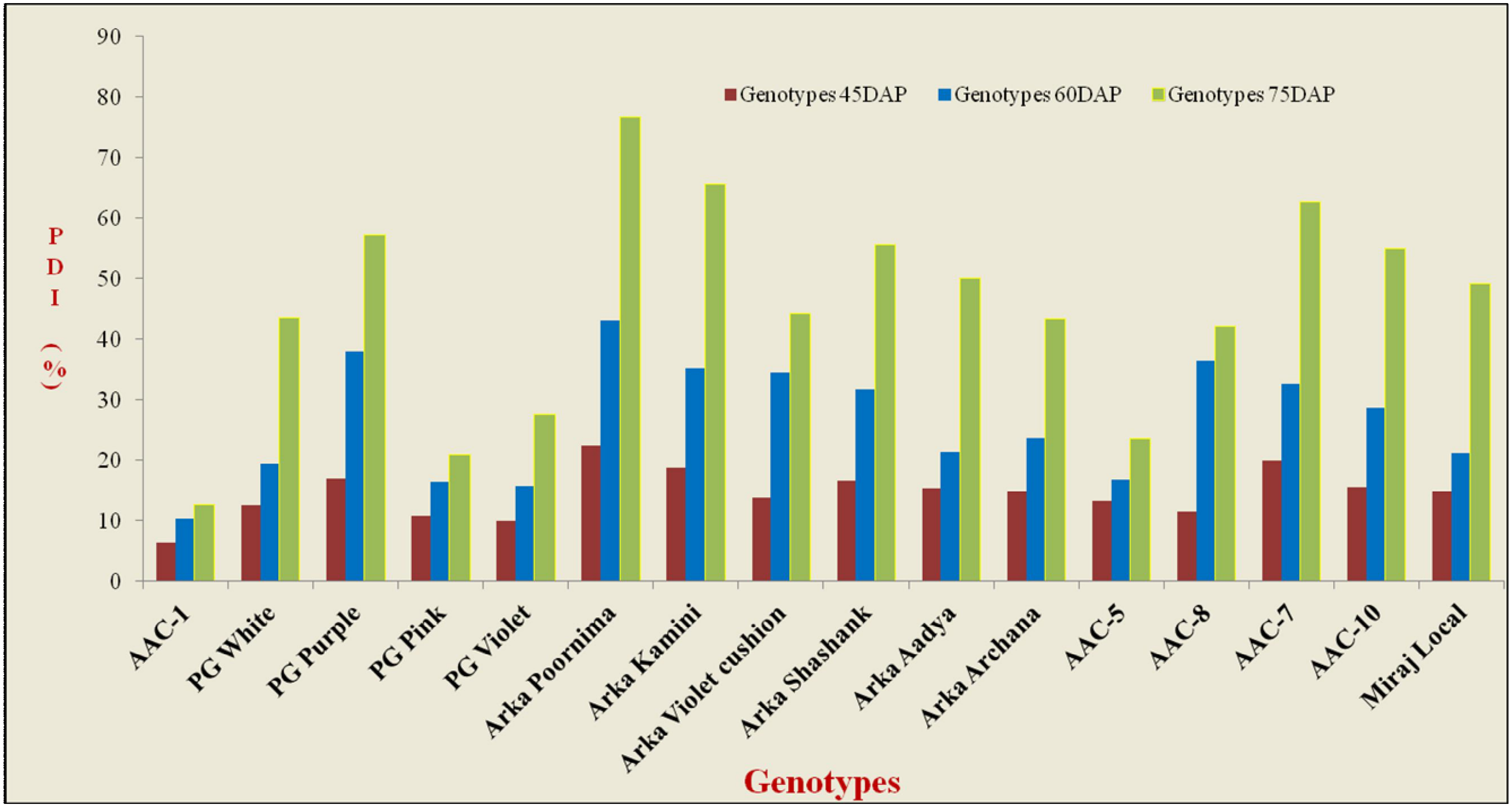


Fig 1: Per cent disease intensity for alternaria leaf spot under natural disease pressure condition

AAC-1 x Arka Kamini with lowest mean per cent disease intensity (26.45%) with a range of 9.28-66.30 per cent was observed (Table 13).

The PCV (43.80% and 44.08%) and GCV (37.66% and 39.09%) values were recorded high in F_2 population AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (73.94% and 78.62%) coupled with genetic advance as per cent of mean (66.72% and 71.41% respectively) were found relatively high in AAC-1 x Arka Kamini and PG-Purple x AAC-1 F_2 population respectively.

4.1.2 Per cent disease intensity for alternaria leaf spot under artificial inoculation

Pot culture experiment was done for artificial inoculation of China aster genotypes. When plants were 30 days old, they were inoculated with conidial suspension, which was prepared by scraping mycelia and spores from plates of actively growing fungal cultures into autoclaved water and filtering the suspension through cloth to remove most of the mycelia. The filtered spore suspension was used for artificial inoculation. Observations were made at regular intervals to know the symptom development on the inoculated leaves.

Per cent disease intensity was recorded 15 days after inoculation. The genotype AAC-1 recorded resistant reaction (9.87%), followed by PG Pink (13.50%), PG Violet (15.70%), Arka Archana (16.03) whereas, the genotype Arka Poornima (41.57%) recorded susceptible reaction when screened under artificial inoculation.

Per cent disease intensity was recorded 30 days after inoculation. The genotype AAC-1 shown resistant reaction (14.23%), followed by PG Pink (23.73%) and AAC-5 (24.60%) recorded moderately resistant reaction whereas, Arka Kamini (67.33%), AAC-7 (64.30%), PG Purple (59.81%) and Arka Shashank (58.07%) recorded moderately susceptible reaction. The genotype Arka Poornima (80.40%) had shown highly susceptible reaction when screened under artificial inoculation (Table 5, 6 and Fig. 2).

Table 5: Per cent disease intensity of *Alternaria alternata* under artificial inoculation condition

Genotypes	Per cent disease intensity (%)	
	15 DAI	**30 DAI**
AAC-1	9.87	14.23
PG White	19.38	48.40
PG Purple	35.12	59.81
PG Pink	13.50	23.73
PG Violet	15.70	32.70
Arka Poornima	41.57	80.40
Arka Kamini	30.87	67.33
Arka Violet Cushion	20.70	50.33
Arka Shashank	34.10	58.07
Arka Aadya	31.61	52.63
Arka Archana	16.03	47.80
AAC-5	22.73	24.60
AAC-7	29.50	64.30
AAC-8	33.97	46.24
AAC-10	36.63	54.40
Miraj Local	27.77	52.70
S.Em ±	**0.88**	**1.43**
C.D.@ 5%	**2.55**	**4.12**

PG: Phule Ganesh AAC: Arabhavi Aster Collection DAI: Days after inoculation

Table 6: Grading of China aster varieties in different disease reaction under artificial inoculation condition

SL. No.	Grade of rating	Reaction	Disease intensity	Genotypes
1	0	Immune (I)	<1	-Nil-
2	1	Resistant (R)	1-15	AAC-1
3	2	Moderately resistant (MR)	16-25	PG Pink, AAC-5
4	3	Moderately susceptible (MS)	26-50	PG Violet, PG White, AAC-8, Arka Archana
5	4	Susceptible (S)	51-75	Miraj local, PG Purple, AAC-10, AAC-7, Arka Shashank, Arka Kamini, Arka Violet Cushion, Arka Aadya,
6	5	Highly susceptible (HS)	>76	Arka Poornima,

PG: Phule Ganesh   AAC: Arabhavi Aster Collection

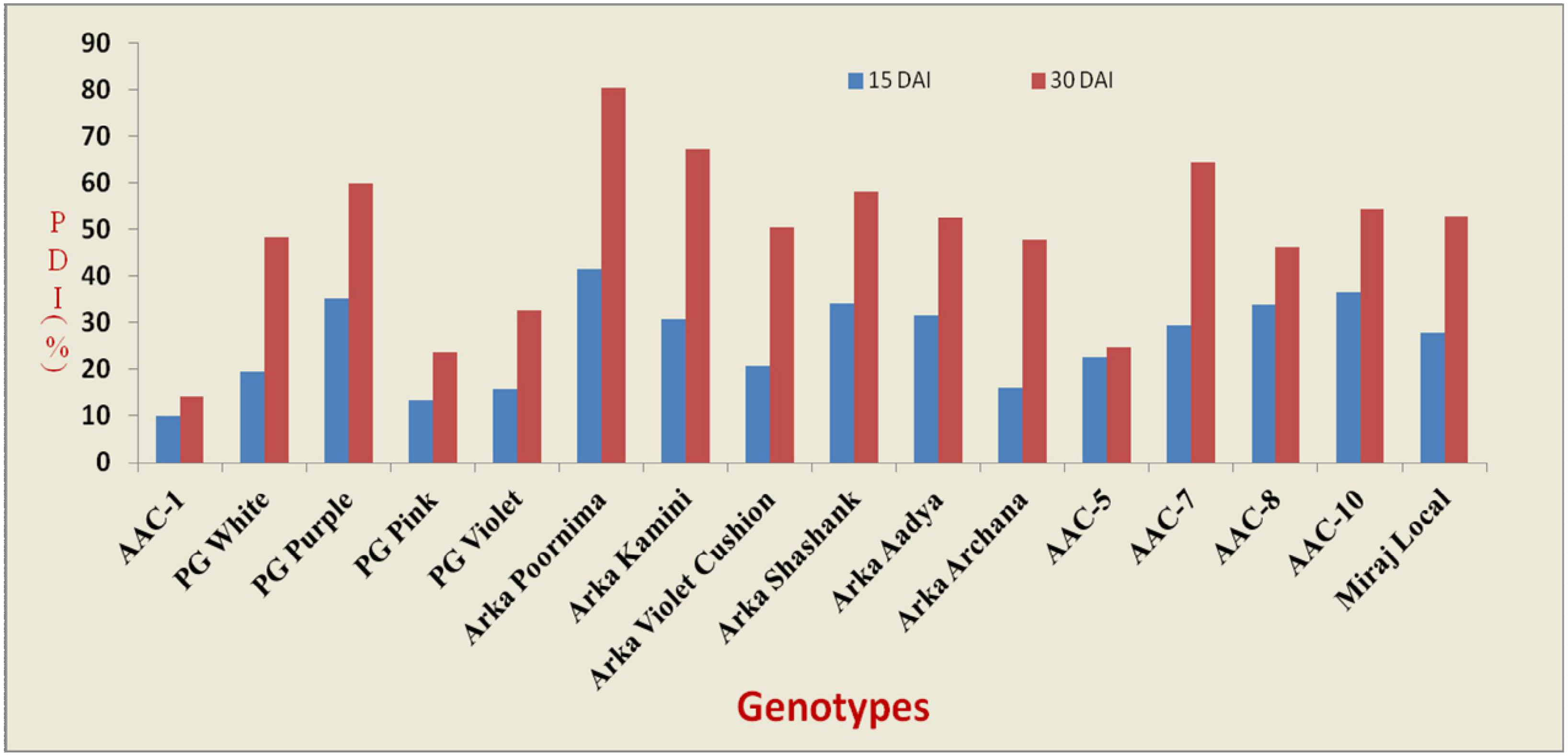


Fig. 2: Per cent disease intensity for alternaria leaf spot under artificial condition

Susceptible cv. Arka Poornima

Plate 3: Alternaria leaf spot disease symptoms in susceptible cultivar Arka Poornima

4.2 Host pathogen relationship

The relationship between host and pathogen is governed by certain biochemical constitution like chlorophyll, carotenoids, sugars, phenols are known to impart resistance against disease and also helps to know the type of resistance mechanism.

4.2.1 Chlorophyll

The chlorophyll 'a', chlorophyll 'b' and total chlorophyll content of different genotypes are presented in Table 7. The resistant and moderately resistant entries recorded higher amounts of chlorophyll 'a', 'b' and total chlorophyll than susceptible entries before and after infection of leaf spot causing organism in China aster. In all the entries, there was decrease in chlorophyll 'a' content. The highest per cent reduction was observed in susceptible cultivar Arka Poornima (75.97%), followed by Arka Kamini (64.58%) and AAC-7 (64.28%) and least per cent of reduction was recorded in AAC-1 (22.79%).

Whereas, per cent decrease in chlorophyll 'b' content was highest in susceptible cultivar Arka Poornima (74.42%), followed by Arka Kamini (69.66%) and least per cent reduction was recorded in resistant genotype AAC-1 (15.78%).

Per cent reduction in total chlorophyll content was recorded highest in Arka Poornima (73.40%), followed by Arka Kamini (66.13%) and least per cent of reduction was recorded in resistant genotype AAC-1 (16.42%).

Results for all susceptible and moderately susceptible varieties were recorded similar results. There was high per cent reduction of chlorophyll content in the susceptible and moderately susceptible genotypes whereas, resistant genotype showed less per cent reduction.

4.2.3 Phenols

Phenols also play an important role in imparting disease resistance. In the present investigation total phenols were estimated in resistant, moderately resistant and susceptible genotypes before and after artificial infection by *Alternaria* sp. The results are presented in Table 8.

Table 7: Chlorophyll content as influenced by alternaria leaf spot in different varieties of China aster

Genotypes	Category	Chlorophyll 'a' (mg/g of fresh weight)			Chlorophyll 'b' (mg/g of fresh weight)			Total Chlorophyll (mg/g of fresh weight)		
		Healthy	**Infected**	**Per cent reduction**	**Healthy**	**Infected**	**Per cent reduction**	**Healthy**	**Infected**	**Per cent reduction**
AAC-1	R	1.53	1.18	22.79	1.05	0.87	15.78	2.49	2.05	16.42
PG White	MS	0.62	0.40	35.87	0.50	0.29	42.56	1.15	0.69	40.00
PG Purple	S	1.22	0.85	55.34	0.90	0.61	61.42	2.11	1.46	58.36
PG Pink	MR	1.41	0.98	30.01	0.92	0.70	23.65	2.22	1.68	24.32
PG Violet	MS	0.61	0.27	30.14	0.46	0.18	31.60	1.08	0.45	30.65
Arka Poornima	HS	0.70	0.17	75.97	0.51	0.13	74.42	1.12	0.30	73.40
Arka Kamini	S	0.61	0.36	64.58	0.47	0.25	69.66	1.10	0.61	66.13
Arka Violet Cushion	MS	0.97	0.55	43.13	0.73	0.40	45.68	1.66	0.95	42.88
Arka Shashank	S	0.64	0.29	54.96	0.48	0.2	58.42	1.11	0.49	55.71
Arka Aadya	MS	0.72	0.40	43.19	0.64	0.29	54.73	1.42	0.69	51.41
Arka Archana	MS	0.74	0.41	44.80	0.60	0.35	42.04	1.33	0.76	42.96
AAC-5	MR	1.22	0.85	30.49	0.87	0.62	28.71	2.08	1.47	29.37
AAC-7	S	0.31	0.11	64.28	0.54	0.19	64.88	0.86	0.30	65.00
AAC-8	MS	0.78	0.52	33.19	0.60	0.38	37.06	1.37	0.90	34.48
AAC-10	S	0.56	0.28	56.92	0.48	0.15	68.75	1.06	0.43	59.09
Miraj Local	MS	0.65	0.23	40.72	0.49	0.15	46.29	1.12	0.38	44.30
S.Em ±		**0.02**	**0.02**	**3.99**	**0.03**	**0.03**	**3.04**	**0.06**	**0.03**	**2.62**
C.D.@ 5%		**0.07**	**0.07**	**11.53**	**0.09**	**0.08**	**8.79**	**0.17**	**0.10**	**7.57**

PG: Phule Ganesh AAC: Arabhavi Aster Collection mg: Milligram g: Gram R: Resistant
MR: Moderatelyresistant MS: Moderately susceptible S: Susceptible HS: Highly susceptible

Table 8 : Phenol content as influenced by alternaria leaf spot in different varieties of China aster

Genotypes	Category	Phenols (mg/100g of fresh weight)		
		Healthy	Infected	Per cent increase
AAC-1	R	103.43	531.13	80.53
PG White	MS	76.04	190.50	58.23
PG Purple	S	105.65	360.50	44.25
PG Pink	MR	104.63	389.28	73.12
PG Violet	MS	46.51	83.60	70.68
Arka Poornima	HS	87.12	110.50	20.73
Arka Kamini	S	70.48	145.50	40.50
Arka Violet Cushion	MS	53.08	115.57	53.99
Arka Shashank	S	39.58	72.50	45.11
Arka Aadya	MS	55.60	110.00	49.24
Arka Archana	MS	57.82	170.50	66.01
AAC-5	MR	104.10	382.51	72.78
AAC-7	S	55.45	95.50	41.82
AAC-8	MS	57.22	185.50	69.03
AAC-10	S	78.88	150.50	47.45
Miraj Local	MS	31.56	53.00	51.51
S.Em ±		**1.11**	**8.74**	**2.37**
C.D.@ 5%		**3.20**	**25.24**	**6.85**

PG: Phule Ganesh AAC: Arabhavi Aster Collection mg: Milligram g: Grams R: Resistant MR: Moderately resistant MS: Moderately susceptible S: Susceptible HS: Highly susceptible

It is clear that the per cent increase in total phenols was higher in AAC-1 (80.53%), a resistant genotype compared to moderately resistant genotypes and it was lowest in susceptible entry Arka Poornima (20.73%).

4.2.4 Sugars

Sugars are known to impart resistant or susceptibility against the pathogens. In the present investigation the sugar content was estimated in resistant, moderately resistant and susceptible cultivars of China aster leaves before and after infection of the pathogens. The results are presented in Table 9.

Table 9 depicted that the reducing, non-reducing and total sugar content in susceptible genotypes was less compared to resistant and moderately resistant genotypes before infection. However, there was increase in sugar, following the inoculation of pathogen. But this increase in sugar content was at lower rates in susceptible genotypes compared to resistant and moderately resistant cultivars.

The rate of per cent increase in reducing sugar content (16.85%) was less in resistant genotype AAC-1 followed by PG Pink (25.07 %) and per cent in AAC-5 (26.54%) and highest percent increase in reducing sugar content was noticed in susceptible genotype Arka Poornima (70.40 %). Similarly, the highest per cent increase in non reducing sugar content was observed susceptible and moderately susceptible varieties *viz.*, Arka Poornima (65.91%) and Arka Kamini (60.86%) while, lowest per cent increase was recorded in resistant genotype AAC-1 (13.05%).

In all, lesser increase in total sugar content was recorded in resistant genotype AAC-1 (15.42%) followed by PG Pink (24.97%) whereas, Arka Poornima (68.68%) showed highest per cent increase in the total sugar content which might has lead to susceptibility to pathogen.

Table 9: Sugar content as influenced by alternaria leaf spot in different varieties of China aster

Genotypes	Category	Reducing sugars (mg/g of fresh weight)			Non reducing sugars (mg/g of fresh weight)			Total sugars (mg/g of fresh weight)		
		Healthy	Infected	Per cent increase	Healthy	Infected	Per cent increase	Healthy	Infected	Per cent increase
AAC-1	R	2.05	2.47	16.85	1.30	1.50	13.05	3.35	3.97	15.42
PG White	MS	1.85	2.99	38.05	1.73	2.55	32.12	3.58	5.54	35.37
PG Purple	S	1.87	2.62	56.25	1.53	2.10	50.34	3.40	4.72	54.64
PG Pink	MR	1.81	2.42	25.07	1.50	2.00	24.67	3.31	4.42	24.97
PG Violet	MS	1.98	4.60	28.66	1.23	2.50	26.95	3.21	7.10	27.96
Arka Poornima	HS	1.37	4.66	70.40	1.01	2.95	65.91	2.38	7.61	68.68
Arka Kamini	S	1.50	2.70	66.57	1.02	1.55	60.86	2.52	4.25	64.85
Arka Violet Cushion	MS	1.60	2.70	40.20	1.43	2.15	33.02	3.03	4.85	37.43
Arka Shashank	S	1.96	4.10	52.07	1.51	2.89	47.65	3.47	6.99	50.33
Arka Aadya	MS	1.90	3.70	48.61	1.74	2.83	38.50	3.64	6.53	44.25
Arka Archana	MS	1.78	2.80	35.99	1.60	2.30	29.87	3.38	5.10	33.39
AAC-5	MR	1.88	2.56	26.54	1.51	2.04	25.95	3.39	4.60	26.32
AAC-7	S	2.19	5.70	61.66	1.20	2.50	52.05	3.39	8.20	58.72
AAC-8	MS	2.60	3.80	31.22	1.52	2.20	30.16	4.12	6.00	30.86
AAC-10	S	2.10	5.30	60.22	1.50	2.60	52.78	3.33	7.90	57.73
Miraj Local	MS	1.90	5.69	43.99	0.98	2.50	30.24	2.88	8.19	39.69
S.Em ±		**0.06**	**0.14**	**3.02**	**0.07**	**0.13**	**4.49**	**0.10**	**0.20**	**2.76**
C.D.@ 5%		**0.17**	**0.41**	**8.72**	**0.19**	**0.38**	**12.98**	**0.30**	**0.58**	**7.97**

PG: Phule Ganesh AAC: Arabhavi Aster Collection mg: Miligram g: Gram R: Resistant MR: Moderately resistant
MS: Moderately susceptible S: Susceptible HS: Highly susceptible


Resistant cv. AAC-1

Plate 4. Field view of resistant cv. AAC-1

4.3 Segregating pattern for alternaria leaf spot in F_2 segregating population

China aster genotype AAC-1 was used as a resistant parent in crosses with susceptible cultivars Arka Kamini and PG Purple. The reaction of the resistant parent and susceptible parent had been determined from field studies.

Chi-square values were computed on numbers of resistant and susceptible plants in each generation to determine whether the observed ratios deviated from the expected Mendelian ratios for segregation expectations according to gene action type and number of genes controlling resistance to alternaria leaf spot in the China aster.

The reaction of parents to leaf spot disease was noticed as expected, all plants of Arka Kamini and PG Purple were shown susceptible reaction and all plants of AAC-1 were resistant.

Out of 200 plants in the F_2 population of cross between AAC-1 and Arka Kamini, 9 plants recorded resistance reaction to disease with a low PDI of 1-15 per cent and 137 plants reported moderately resistance to disease reaction with PDI range of 16-25 per cent. 39 plants recorded moderately susceptible disease reaction with PDI range of 26-50 per cent and 15 plants shows susceptible reaction with PDI of 51-75 per cent (Table 10). In this population Chi-square value (χ^2= 0.42) falls between P=0.4 and P=0.5 so, results are not significant and hence ratio is constituent with a single factor ratio of 3 : 1.

In F_2 population of cross between PG Purple and AAC-1, out of 200 plants 11 plants recorded resistance disease reaction with a low PDI of 1-15 per cent and 135 plants reported moderately resistance disease reaction with PDI range of 16-25 per cent. 35 plants recorded moderately susceptible disease reaction with PDI range (26-50%) and 19 plants shows susceptible reaction with PDI range of 51-75 per cent. In this population Chi-square value (χ^2=1.30) falls between P=0.2 and P=0.3 so, results are not significant and hence ratio is constituent with a single factor ratio of 3 : 1.

Table 10: Segregating pattern for alternaria leaf spot in F_2 segregating population

Parent/Population	Total	Observed number of Plants		Expected ratio (R:S)	X^2	P Value
		Resistant (R)	Susceptible (S)			
AAC-1	25	25	0	-	-	-
Arka Kamini	30	0	30	-	-	-
PG Purple	30	2	28	-	-	-
F_2 (AAC-1xArka Kamini)	200	146	54	3:1	0.42	0.4 - 0.5
F_2 (PG Purple x AAC-1)	200	143	57	3:1	1.30	0.2 - 0.3

PG: Phule Ganesh AAC: Arabhavi Aster Collection

In both the population resistance and moderately resistance plants are considered as resistance plants. Susceptible and moderately susceptible plants considered as susceptible plants to know the segregating pattern.

The F_2 data from both the crosses AAC-1 x Arka Kamini and PG Purple x AAC-1 fit reasonably well to a 3 resistant : 1 susceptible ratio as expected, so resistance may be controlled by a single dominant gene.

Both the F_2 population segregated phenotypically in the ratio of 3:1 resistant and susceptible plants against alternaria leaf spot in China aster.

4.4 Growth parameters

Growth parameters such as plant height, number of leaves, number of branches, stem girth, plant spread and leaf area of different genotypes and genetic components of two F_2 population, for these parameters were analyzed and presented in Table 11, 12 (genotypes) and Table 13 (F_2 population).

4.4.1 Plant height

The perusal of data revealed that the plant height varied significantly at various stages of crop growth (*viz.* 30 and 60 DAT).

The range for plant height in China aster cultivars at 30 DAT was between 16.95 cm to 34.49 cm. The cv. PG White recorded the highest plant height (34.49 cm) and found to be significant and superior compared to other cultivars, it was followed by cvs. PG Pink and AAC-7 they have recorded the plant height of 29.36 cm and 26.63 cm, respectively. Whereas, the least plant height was noticed in cv. Arka Aadya (16.95 cm).

At 60 DAT, cv. PG White (71.37 cm) recorded maximum plant height followed by cvs. AAC-5 (62.15 cm), PG Violet (61.42 cm) and PG Pink (59.16 cm). The cv. Arka Aadya (38.37 cm) recorded minimum plant height.

The F_2 population of AAC-1 x Arka Kamini recorded high mean for plant height 49.44 cm with a range of 30.60 to 61.50 cm whereas, in F_2 population of PG Purple x

AAC-1 recorded lowest mean of 40.50 cm and range of 38.20 cm to 58.20 cm for number of branches.

The moderate PCV (12.21% and 10.93%) and GCV (11.26% and 10.50%) were recorded by the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (84.92% and 9.35%) coupled with high genetic advance as per cent of mean (21.37% and 20.79%) were found in F_2 population of AAC-1 x Arka Kamini and PG-Purple x AAC-1, respectively.

4.4.2 Number of leaves per plant

The result on number of leaves per plant reveals that, at 30 DAT varied from 15.80 to 25.73. cv. PG White recorded maximum number of leaves (25.73) and was found to be significantly superior over all other cultivars and it was followed by cvs. PG Pink (23.80) and AAC-5 (20.60) whereas, cv. Arka Violet Cushion recorded minimum number of leaves (15.80).

At 60 DAT, maximum numbers of leaves were recorded in cv. AAC-1 (229.13), followed by PG white (215.07) and PG Pink (213.00) whereas, cv. Arka Shashank recorded minimum number of leaves (160.80).

The F_2 population of AAC-1 x Arka Kamini recorded high mean for number of leaves 169.85 with a range of 120 to 235 whereas, in F_2 population of PG Purple x AAC-1 recorded lowest mean 127.92 and range of 110 to 213 for number of leaves.

The high PCV and moderate GCV were recorded by the F_2 population of AAC-1 x Arka Kamini (20.16 % and 18.34%). The moderate PCV (13.49%) and GCV (12.67%) were found in F_2 population of PG Purple x AAC-1 for number of leaves.

High heritability (82.73% and 88.18%) coupled with high genetic advance as per cent of mean (34.36% and 24.51%) were found in AAC-1 x Arka Kamini and PG-Purple x AAC-1 F_2 population, respectively.

4.4.3 Number of branches per plant

At 30 DAT, there was significant difference among the different China aster cultivars for number of branches per plant. However, maximum number of branches per plant was recorded in cv. PG White (5.40) and minimum number was recorded in cv. Arka Kamini (0.87).

At 60 DAT, cv. Arka Archana (28.83) recorded significantly highest number of branches per plant followed by cvs. Arka Aadya (25.57), AAC-5 (19.60) and PG White (18.80). The lowest number of branches per plant was recorded in the cv. Arka Violet Cushion (12.54).

The F_2 population of AAC-1 x Arka Kamini recorded high mean for number of branches 17.35 with a range of 10 to 25 whereas, in F_2 population of PG Purple x AAC-1 recorded lowest mean of 16.05 and range of 12 to 23 for number of branches.

The high PCV (24.37% and 20.23%) and moderate GCV (19.94% and 16.18%) were recorded by the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (66.98% and 63.93%) coupled with high genetic advance as per cent of mean (33.62% and 26.64%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively (Table 15).

4.4.4 Stem girth

The data pertaining to the stem girth at various stages of plant growth differed significantly among the China aster cultivars.

There was no significant difference observed among the different China aster cultivars for stem girth at 30 DAT.

The cv. PG Pink recorded maximum stem girth at 60 days after transplanting (1.84 cm) followed by cvs. AAC-1 (1.81 cm) and Miraj Local (1.74 cm). Minimum stem girth was recorded in the cv. AAC-8 (1.24).

Table 11. Growth parameters in different genotypes of China aster at various stages of plant growth

Genotypes	Plant height (cm)		No. of branches		No. of leaves		Stem girth (cm)	
	30 DAT	60 DAT	30DAT	60DAT	30DAT	60DAT	30DAT	60DAT
AAC-1	23.47	57.57	2.47	18.33	19.33	229.13	0.50	1.81
PG White	34.49	71.37	5.40	18.80	25.73	215.07	0.50	1.69
PG Purple	24.09	49.24	1.93	16.33	19.13	207.47	0.58	1.48
PG Pink	29.36	59.16	4.80	17.80	23.80	213.00	0.54	1.84
PG Violet	21.38	61.42	1.00	16.20	20.53	165.07	0.52	1.36
Arka Poornima	22.92	52.93	3.00	16.60	20.40	196.33	0.49	1.53
Arka Kamini	22.41	52.12	0.87	15.73	19.73	204.27	0.53	1.39
Arka Violet Cushion	21.61	50.66	2.67	12.54	15.80	176.40	0.56	1.46
Arka Shashank	22.15	49.65	2.60	15.67	18.87	160.80	0.53	1.43
Arka Aadya	16.95	38.37	4.13	25.57	20.07	169.87	0.51	1.47
Arka Archana	17.30	40.60	3.07	28.83	18.53	182.60	0.52	1.47
AAC-5	22.08	62.15	1.40	19.60	20.60	209.33	0.53	1.42
AAC-7	26.63	51.73	3.13	18.53	19.67	179.13	0.52	1.41
AAC-8	25.17	52.96	1.20	15.47	19.47	201.07	0.52	1.24
AAC-10	23.58	57.61	3.07	15.33	19.07	181.67	0.52	1.50
Miraj Local	26.07	58.63	3.20	18.77	19.73	207.60	0.51	1.74
S.Em ±	**0.31**	**0.59**	**0.17**	**0.57**	**0.48**	**3.06**	**0.03**	**0.009**
C.D.@ 5%	**0.91**	**1.71**	**0.50**	**1.65**	**1.39**	**8.82**	**NS**	**0.027**

PG: Phule Ganesh   AAC: Arabhavi Aster Collection   cm: centimeter   No: Number

Table 13: Estimates of mean, range, components of variance, heritability and genetic advance for growth parameters in F_2 population of China aster

Sl. No.	Characters	Population	Mean	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
(a)	**Growth parameters**										
1	Plant height (cm)	AAC-1 X Arka Kamini	49.44	30.60-61.50	30.97	36.47	11.26	12.21	84.92	10.56	21.37
		PG Purple X AAC-1	40.50	38.20-58.20	18.10	19.60	10.50	10.93	92.35	8.42	20.79
2	No. of branches	AAC-1 X Arka Kamini	17.35	10.00-25.00	11.97	17.87	19.94	24.37	66.98	5.83	33.62
		PG Purple X AAC-1	16.05	12.00-23.00	6.74	10.54	16.18	20.23	63.93	4.27	26.64
3	No. of leaves	AAC-1 X Arka Kamini	169.85	120.0-235.0	970.32	1172.82	18.34	20.16	82.73	58.37	34.36
		PG Purple X AAC-1	127.92	110.0-213.0	262.70	297.90	12.67	13.49	88.18	31.35	24.51
4	Stem girth (cm)	AAC-1 X Arka Kamini	1.36	1.02-1.85	0.02	0.04	10.46	15.13	47.82	0.20	14.91
		PG Purple X AAC-1	1.43	1.02-1.90	0.02	0.03	9.00	11.79	58.22	0.20	14.14
6	Plant spread N-S (cm)	AAC-1 X Arka Kamini	21.18	16.40-27.80	7.53	8.33	12.96	13.63	90.40	5.38	25.38
		PG Purple X AAC-1	22.04	17.20-29.50	6.01	6.41	11.12	11.48	93.76	4.89	22.18
7	Plant spread E-W (cm)	AAC-1 X Arka Kamini	29.71	20.10-38.30	18.98	21.78	14.66	15.71	87.14	8.38	28.19
		PG Purple X AAC-1	22.64	17.90-32.60	7.10	7.80	11.77	12.34	91.02	5.24	23.13
5	Leaf area (cm^2)	AAC-1 X Arka Kamini	4906.56	2640.2-7520.8	773082.80	870626.50	17.92	19.02	88.80	1706.78	34.79
		PG Purple X AAC-1	4944.09	2590.5-7668.6	811989.70	907644.61	18.23	19.27	89.46	1755.74	35.51
(b)	**Percent disease intensity**	AAC-1 X Arka Kamini	26.45	9.28-66.30	99.33	134.33	37.66	43.80	73.94	17.65	66.72
		PG Purple X AAC-1	26.71	9.20-64.30	109.03	138.66	39.09	44.08	78.62	19.07	71.41

PG: Phule Ganesh   AAC: Arabhavi Aster Collection   No: Number

Table 12. Plant spread and leaf area in different genotypes of China aster at various stages of plant growth

Genotypes	Plant spread (cm)				Leaf area/ plant (cm^2)
	30 DAT		60 DAT		
	N-S	E-W	N-S	E-W	60DAT
AAC-1	23.41	25.77	38.30	37.37	7225.64
PG White	22.63	22.60	31.87	31.20	6376.87
PG Purple	19.83	22.04	32.40	30.50	5329.24
PG Pink	25.68	19.30	35.73	36.07	8635.36
PG Violet	16.90	18.60	30.40	28.53	5710.13
Arka Poornima	16.70	22.83	31.40	29.43	5300.62
Arka Kamini	17.71	18.51	31.97	30.80	6267.52
Arka Violet Cushion	17.14	17.34	34.20	32.20	6427.21
Arka Shashank	20.37	22.23	32.07	30.73	5038.14
Arka Aadya	21.57	22.07	31.73	30.83	4732.94
Arka Archana	19.52	19.29	32.70	32.70	4999.84
AAC-5	18.97	18.27	29.83	27.97	6721.77
AAC-7	19.33	21.67	27.87	26.93	5890.90
AAC-8	20.63	21.20	30.83	30.40	6048.87
AAC-10	18.53	21.26	30.33	29.77	3694.60
Miraj Local	16.73	23.43	28.63	28.17	4963.17
S.Em ±	**0.92**	**0.75**	**1.27**	**1.17**	**144.55**
C.D.@ 5%	**2.65**	**2.18**	**3.68**	**3.39**	**417.48**

DAT: Days after transplanting PG: Phule Ganesh AAC: Arabhavi Aster Collection
cm: centimeter (E-W, East- West and N-S, North – South) cm^2: centimeter square No: Number

Highest mean stem girth (1.43cm) with a range of 1.02 to 1.90 cm was recorded in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini with a lowest mean stem girth (1.36 cm) with a range of 1.02 to 1.85 cm.

The moderate PCV and GCV (15.13% and 10.46%) were recorded by the F_2 population of AAC-1 x Arka Kamini respectively. Moderate PCV (11.79%) and low GCV (9.00%) were recorded by the F_2 population of PG Purple x AAC-1 for stem girth.

Moderate heritability (47.82% and 58.22%) coupled with moderate genetic advance as per cent of mean (14.91% and 14.14%, respectively) were found relatively in AAC-1 x Arka Kamini and PG Purple x AAC-1 F_2 population, respectively.

4.4.5 Plant spread in North-South direction

The plant spread at 30 days after transplanting varied from 16.70 cm to 25.68 cm (Table 11). The genotype PG Pink recorded maximum plant spread (25.68 cm) it was found on par with the cv. AAC-1 (23.41 cm) and Arka Poornima recorded the least (16.70 cm).

The plant spread at 60 days after planting ranged from 27.87 cm to 38.30 cm. The genotype AAC-1 recorded maximum plant spread (38.30 cm) followed by PG Pink (35.73 cm) and lowest was observed in AAC-7 (27.87 cm).

Highest mean value for plant spread in North-South direction 22.04 cm with a range of 17.2 to 29.5 cm was recorded in F_2 population of cross PG Purple x AAC-1 followed by AAC-1 x Arka Kamini recorded lowest mean plant spread in N-S direction (21.18 cm) with a range of 16.4-27.8 cm.

The PCV (13.63% and 11.48%) and GCV (12.96% and 11.12%) values were recorded moderate in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (90.40% and 93.76%) coupled with genetic advance as per cent of mean (25.38% and 22.18%) were found relatively high in AAC-1 x Arka Kamini and PG Purple x AAC-1 F_2 population, respectively.

4.4.6 Plant spread in East-West direction

The plant spread E-W varied significantly at various stages of crop growth (*viz.*, 30 and 60 DAT).

The plant spread at 30 days after transplanting varied from 17.34 cm to 25.77 cm (Table11). The genotype AAC-1 recorded maximum plant spread (25.77 cm) followed by Miraj Local (23.43 cm) and Arka Violet Cushion recorded the least (17.3 cm).

The plant spread at 60 days after planting ranged from 26.93 cm to 37.37 cm. The genotype AAC-1 recorded maximum plant spread (37.37 cm) followed by PG Pink (36.07 cm) and lowest was observed in AAC-7 (26.93 cm).

The F_2 population of AAC-1 x Arka Kamini recorded high mean for plant spread in E-W direction (29.71 cm) with a range of 20.1 to 38.3 cm whereas, in F_2 population of PG Purple x AAC-1 recorded lowest mean (22.64 cm) and with a range of 17.90 to 32.60 cm.

The PCV (15.71% and 12.34%) and GCV (14.66% and 11.77%) values were recorded moderate in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (87.14% and 91.02%) coupled with high genetic advance as per cent of mean (28.19% and 23.13%) were found in AAC-1 x Arka Kamini and PG Purple x AAC-1 F_2 population, respectively.

4.4.7 Leaf area

Cultivars varied significantly with respect to leaf area at grand growth stage. The cv. PG Pink recorded the highest leaf area of (8635 cm^2) followed by AAC-1 (7225.64 cm^2) whereas, the cv. AAC-10 recorded the lowest leaf area (3694 cm^2) Table 11.

The F_2 population of PG Purple x AAC-1 recorded high mean for leaf area 4944.09 cm^2 with a range of 2590.5 to 7668.6 cm^2 whereas, in F_2 population of AAC-1 x Arka Kamini recorded lowest mean 4906.56 cm^2 with a range of 2640.2 to 7668.6 cm^2 for leaf area.

The moderate PCV (19.02% and 19.27%) and moderate GCV (17.92% and 18.23%) were recorded by the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (88.80% and 89.46%) coupled with high genetic advance as per cent of mean (34.79% and 35.51%) were found in AAC-1 x Arka Kamini and PG Purple x AAC-1 F_2 population, respectively (Table 15).

4.5 Flowering parameters

Data pertaining to flowering characters like days taken for first bud initiation, days taken for first flowering, days taken for 50 per cent flowering and duration of flowering in different genotypes and genetic components of two F_2 population, for these parameters were analyzed and presented in table 14 (genotypes) and table 15 (F_2 population).

4.5.1 Days taken for the first bud initiation

Cultivars varied significantly with respect to days taken for first bud initiation. The cv. Arka Aadya recorded the least number of days to first bud initiation (35.77 days) and it was on par with the cvs. like, Arka Archana (37.86 days) and AAC-8 (38.00 days) whereas, cv. AAC-1 recorded the highest number of days taken for first bud initiation (50.60 days) and it was followed by the cvs. Miraj Local (48.33 days) and Arka Kamini (45.73 days).

The lowest mean (45.28 days) with a range of 35 to 56 days was recorded for days to first bud initiation in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini with a highest mean (46.10 days) with a range of 32 to 55 for days taken for first flower bud initiation.

The lowest PCV (9.31% and 8.98%) and GCV (8.63% and 8.36%) were recorded lowest in the F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

High heritability (86.59% and 85.94%) coupled with low genetic advance as per cent of mean (16.03% and 16.49%) were found in AAC-1 x Arka Kamini and PG Purple x AAC-1 F_2 population, respectively.

4.5.2 Days taken for the first flowering

Cultivars varied significantly with respect to days taken for first flowering. The cv. Arka Archana recorded the least number of days to first flowering (41.65 days) whereas, cv. AAC-1 recorded the highest number of days taken for first flowering (57.93days) and it was followed by the cvs. PG White (57.53 days) and Arka Kamini (54.83 days).

The lowest mean (54.10 days) with a range of 42-62 days were recorded for days taken for the first flowering in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini with a mean (55.46 days) and range of 42 to 64 days for days taken for first flowering.

The low values for PCV (7.73% and 7.18%) and GCV (7.47% and 6.66%) were recorded in F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

High heritability (93.47% and 86.07%) coupled with low genetic advance as per cent of mean (14.89% and 12.72%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1 respectively.

4.5.3 Days taken for 50 per cent flowering

The days taken for 50 per cent flowering varied significantly among different China aster cultivars. Cultivar Arka Aadya took minimum number of days for 50 per cent of plant to flower (62.37 days) which was followed by cv. Arka Archana (63.37 days) and other cvs. AAC-5 (70.40 days), Miraj Local (70.80 days) and AAC-8 (71.43

days) were moderately early to put forth 50 per cent flowering. Whereas, cv. AAC-1 was late (75.20 days) to reach 50 per cent flowering.

The lowest mean (71.02 days) with a range of 52-85 days was recorded for days taken to 50 per cent flowering in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini with a mean (73.31 days) and range of 53 to 83 days for days taken for 50 per cent flowering.

The lowest values of PCV (9.52% and 9.70%) and GCV (8.31% and 8.22%) were recorded in F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

High heritability (71.91% and 76.24%) coupled with low genetic advance as per cent of mean (14.37% and 14.95%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.5.4 Duration of flowering

Significant variation was observed among the different cultivars of China aster for duration of flowering. Cultivar PG Pink flowered for a maximum period of 34.27 days and it was followed by cv. AAC-1(33.77 days). Duration of flowering was recorded minimum in cv. Arka Aadya (26.47 days) and which was on par with cvs. Arka Archana (26.87 days) and Arka Violet Cushion (29.33 days).

The F_2 population of AAC-1 x Arka Kamini recorded high mean for duration of flowering 30.08 days with a range of 23 to 35 whereas, in F_2 population of PG Purple x AAC-1 recorded lowest mean 29.23 days and range of 22 to 33 days for duration of flowering.

The PCV (7.61% and 6.77%) and GCV (4.75% and 5.02%) values were recorded lowest in the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

Moderate heritability (38.93% and 54.89%) coupled with low genetic advance as per cent of mean (6.10% and 7.66%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

Table 14. Flowering parameters in different genotypes of China aster

Genotypes	Days taken for bud initiation (DAT)	Days taken for first flowering (DAT)	Days taken for 50% flowering (DAT)	Duration of flowering (Days)
AAC-1	50.60	57.93	75.20	33.77
PG White	45.03	57.53	74.37	31.73
PG Purple	39.47	46.07	69.13	29.90
PG Pink	45.17	54.53	71.87	34.27
PG Violet	38.77	45.83	69.07	31.13
Arka Poornima	40.60	49.27	67.27	30.07
Arka Kamini	45.73	54.83	67.02	31.67
Arka Violet Cushion	44.83	53.87	68.60	29.33
Arka Shashank	44.13	53.00	68.53	29.73
Arka Aadya	35.77	41.65	62.37	26.47
Arka Archana	37.86	44.93	63.37	26.87
AAC-5	43.13	50.33	70.40	30.27
AAC-7	40.07	45.53	65.23	32.00
AAC-8	38.00	43.40	71.43	32.20
AAC-10	43.80	46.50	68.77	30.37
Miraj Local	48.33	52.67	70.80	29.77
S.Em ±	**1.27**	**1.91**	**2.12**	**1.12**
C.D.@ 5%	**3.67**	**5.52**	**6.12**	**3.23**

PG: Phule Ganesh AAC: Arabhavi Aster Collection DAT: Days after transplanting

Table 15: Estimates of mean, range, components of variance, heritability and genetic advance for flowering and quality parameters in F_2 population of China aster

Sl. No.	Characters	Population	Mean	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM
(b)	**Flowering parameters**										
1	Days taken for first bud initiation	AAC-1 X Arka Kamini	46.10	32-55	14.86	17.16	8.36	8.98	86.59	7.39	16.03
		PG Purple X AAC-1	45.28	35-56	15.28	17.78	8.63	9.31	85.94	7.47	16.49
2	Days taken for first flowering	AAC-1 X Arka Kamini	55.46	42-64	17.18	18.38	7.47	7.73	93.47	8.25	14.89
		PG Purple X AAC-1	54.10	42-62	12.98	15.08	6.66	7.18	86.07	6.88	12.72
3	Days taken for 50% flowering	AAC-1 X Arka Kamini	73.31	53-83	36.34	50.54	8.22	9.70	71.91	10.53	14.37
		PG Purple X AAC-1	71.02	52-85	34.86	45.73	8.31	9.52	76.24	10.62	14.95
4	Duration of flowering	AAC-1 X Arka Kamini	30.08	23-35	2.04	5.24	4.75	7.61	38.93	1.84	6.10
		PG Purple X AAC-1	29.23	22-33	2.15	3.92	5.02	6.77	54.89	2.24	7.66
(C)	**Quality parameters**										
1	Flower diameter(cm)	AAC-1 X Arka Kamini	5.80	3.50-7.20	0.30	0.42	9.42	11.15	71.30	0.95	16.38
		PG Purple X AAC-1	5.77	3.40-7.50	0.36	0.51	10.38	12.36	70.48	1.03	17.95
2	Ray florets length(cm)	AAC-1 X Arka Kamini	3.46	1.70-5.20	0.38	0.53	17.76	21.10	70.85	1.06	30.80
		PG Purple X AAC-1	3.38	1.50-4.95	0.35	0.50	17.41	20.85	69.73	1.01	29.95
3	Disc diameter (cm)	AAC-1 X Arka Kamini	2.34	1.60-3.10	0.08	0.12	12.03	14.75	66.50	0.47	20.21
		PG Purple X AAC-1	2.39	1.10-3.80	0.15	0.20	16.24	18.74	75.10	0.69	28.99
4	Stalk length (cm)	AAC-1 X Arka Kamini	26.70	20.1-38.5	17.71	27.21	15.76	19.53	65.08	6.99	26.19
		PG Purple X AAC-1	23.45	17.2-34.2	10.70	15.30	13.95	16.68	69.93	5.63	24.03

PG: Phule Ganesh AAC: Arabhavi Aster Collection cm: centimeter

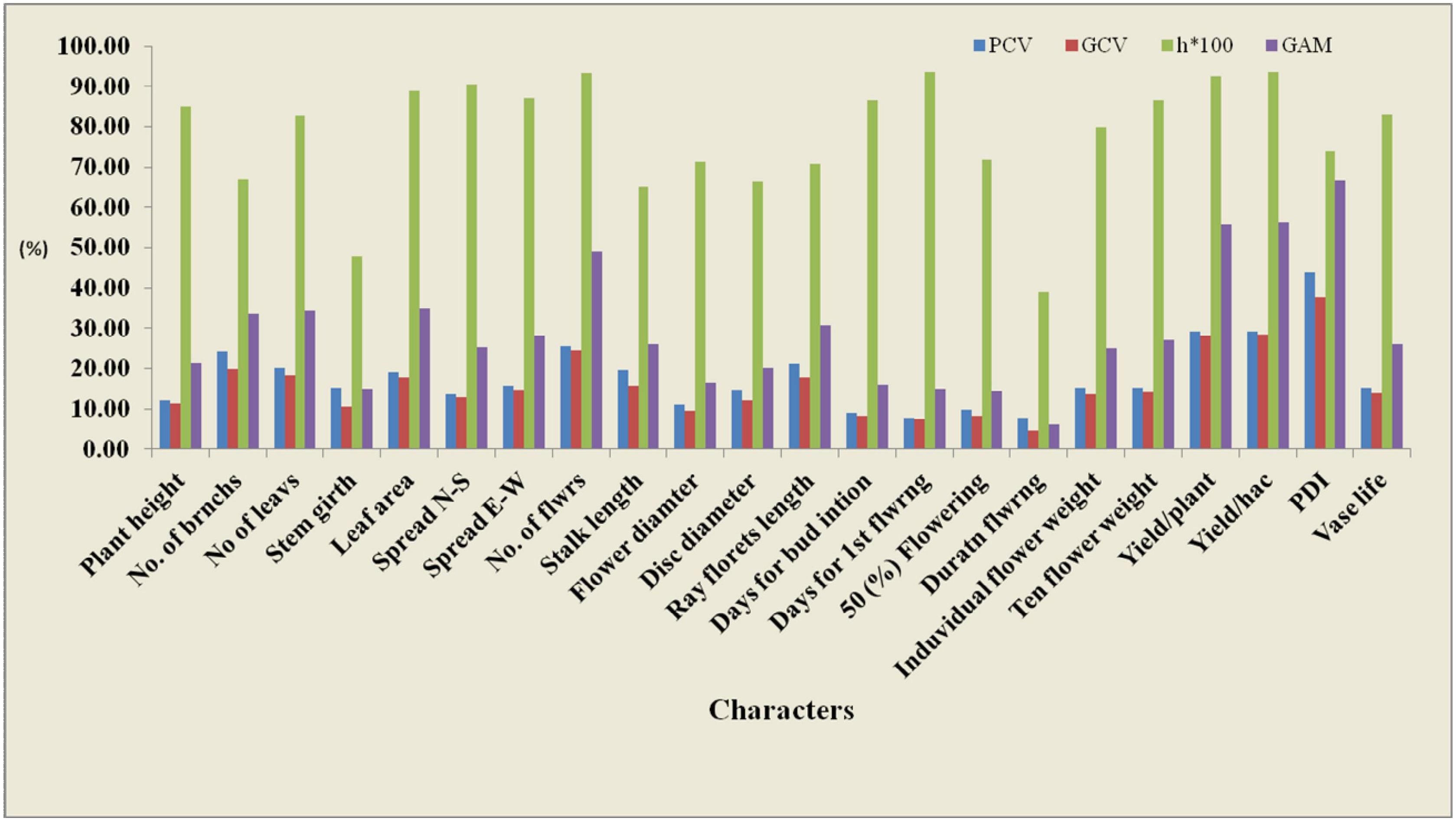


Fig 3: GCV, PCV, heritability and GAM for F_2 population of AAC-1 x Arka Kamini

4.6 Flower quality parameters

The different flower quality parameters like flower diameter, ray florets length, disc diameter and stalk length of different China aster genotypes and genetic components of two F_2 population, for these parameters were analyzed and presented in Table 16 (genotypes) and Table 15 (F_2 population).

4.6.1 Flower diameter (cm)

Significant difference was observed among the different cultivars of China aster with respect to flower diameter. It was maximum in cv. PG Pink (7.80 cm) which was on par with the cv. PG White (7.37 cm) whereas, it was recorded minimum in cv. Arka Shashank (4.82 cm).

The F_2 population of AAC-1 x Arka Kamini recorded high mean for flower diameter 5.80 cm with a range of 3.5 to 7.2 cm followed by the F_2 population of PG Purple x AAC-1 with mean value of 5.77 cm and range of 3.4 to 7.5 cm.

The moderate PCV (11.15% and 12.36%) was recorded by the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively. Lowest GCV (9.42%) was observed by the F_2 population of AAC-1 x Arka Kamini and moderate GCV (10.38%) was recorded in F_2 population of PG Purple x AAC-1.

High heritability (71.30% and 70.48%) coupled with moderate genetic advance as per cent of mean (16.38% and 17.95%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.6.2 Ray florets length (cm)

Maximum length of ray floret was recorded in the genotype PG White (3.07cm) which was on par with the cvs. PG Pink (3.05 cm) and PG Purple (2.81 cm) however, minimum length of ray floret was recorded in cv. Arka Shashank.

Highest mean for ray florets length (3.46 cm) with a range of 1.7-5.2 cm was recorded in F_2 population of AAC-1 x Arka Kamini followed by PG-Purple x AAC-1 with a lowest mean for ray florets length (3.38 cm) with a range of 1.5 to 4.95 cm.

The highest PCV (21.10% and 20.80%) and moderate GCV (17.76% and 17.41%) values were recorded in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (70.85% and 69.73 %) coupled with high genetic advance as per cent of mean (30.80% and 29.95%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.6.3 Disc diameter (cm)

The genotype PG Purple was recorded maximum disc diameter (2.95 cm) and it was on par with the cvs. PG White (2.91 cm), Arka Shashank (2.85 cm), PG Pink (2.83 cm) and Arka Kamini (2.81 cm) and minimum length of disc diameter was recorded in cv. Arka Archana (1.85 cm).

The F_2 population of PG Purple x AAC-1 recorded high mean for disc diameter of 2.39 cm with a range of 1.1 to 3.8 cm followed by the F_2 population of AAC-1 x Arka Kamini recorded mean value of 2.34 cm and range of 1.6 to 3.1cm.

The PCV (14.75% and 18.74%) and GCV (12.03% and 16.24%) values were relatively moderate in the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (66.50% and 75.10%) coupled with high genetic advance as per cent of mean (20.21% and 28.99%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.6.4 Stalk length (cm)

Significant difference was observed among the different cultivars of China aster for stalk length. It was maximum in cv. PG White (32.57 cm) but it was on par with cvs. PG Violet (31.67 cm), AAC-10 (31.17 cm) and PG Pink (30.57 cm) whereas, it was minimum in the cv. Arka Aadya (17.33 cm).

High mean stalk length of 26.70 cm with a range of 20.1 to 38.5 cm was recorded in F_2 population of AAC-1 x Arka Kamini whereas, the F_2 population of PG

Table 16. Flower quality parameters in different genotypes of China aster.

Genotypes	Flower diameter (cm)	Ray florets length (cm)	Disc diameter (cm)	Flower stalk length (cm)
AAC-1	5.12	2.19	1.95	25.88
PG White	7.37	3.07	2.91	32.57
PG Purple	6.28	2.81	2.95	25.23
PG Pink	7.80	3.05	2.83	30.57
PG Violet	6.98	1.91	1.94	31.67
Arka Poornima	5.52	2.08	2.26	28.97
Arka Kamini	5.77	2.19	2.81	30.25
Arka Violet Cushion	5.34	2.54	2.13	24.50
Arka Shashank	4.82	1.74	2.85	29.60
Arka Aadya	5.82	2.08	1.91	17.33
Arka Archana	5.54	1.93	1.85	18.28
AAC-5	5.63	1.94	2.61	29.17
AAC-7	6.28	1.93	1.98	28.17
AAC-8	5.60	1.90	1.88	28.22
AAC-10	5.21	2.04	2.13	31.17
Miraj Local	5.82	2.22	2.61	30.50
S.Em ±	**0.21**	**0.10**	**0.09**	**1.58**
C.D.@ 5%	**0.60**	**0.29**	**0.27**	**4.56**

cm: centimeters

Purple x AAC-1 recorded mean stalk length of 23.45 cm with a range of 17.2 to 34.2 cm.

The PCV (19.53% and 16.68%) and GCV (15.76% and 13.95%) values were moderate in the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (65.08% and 69.93 %) coupled with high genetic advance as per cent of mean (26.19% and 24.03%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.7 Yield parameters

The data recorded on yield components *viz.*, number of flowers per plant, individual flower weight, weight of ten flowers, flower yield per plant and flower yield per hectare area as influenced by different China aster cultivars and genetic components of two F_2 population, for these parameters were analyzed and presented in Table 17 (genotypes) and Table 18 (F_2 population).

4.7.1 Number of flowers per plant

The perusal data presented in table revealed that the significantly maximum number of flowers recorded in cv. Arka Archana (41.37) and it was on par with the cvs. Arka Aadya (40.17) and Miraj Local (37.23) whereas, cv. Arka Violet Cushion (17.40) registered minimum number of flowers.

Highest mean number of flowers (21.11) with a range of 12-42 was recorded in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini recorded the mean value of 19.61 with a range of 10 to 38 for number of flowers.

The highest PCV (25.53% and 26%) and GCV (24.65% and 23.30%) values were recorded in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

High heritability (93.22% and 80.30%) coupled with high genetic advance as per cent of mean (49.02% and 43.00%) were recorded in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.7.2 Individual flower weight (g)

An individual flower weight was recorded maximum in genotype PG Pink (5.50 g) which was found on par with the cv. PG White (5.48 g) and minimum was recorded in the genotype AAC-5 (2.66 g).

The F_2 population of PG Purple x AAC-1 recorded high mean value for individual flower weight 5.07 g with a range of 2.85 to 8.2 g followed by the F_2 population of AAC-1 x Arka Kamini with mean (4.66 g) and range of 3.15-6.36 g.

The PCV (15.16% and 17.01%) and GCV (13.56% and 15.58%) values were found relatively moderate in F_2 population of both crosses (AAC-1 x Arka Kamini and PG Purple x AAC-1).

High heritability (79.95% and 83.85%) coupled with high genetic advance as per cent of mean (24.97 % and 29.39%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.7.3 Flower yield per plant (g)

The highest flower yield per plant (197.89 g) was recorded in the cv. PG Pink and it was followed by cvs. PG White (168.03 g) and AAC-1 (157.03 g) whereas, the cv. Arka Shashank recorded least flower yield per plant (59.36 g).

The F_2 population of PG-Purple x AAC-1 recorded high mean for flower yield per plant 106.91 g with a range of 48.45 to 201 g whereas, F_2 population of AAC-1 x Arka Kamini recorded mean value of 91.06g with a range of 43.78 to 193.8 g.

The PCV (30.62% and 29.11%) and GCV (29.50% and 28.19%) values were recorded highest in F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

Table 17: Flower yield parameters in different genotypes of China aster

Genotypes	Number of flowers per plant	Individual flower weight (g)	Flower yield per plant (g)	Flower yield per hectare (t)	Vase life
AAC-1	32.27	4.87	157.03	17.44	8.14
PG White	30.67	5.48	168.03	18.67	9.68
PG Purple	32.67	3.92	128.18	14.24	9.07
PG Pink	36.03	5.50	197.89	21.99	9.80
PG Violet	28.40	3.44	98.43	10.93	7.87
Arka Poornima	26.27	3.28	86.31	9.58	7.30
Arka Kamini	30.40	3.49	105.79	11.75	7.97
Arka Violet Cushion	17.40	3.57	62.10	6.90	7.50
Arka Shashank	19.80	3.00	59.36	6.59	9.64
Arka Aadya	40.17	2.67	107.26	11.91	8.17
Arka Archana	41.37	2.83	117.08	13.01	8.27
AAC-5	35.53	2.66	94.59	10.51	7.40
AAC-7	35.93	2.96	106.32	11.81	7.80
AAC-8	33.83	2.85	95.91	10.65	8.12
AAC-10	23.03	3.02	69.27	7.69	8.03
Miraj Local	37.23	3.20	118.86	13.20	8.08
S.Em ±	**1.45**	**0.13**	**6.52**	**0.72**	**0.33**
C.D.@ 5%	**4.19**	**0.36**	**18.82**	**2.09**	**0.94**

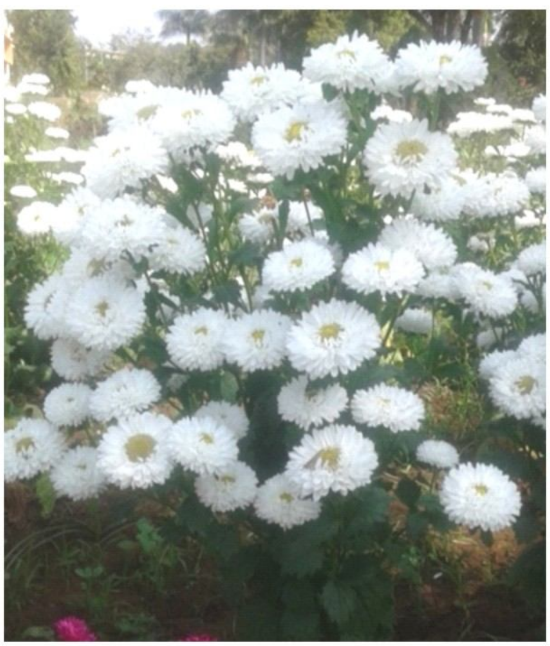
PG: Phule Ganesh AAC: Arabhavi Aster Collection g: Gram t: tonnes

Table 18: Estimates of mean, range, components of variance, heritability and genetic advance for yield parameters in F_2 population of China aster

Sl. No.	Characters	Population	Mean	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM
(e)	**Yield parameters**										
1	No. of flowers/plant	AAC-1 X Arka Kamini	19.61	10-38	23.36	25.06	24.65	25.53	93.22	9.61	49.02
		PG Purple X AAC-1	21.11	12-42	24.19	30.12	23.30	26.00	80.30	9.08	43.00
2	Individual flower weight (g)	AAC-1 X Arka Kamini	4.66	3.15-6.36	0.40	0.50	13.56	15.16	79.95	1.16	24.97
		PG Purple X AAC-1	5.07	2.85-8.3	0.62	0.74	15.58	17.01	83.85	1.49	29.39
3	Flower yield /plant (g)	AAC-1 X Arka Kamini	91.06	43.78-193.8	659.04	711.74	28.19	29.30	92.60	50.89	55.89
		PG Purple X AAC-1	106.91	48.45-201	968.91	1071.41	29.11	30.62	90.43	60.98	57.04
4	Flower yield / ha (t)	AAC-1 X Arka Kamini	10.12	4.86-21.53	8.22	8.79	28.33	29.30	93.51	5.71	56.44
		PG Purple X AAC-1	11.88	5.38-22.33	12.28	13.23	29.50	30.62	92.82	6.95	58.54
(f)	**Vase life**	AAC-1 X Arka Kamini	7.05	5-9	0.98	1.16	13.96	15.33	82.89	1.84	26.18
		PG Purple X AAC-1	7.30	11-5	1.43	1.73	16.37	18.00	82.66	2.24	30.66

PG: Phule Ganesh AAC: Arabhavi Aster Collection g: Gram t: tonnes

Phule Ganesh Pink



Phule Ganesh White

Plate 5: Promising genotypes for yield in the China aster germplasm

High heritability (92.60% and 90.43%) coupled with high genetic advance as per cent of mean (55.89% and 57.04%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.7.4 Flower yield (t/ha)

There was significant difference among the cultivars with respect to flower yield per hectare. Highest flower yield per hectare was recorded in the cv. PG Pink (21.99 tonnes) and it was followed by cvs. PG White (18.67 tonnes) and AAC-1 (17.44 tonnes) while lowest flower yield was in the cv. Arka Shashank (6.59 tonnes).

Highest mean for flower yield per hectare (11.88) with a range of 5.38-22.33 was recorded in F_2 population of PG Purple x AAC-1 followed by AAC-1 x Arka Kamini with a mean value (10.12) and range of 4.86 to 38 for flower yield per hectare.

The highest PCV (30.62% and 29.30%) and GCV (29.50% and 28.33%) values were recorded in F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

High heritability (93.51% and 92.82%) coupled with high genetic advance as per cent of mean (56.44% and 58.54%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

4.8 Vase life

The data recorded on vase life by different China aster cultivars and genetic components of two F_2 population, for these vase life was analyzed and presented in Table 17 (genotypes) and Table 18 (F_2 population).

Significant difference was obtained among the different cultivars of China aster for vase life of flowers. Cv. PG Pink extended its vase life up to maximum of 9.80 days, which was statistically on par with cvs. PG White (9.68 days), Arka Shashank (9.64 days) and PG Purple (9.07 days) whereas, cv. Arka Poornima recorded minimum vase life 7.30 days.

AAC-1 x Arka Kamini   PG Purple x AAC-1

P 95   P 82   P 29   P 16   P 27   P 197

Plate 6(a): Promising plants for yield in the F_2 population

P 7   P 22   P 48   P 8   P 18   P 32

Plate 6(b): Promising plants for alternaria leaf spot resistance in the F_2 population.

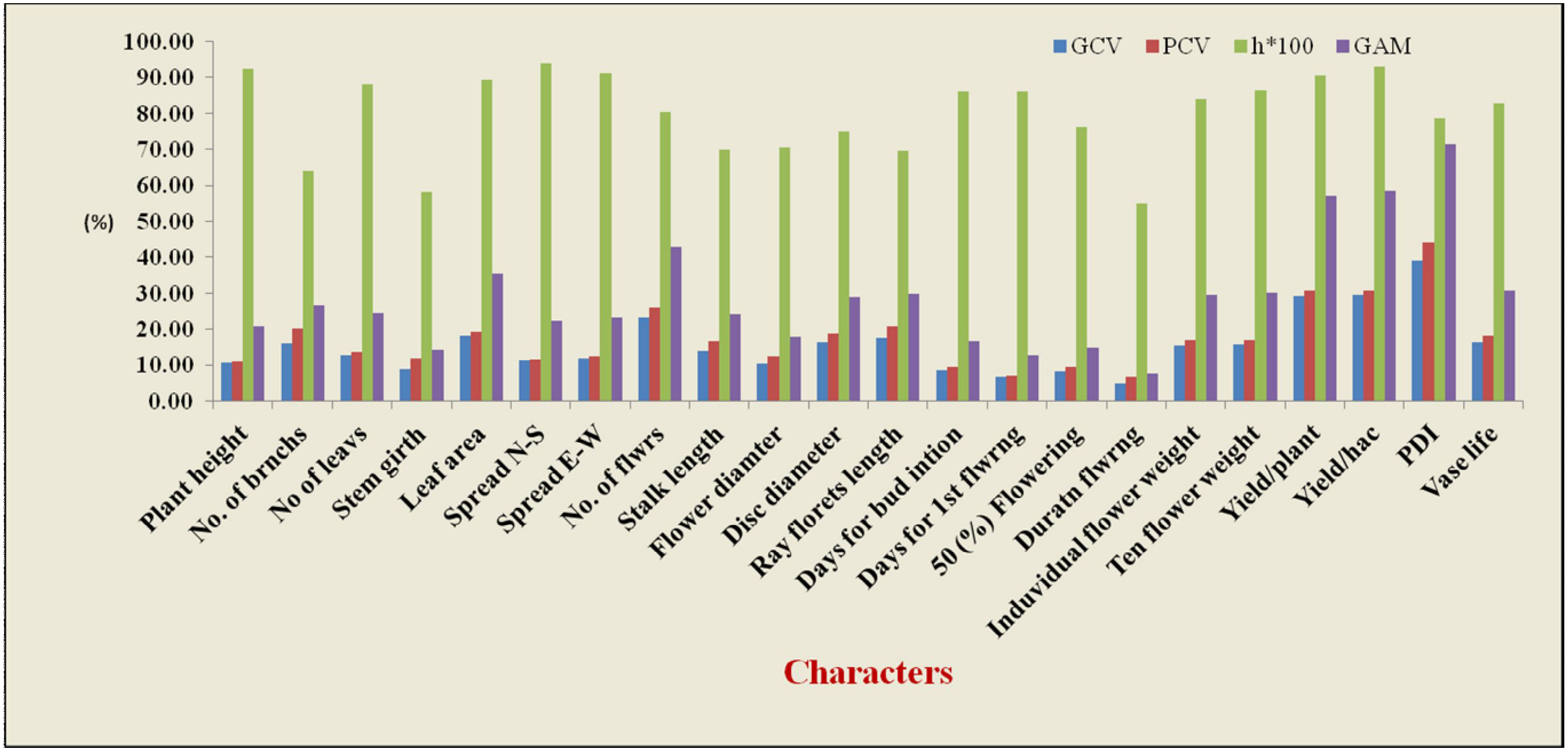


Fig 4: GCV, PCV, heritability and GAM for F_2 population of PG Purple x AAC-1

The F_2 population of PG Purple x AAC-1 recorded high mean of 7.30 days with a range (5 to 11) days whereas, the F_2 population of AAC-1 x Arka Kamini recorded mean value of 7.05 days with a range (5 to 9) for vase life.

The PCV (18.00% and 15.33%) and GCV (16.37% and 13.96%) values were recorded highest in F_2 population of PG Purple x AAC-1 and AAC-1 x Arka Kamini, respectively.

High heritability (82.89% and 82.66%) coupled with high genetic advance as per cent of mean (26.18% and 30.66%) were found in F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1, respectively.

5. DISCUSSION

China aster is one of the important commercial flower crop used as loose flower for garland making, cut flower for decoration and as herbaceous borders in the garden. The crop is subjected to attack by a number of diseases, of which leaf spot caused by *Alternaria alternata* is serious and also major limiting factor in the cultivation of China aster. It is most conspicuous by its severe blighting on leaves and thus destroying most of the photosynthetic area of the plant.

In recent years, this disease has become a menace to China aster growers in India and more so in Karnataka. Though, for the past few years the disease is spreading in epiphytotic proportion in areas where China aster has been under cultivation. Therefore, keeping the above objective in view, in the present study an endeavour was made to find resistant source for alternaria leaf spot in China aster.

The findings of present study revealed that symptoms of alternaria leaf spot disease initially appeared in the form of small, scattered dark brown spots, surrounded by a yellow hallow on leaves. Gradually these spots enlarged and resulted in the formation of irregular sunken patches with dark brown margins and rarely light grey centre which was later covered by olive brown fungal growth. In advanced stage the concentric rings were noticed and defoliation of the leaf was also noticed. These results are in confirmation with the findings of Atia and Tohamy (2004) in okra, Raja *et al*. (2005)in egg plant, Mangala *et al*. (2006) in chilli, Bajwa *et al*. (2010) in *Aloe vera* and Li *et al* (2011) in sweet pepper.

5.1 Screening of genotypes and F_2 segregating population against alternaria leaf spot

Alternaria leaf spot is one of the major constraints in China aster, which reduces the yield potential considerably. So management of alternaria leaf spot is of great importance for achieving higher productivity. Hence, the identification of resistant sources for alternaria leaf spot is one of the most important aspects in the management of this disease. In the present study sixteen genotypes and two F_2 population were screened for alternaria leaf spot resistance. The per cent disease intensity values ranged from 12.53 to 76.60 per cent (Table 3) under natural disease pressure condition. In artificially inoculated condition the PDI values ranged from 14.23-80.40 per cent (Table 5).

Varietal screening is the most promising method of managing the leaf spot disease of China aster. Among the sixteen varieties tested, none of them showed immune reaction. In the present study AAC-1 recorded resistant reaction, followed by PG Pink, PG Purple and AAC-5 whereas, Miraj Local, AAC-10, AAC-7, Arka Shashank and PG Violet recorded moderately susceptible reaction. Variety Arka Poornima recorded susceptible reaction. Similar results were reported by Sreenivasulu *et al*. (2004), Thammaiah *et al*. (2004) and Rachappa (2014) in China aster.

It is evident from the Table 3 that, none of the genotype recorded immune to alternaria leaf spot. Among 16 genotypes, one genotype recorded resistant reaction whereas, two genotypes falls under moderately resistant category, 7 genotypes under moderately susceptible category, 5 genotypes under susceptible category and one genotype recorded highly susceptible reaction. These results are in confirmation with Sackston (1988) who reported that although differences exist in reaction to *Alternaria helianthi* infection among genotypes, no stable resistant varieties or hybrids have been released so far in any part of the world. The level of resistance available was very low and usefulness of such resistance in reducing the yield loss was uncertain. All the 27 entries of National Oil seed Nursery in Minnesota were susceptible to *A. helianthi* (Shane *et al.*, 1981). Morries *et al*. (1983) concluded that no absolute resistance was available among the 21 annual and 37 perennial *Helianthus* sp. for resistance to *A. helianthi*. However, moderate level of resistance was observed in three perennial species viz., *Helianthus hirsutus, H. rigidus* sub sp. *subrhomboides* and *H. tuberosus*. There were significant differences in alternaria leaf blight reactions among 24 inbred lines of sunflower evaluated by Carson (1985). The inbred male sterile lines HA-89 and HA-302 showed less severity whereas, fertile inbreds RHA-298 and RHA-299 showed higher level of disease severity.

Screening studies of F_2 population of AAC-1 x Arka Kamini under natural disease pressure condition revealed that out of 200 plants nine plants reported resistance reaction, 137 plants recorded moderate resistant reaction and 39 plants shows moderately susceptible reaction, 15 plants recorded susceptible reaction. The F_2 population of PG Purple x AAC-1 was screened under natural disease pressure condition against alternaria leaf spot revealed that out of 200 plants eleven plants reported resistance reaction. However, 135 plants recorded moderate resistant reaction and 35 plants showed moderately susceptible reaction, 19 plants recorded susceptible reaction. Similar, result was reported by Shivakumar (2008) in soybean.

5.2 Host pathogen relationship

The biochemical constituents like chlorophyll, carotenoids, phenols and sugars are important in imparting resistance to the crop plants. Sometimes host plant is induced to synthesize these compounds upon infection. In the present study taking genotypes from each category of resistant, moderately resistant and susceptible groups, an attempt has been made to find out the role of some biochemical constituents present in China aster plants.

5.2.1 Chlorophyll

In the present study, it was found that chlorophyll ‘a’, ‘b’, total chlorophyll and carotenoids were present in higher amounts in resistant cultivar than susceptible cultivars. Their relative concentration was also found to decrease as a result of infection by the pathogens, but the rate of decrease was higher in susceptible entries than resistant entries. Abnormalities in the form and destruction of chloroplasts were common features of diseased tissue in plant infected with pathogens, which usually exhibited reduced photosynthetic rate, phosphorylation, hill reaction and carbon dioxide assimilation. These changes may be partially or completely accounted by a reduction in chlorophyll content may be due to death of more leaf tissues as a result of infection. Also in the present study, chlorophyll ‘b’ was found to be more sensitive than chlorophyll ‘a’ as it recorded higher reduction percentage after infection by the pathogen.

In all the entries, there was decrease in chlorophyll ‘a’ content. The highest per cent reduction was observed in susceptible cultivar Arka Poornima (75.97) and least per cent of reduction was recorded in AAC-1 (22.79%). Whereas, per cent decrease in chlorophyll ‘b’ content was highest in susceptible cultivar Arka Poornima (74.42%) and least per cent reduction was recorded in resistant genotype AAC-1 (15.78%).

Per cent reduction in total chlorophyll content was recorded highest in Arka Poornima (73.40%) and least per cent of reduction was recorded in resistant genotype AAC-1 (16.42%). These results are in confirmation with earlier findings, reduction of synthetic pigments was reported by Bhaskaran and Kandaswamy (1978) in necrotic halo tissues of sunflower leaves infected leaves by *Alternaria helianthi*. Theerthaprasad and Shambulingappa (1986) noticed that, there was rapid loss of chlorophyll ‘a’ and ‘b’ in susceptible varieties of sunflower. Bhavani *et al.* (1998) also reported reduction in total chlorophyll, chlorophyll ‘a’ and chlorophyll ‘b’ in sunflower mosaic virus infected leaves.

5.2.2 Phenols

Phenolic compounds exhibit anti microbial activity against fungi, bacteria and viruses and they also act as protective compounds. High concentration of phenols causes an instant lethal action by a general tanning effect, while low concentration causes only gradual effect on the cellular constituents of the pathogen. If the concentration does not occur in toxic level the inhibition will be obviously low. Besides this, the pathogens readily detoxify low concentration of toxicant rather than high concentrations (Dasgupta 1998).

It is clear that the per cent increase in total phenols was higher in AAC-1 (80.53%), a resistant genotype compared to moderately resistant genotypes and it was lowest in susceptible entry Arka Poornima (20.73%). These results are in confirmation with earlier findings, there was an increase in phenol content of sunflower plants in response to inoculation of *Alternaria helianthi*. This increase in phenol content was at higher rates in resistant and moderately resistant genotypes, while it was at lower rates in susceptible genotypes. Concentration of phenolic compounds was usually higher in resistant genotypes than susceptible genotypes of different crop plants (Arora and Wagle, 1985 and Saini *et al*., 1988).

5.2.3 Sugars

In the present study, level of total sugar, reducing sugar and non-reducing sugar content increased at higher rates in response to infection. It may be due to their accumulation as a result of disruption of normal phloem on transport or due to the release of amylase in the disorganized host cells and their secretion by the invading pathogen.

The rate of per cent increase in reducing sugar content (16.85%) was less in resistant genotype AAC-1 and highest percent increase in reducing sugar content was recorded in Arka Poornima i.e. 70.40 per cent (susceptible). Similarly, the highest per cent increase in non reducing sugar content was observed susceptible variety Arka Poornima (65.91%) while, lowest percent increase was recorded in resistant variety AAC-1 (13.05%).

In all, lesser increase in total sugar content was recorded in AAC-1 (15.42%) whereas, Arka Poornima (68.68%) showed highest increase in the sugar content which might has lead to susceptibility to pathogens. However Ranganatha *et al*. (2003) reported that there is increase in sugar content in wild sunflower, *H. occidentalis* after 24 hours of infection of *A. helianthi*. Similar result was also reported by Madalagi (2014) in chrysanthemum.

5.3 Segregation pattern of alternaria leaf spot in F_2 segregating population

China aster genotype AAC-1 was used as the resistant parent in crosses with susceptible cultivars Arka Kamini and PG Purple. The reaction of the resistant parent and susceptible parent had been determined from field studies.

The per cent disease intensity data for alternaria leaf spot of parents and F_2 generation was recorded. Majority of the plants in the AAC-1 population exhibited a resistant reaction. All plants in the PG Purple and Arka Kamini exhibited a susceptible reaction. Majority of plants in the F_1 population exhibited a resistant reaction with the less PDI, suggesting that the alternaria leaf spot resistance is inherited as a dominant trait.

The segregation data indicated that alternaria leaf spot resistance in AAC-1 is conditioned by a major gene. While segregation for resistance in the F_2 population was consistent with a ratio of 3:1 as resistant : susceptible plants in a population of AAC-1 x Kamini and PG Purple x AAC-1. These results support the hypothesis that a single dominant gene in AAC-1 controls resistance to *Alternaria alternata.* Tryphone *et al*. (2012) reported that Chi-square values were computed to determine whether the observed ratios for disease reactions deviated from expected Mendelian ratios for a single, dominant gene controlling resistance to angular leaf spot in common bean. However, in F_2 generation plants are segregated in the ratio of 3 resistant: 1 susceptible. Similar results were reported by Thomas *et al*. (1990) in musk melon the resistant inbred line MR-1 and susceptible cultivars Perlita and PMR 6 were used to determine inheritance of resistance to *Alternaria cucumerina.* All the plants in the F_1 population were resistant. F_2 population plants were segregated phenotypically in 3 resistant : 1 susceptible ratio.

5.4 Growth parameters

Vegetative growth is measured in a better way in terms of plant height, number of branches, number of leaves, stem girth, plant spread and leaf area. These parameters play an important role in deciding the quality and productivity of China aster. Different cultivars were found to influence these characters in the present study.

Plant height was significantly influenced by different cultivars throughout the experimental period. The cv. PG White was vigorous in growth in terms of plant height. Whereas, the other cvs. like AAC-5, PG Violet and PG Pink were medium in vigour in terms of plant height. The cv. Arka Aadya recorded minimum plant height. Plant height being a genetically controlled factor, it varied among the cultivars. Similar variation in plant height due to cultivars was also observed in China aster by Rao and Negi (1990), Kulkarni and Reddy (2004), Poornima *et al.* (2006) and Munikrishnappa *et al*. (2011).

Number of branches produced per plant was maximum in cv. Arka Archana followed by Arka Aadya, AAC-5 and PG White whereas, the cv. Arka Violet Cushion recorded minimum number of branches. The difference in number of branches could be attributed to the genetic makeup of the cultivars. Similar variations for number of branches were also observed in China aster by Rao and Negi (1990), Munikrishnappa *et al.* (2011) and Zosiamliana *et al*. (2012).

Leaves are the prime important functional units for photosynthesis, which greatly influence the growth and flower yield of crop. Among the cultivars, number of leaves produced per plant was maximum in cv. AAC-1 followed by PG white, PG Pink and AAC-5. The production of more number of leaves per plant in these cultivars was due to increased plant height. Such variations in number of leaves among the cultivars were also observed by earlier workers Poornima *et al.* (2006) and Zosiamliana *et al*. (2012) in China aster.

Stem girth of China aster varied from different stages of plant growth. Maximum stem girth was recorded in the cv. PG Pink and it was followed by cvs. AAC-1 and Miraj Local. Genetic makeup of these cultivars may be the reason for higher stem girth. A similar variation for stem girth was also observed in chrysanthemum by Rajivkumar *et al.* (2007).

Plant spread North-South direction was recorded significantly maximum in the cv. AAC-1 followed by cv. Miraj Local. The least plant spread was recorded in the cv. Arka Violet Cushion. The better performance of the cv. AAC-1 may be due to its genetic makeup and its better adaptability to the prevailing environmental conditions. These results are in conformity with the results reported earlier in China aster by Rao and Negi (1990), Ravikumar (2002), Munikrishnappa *et al.* (2011) and Zosiamliana *et al.* (2012).

Plant spread East - West direction was recorded significantly maximum in the cv. AAC-1 which was on par with cv. PG Pink. The least plant spread was recorded in the cv. AAC-7. The better performance of the cv. AAC-1 may be due to its genetic makeup and its better adaptability to the prevailing environmental conditions. These results are in conformity with the results reported earlier in China aster by Rao and Negi (1990), Ravikumar (2002), Munikrishnappa *et al.* (2011) and Zosiamliana *et al.* (2012).

The cultivar of PG Pink recorded maximum leaf area and it was followed by the cv. AAC-1, minimum leaf area was recorded in the cv. AAC-10. This might be due to increased number of leaves, leaf length and width which intern helped in maintaining higher leaf area. These results are in conformity with the reports of Ravikumar (2002), Munikrishnappa *et al.* (2011), in China aster.

5.5 Flowering parameters

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

The days taken for first bud initiation was recorded minimum in cv. Arka Aadya whereas, maximum days taken for first bud initiation was recorded by the cv. AAC-1 variations in flower characters were expected due to China aster cultivars as evidenced by Negi *et al.* (1983) Munikrishnappa *et al.* (2011) and Zosiamliana *et al.* (2012) in China aster.

As far as flowering duration is concerned, the cv. PG Pink flowered for maximum duration whereas, flowering duration was minimum in cv. Arka Aadya. These results are in conformity with the China aster reports of Poornima *et al.* (2006) and Zosiamliana *et al.* (2012).

5.6 Yield parameters

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

The flower yield per plant and per hectare was highest in cv. PG Pink. The increased flower yield was because of increased number of flowers per plant and individual flower weight as in case cv. PG Pink. The flower yield was less in cv.Arka Violet Cushion. Variation in flower yield was also observed previously in China aster (Negi and Raghava, 1985, Munikrishnappa *et al.*, 2011, Zosiamliana *et al.*, 2012).

5.7 Variability, heritability and genetic advance as per cent of mean in F_2 population

The wide range of variability existed for all the characters among the F_2 population and can be exploited through selection. One of the ways in which the variability of these characters assessed is through a simple approach of examining the range of variation. Range of variation observed for all the traits in the present study indicates the presence of sufficient amount of variation among the F_2 population for most of the characters studied. The material considered for the study was appropriate.

The range in the values reflect the amount of phenotypic variability, which is not very reliable since it includes genotypic, environmental and genotype x environmental interaction components and does not reveal as to which character showing higher degree of variability. Further, the phenotype of the crop is influenced by additive gene effect (heritable), dominance (non- heritable) and epitasis (non- allelic interaction). Hence, it becomes necessary to work out the observed variability into phenotypic coefficients of variability (PCV) and genotypic coefficients of variability (GCV), which ultimately indicate the extent of variability existing for various traits. However, even this does not give a true picture about the extent of inheritance of the character.

The effectiveness of selection for any character does not depend on the amount of variability alone but also with estimates of heritability. It is of great interest to the plant breeder to determine how much of the phenotypic variability which is present in a particular generation is heritable and the accuracy with which a genotype can be evaluated by its phenotypic expression. Therefore, the heritability (h^2) of a character can be relied upon, as it enables them to decide the extent of selection pressure to be applied under particular environment, which separate out the environmental influence from the total variability. Nevertheless, its use would be limited as this is prone to changes in environment, material, etc. The estimation of heritability has a greater role to play in determining the effectiveness of selection of a character provided it is considered in conjunction with the predicted genetic advance as suggested by Johnson *et al.* (1955) and Panse and Sukhatme (1967). Since, heritability is influenced by bio-metrical method, generation of hybrid, sample size of experimental material and environment (Hanson, 1963).

For growth parameters, both the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1 estimates higher phenotypic variance (PV) compared to genotypic variance (GV) for all the characters, indicating the role of environmental factors for the expression of these characters. Less difference were observed for genotypic and phenotypic variance for number of branches, number of leaves, stem girth, leaf area (at grand growth stage) indicating the fact that these characters are not much influenced by environmental factors. This also suggests the presence of sufficient variability, which can be exploited by practicing selection based on phenotype for growth parameters. Similar results were obtained by Rao (1982) in China aster, Kannan and Ramdas (1990) and Anuradha and Narayanagowda (1999) in gerbera, Ponnuswami *et al.* (1985), Siroshi and Behera (2000) in chrysanthemum, Mathad *et al.* (2003) and Kanwar and Saha (2006) in marigold.

The coefficients of variations for both the genotypic and phenotypic for growth parameters of F_2 population revealed that the low differences were observed for plant height, number of branches, number of leaves and leaf area, thus suggesting the major contribution of genetic variability towards the total variance indicating ample scope for improvement. Similar trend was reported in dahlia for all the characters by Mishra *et al.* (1987) and Anuja and Jahnavi (2012).

Heritability (h^2) and genetic advance over per cent mean (GAM) varied for growth parameters. Higher heritability indicates the effectiveness of selection through phenotypic performance, but it does mean a high genetic gain. The magnitude of heritable variability is the most important aspect of the genetic constitution of breeding material. However, high heritability associated with high GAM proves more useful for efficient improvement of a character through simple selection (Panse and Sukhatme, 1967).

In present study, both the F_2 population of AAC-1 x Arka Kamini and PG Purple x AAC-1 estimates of high heritability with high genetic advance over per cent mean (GAM) were observed for plant height, number of branches per plant, number of leaves per plant, leaf area and plant spread indicating the possible role of additive gene action. The results are in conformity with observation made by Negi *et al.* (1983) for plant height in China aster, number of leaves per plant (Kannan and Ramdas, 1990) in gerbera and in chrysanthemum by Talukdar *et al.* (2003).

Significant variations were observed for flowering parameters, indicating the wide variability present among the F_2 population. The difference among the phenotypic variance and genotypic variance were very low for days taken for first flower initiation indicating the low effects of environment on the expression of this character or less genotype x environment interactions.

In both the F_2 population phenotypic coefficient of variability (PCV) was higher than the genotypic coefficients of variability (GCV) for the flowering characters studied. Similar results were obtained by Naik *et al.* (2004) in China aster and Vikas *et al.* (2011) in Dahlia. It is obvious because PCV embodies variability due to genotypes, environment and genotype x environment interaction. The differences among the phenotypic coefficients of variations and genotypic coefficients of variations was very less for days taken for first bud initiation, days taken for first flowering and days taken for 50 per cent flowering, indicating less role of environment or contribution of genetic variability towards total variance. It may be concluded that these are the characters in China aster breeding programme for effective utilization of the existing variability.

High heritability with moderate GA was observed for days taken for first bud initiation, days taken for first flowering and days taken for 50 per cent flowering which can be exploited through hybridization. Similar results were obtained by Janakiram and Rao (1991), Singh and Sen (2000) in marigold and Beura *et al.* (1995) in dahlia for days taken for 50% flowering.

For flower quality parameters, both the F_2 population AAC-1 x Arka Kamini and PG Purple x AAC-1 exhibited little higher phenotypic variance for stalk length, flower diameter, disk diameter and ray floret length. High estimates of heritability associated with high genetic advance were observed for stalk length, disc diameter and ray florets length. Similar results were obtained in chrysanthemum for diameter of the disc, number of flowers per plant by Barigidad (1992) and Sirohi and Behera (2000) in gerbera for number of flower per plant, Kannan and Ramdas (1990) in Dahlia for number of ray florets per head, Srinivas and Narayanagowda (1995) for number of ray floret in China aster by Rao (1982).

High heritability with moderate genetic advance as per cent mean (GAM) in both the F_2 population was observed for flower diameter. Similar results were reported for flower diameter in Dahlia by Choudhary (1989), Mishra *et al.* (1987), Mishra and Saini (1997) and Singh (2003) and Srinivas and Narayanagowda (1995) for flower diameter.

For yield parameters, both the F_2 population AAC-1 x Arka Kamini and PG Purple x AAC-1 exhibited high genetic variability for most of the characters indicating the adequate amount of genetic variability existed in the material. The estimates of phenotypic variance were higher compare to genotypic variance indicating the role of environment in the expression of the characters. Number of flowers per plant, flower yield per plant and flower yield per hectare had high phenotypic variance than genotypic variance. Similar results were confirmed by Mathad *et al.* (2003), Singh *et al.* (2008) in marigold, Kavitha and Anburani (2010) in Dahlia. It also indicates the sufficient genetic variability which can be exploited by selection. However, the difference among phenotypic coefficient of variation and genotypic coefficient of variation was very less indicating the contribution of genetic variability to the total variability. Similar results were obtained by Beura *et al.* (1995) and Singh (2003) for number of flowers per plant, weight of flower and number of tuber per plant in Dahlia. In African marigold by Janakiram and Rao (1991) for total flower yield per plant.

In the present investigation, high heritability estimates associated with high genetic advance was noticed for number of flowers per plant, flower yield per plant and flower yield per hectare indicating the role of additive gene action. Similar results reported by Chaugule (1985), Chezhiyan *et al.* (1985), Barigidad (1992), Sirohi and Behera (2000) and Talukdar *et al.* (2003) in chrysanthemum, Singh and Saha (2006), Singh *et al.* (2008) and Kavitha and Anburani (2010) in marigold, in dahlia by Choudhary (1989) and Sashikala *et al.* (1995)

Overall yield and yield contributing characters have exhibited high heritability coupled with high GAM, indicating the scope of further improvement through selection.

In general for all the characters studied two population *viz.* AAC-1 x Arka Kamini and PG Purple x AAC-1 emerged as potential population for improving productivity in China aster, as revealed by the genetic variability parameters. Hence, these population advanced further through selection to derive a potential genotype.

6. SUMMARY AND CONCLUSION

Field experiment was under taken to screen the genotypes and F_2 population of China aster (*Callistephus chinensis* L. Nees) for alternaria leaf spot with the objective to identify the resistance sources and to assess the growth and yield parameters among the genotypes and F_2 population. The experiment was laid out at the research field of Department of Floriculture and Landscape Architecture, K. R. C. College of Horticulture, Arabhavi during 2015-16. The results of the present investigation are summarized here under.

Among the sixteen genotypes screened for alternaria leaf spot resistance, cv. AAC-1 recorded resistant disease reaction under the both natural disease pressure and artificial inoculated conditions (12.53% and 14.23%). Two genotypes PG Pink (20.87% and 23.73%) and AAC-5 (23.41% and 24.60%) recorded moderately resistant reaction. However, cv. Arka Poornima recorded highly susceptible reaction with the highest PDI (76.60% and 80.40%).

Screening of F_2 population under natural disease pressure conditions revealed that out of 200 plants in the F_2 population of AAC-1 x Arka Kamini, 9 plants recorded resistance disease reaction (1-15%) and 137 plants reported moderately resistance disease reaction (16-25%). 39 plants recorded moderately susceptible disease reaction (26 -50%) and 15 plants shows susceptible reaction (51-75%).

In F_2 population PG Purple x AAC-1, out of 200 plants 11 plants recorded resistance disease reaction (1-15%) and 135 plants reported moderately resistance disease reaction (16-25%). 35 plants recorded moderately susceptible disease reaction (26-50%) and 19 plants shows susceptible reaction (51-75%).

The F_2 data from both the crosses AAC-1 x Kamini and PG-Purple x AAC-1 fit reasonably well to segregation ratio of 3 resistant : 1 susceptible.

Among the different cultivars, cvs. PG White, AAC-5 and PG Violet were vigorous in growth. Highest plant height was recorded in cv. PG White (71.37 cm), whereas, cv. Arka Aadya recorded minimum plant height (38.37 cm).

Along with other growth attributes, number of branches per plant also went on increasing as the growth period progressed. cvs. Arka Archana, Arka Aadya and AAC-5 were had more branches at 60 DAT. Among them cv. Arka Archana produced maximum number of branches (28.83) and minimum was recorded in cv. Arka Violet Cushion (12.54). The mean number of leaves per plant was significantly differed among the cultivars. Maximum number of leaves per plant was produced in cv. AAC-1 (229.13) and cv. Arka Shashank (160.80) recorded minimum number of leaves per plant.

The stem girth varied among the cultivars due to their genetic makeup. Stem girth was maximum in the cv. PG Pink (1.84 cm). The plants of cv. AAC-8 (1.24 cm) had the minimum stem girth. In general all the cultivars exhibited continuous increased plant spread as the growth period advanced. The cv. AAC-1(37.37 cm) was spreading in East - West direction and recorded maximum plant spread. Whereas, the minimum spreading habit in East - West direction was recorded in the cv. AAC-7 (26.93 cm). The cv. AAC-1 was spreading in North-South direction and recorded maximum plant spread (38.30 cm). Whereas, the minimum spreading habit in North-South direction was recorded in the cv. AAC-7 (27.87 cm).

The leaf area was significantly different among the cultivars tried. Cv. PG Pink had maximum leaf area (8635.36 cm^2), while the cv. AAC-10 recorded minimum leaf area (3694.60 cm^2).

Cultivars varied significantly for days taken for first flower bud initiation was noticed early in cv. Arka Aadya (35.77days), whereas it was late in cv. AAC-1 (50.60 days).

Cultivars varied significantly for days taken for first flowering and days taken for 50 per cent flowering were noticed early in cv. Arka Aadya (41.65 and 62.37 days), whereas it was late in cv. AAC-1 (57.93 and 75.20 days).

The duration of flowering was significantly different among the cultivars tried. Cv. PG Pink had maximum duration of flowering (34.27 days), while the cv. Arka Aadya recorded minimum duration of flowering (26.47 days).

Maximum number of flowers per plant was recorded in cv. Arka Archana (41.37), while these were least in cv. Arka Violet Cushion (17.40). The flower yield per plant varied from cultivar to cultivar as per their genetic constitution. Highest was recorded in cv. PG Pink (197.89 g) whereas, least flower yield per plant was noticed by cv. Arka Shashank (59.36 g).

Among the cultivars studied, cv. PG White recorded maximum stalk length (32.57 cm) and minimum was registered in cv. Arka Aadya (17.33 cm).

The experimental data for different components of growth, flowering, yield and quality parameters of F_2 population were subjected to statistical analysis. The genetic variation was assessed using parameters like genotypic variance (GV), phenotypic variance (PV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense), genetic advance (GA) and genetic advance over per cent of mean (GAM). The salient findings of the investigation are summarized here under.

The estimate of phenotypic variance (PV) was higher compared to genotypic variance (GV) for all the characters, indicating the role of environmental factors for the expression of these characters. Less difference was observed for genotypic and phenotypic variance for number of branches, number of leaves, stem girth, plant spread, flower per hectare, flower diameter, disk diameter, ray floret length and individual flower weight in both the F_2 population indicating the fact that these characters are not much influenced by environmental factors. This also suggests the presence of sufficient variability, which can be exploited by practicing pure line selection.

The genotypic coefficient of variance and phenotypic coefficient of variance revealed that the low differences were observed for plant height, number of branches, number of leaves, leaf area, plant spread (E-W and N-S), days for first bud initiation, days taken for first flowering, flower yield/plant and number of flower/plant in both the F_2 population, suggesting the major contribution of genetic variability towards the total variance, indicating ample scope for improvement by selection.

Estimates of high heritability with high genetic advance as per cent of mean (GAM) were observed for plant height, number of leaves, number of branches per plant, leaf area, plant spread at 60 DAT (E-W and N-S), number of flowers per plant, flower yield per hectare, stalk length, disk diameter, individual flower weight indicating the possible role of additive gene action. Whereas, high heritability coupled with moderate genetic advance were observed for other traits like stem girth, flower diameter, stalk length, days for first bud initiation, days for first flowering and days taken for 50% flowering which can be exploited through hybridization.

In general for all the characters studied in the two F_2 population viz., AAC-1 x Arka Kamini and PG Purple x AAC-1 emerged as potential population for improving productivity in China aster, as revealed by the genetic variability parameters. Hence these population advanced further through selection to derive a potential genotype.

Genotypes, PG Pink and AAC-1 have emerged as promising genotypes with respect to growth, flowering, flower yield, quality and also shows resistant reaction to alternaria leaf spot so, these cultivars can be recommended for commercial cultivation.

Future line of work

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

1. Crop improvement work for disease resistance can be initiated from these material
2. Promising genotypes and F_2 lines from these F_2 population may be used for improving alternaria leaf spot resistance and productivity in China aster, as revealed by the genetic variability parameters. Hence, these population advanced further through selection to derive a potential genotype.
3. Pathological studies for alternaria leaf spot disease resistance to identify gene specific marker for this trait may be carried out.

7. REFERENCES

*Acimovic, M., 1976, Inbred sunflower lines as sources of resistance to economically important diseases. Poljoprivredna Znanstvena Smotra, **39**: 79-88.

Agarwal, J. M., Chippa, H. P. and Mathur, S. J., 1979, Screening of sunflower germplasms against *Alternaria helianthi*. Indian J. of Mycology and Plant Pathol., **9**: 85-86.

Akoijam, R. S. and Chandel, S., 2010, Screening of some marigold cultivars for resistance against leaf spot and flower blight caused by *Alternaria zinnia* Pape. J. Indian Phyto Path., **63**(3): 354-355.

Amaresh, 2000, Epidemiology and management of alternaria leaf blight and rust of sunflower (*Helianthus annus* L.). Ph.D. Thesis, Univ. Agric. Sci., Dharwad.

Angadi, S. M., 2000, Studies on performance of China aster (*Callistephus chinensis* Nees.) cultivars. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad.

Anilkumar, T. B., Urs, S. D., Seshdri, V.S. and Hegde, R. K., 1976, alternaria leaf spot of sunflower. Curr. Sci. **43**: 93-94.

Anonymous, 2008, Package of practices for horticulture crops (In Kannada). Univ. Agric. Sci., Dharwad. pp : 167-168.

Anonymous, 2012, Statistical data on horticulture crops in Karnataka state. Department of Horticulture, Lalbagh, Bangalore.

Anuja, S. and Jahnavi, K., 2012, Variability, heritability and genetic advance studies in French marigold (*Tagetes patula* L.) Asian J. Hort. **7**(2): 362-364

Anuradha, S. and Gowda, J. V. N., 1999, Genetic difference in the post harvest life of gerbera cultivar. Mysore J. Agri. Sci., **33:** 312-316.

*Arora, Y. K. and Wagle, D. S., 1985, Inter-relationship between peroxidase, polyphenol oxidase activities and phenolic contents of whear for resistance to loose smut. Biochemic and Physiologic der Pflanzen, **180**: 75-80.

Arora, J. S. and Singh, J., 1980, Performance of marigold cultivars under north Indian conditions. In: National Seminar on Production Technology for Commercial Flower Crops, pp. 81-82.

Aswath, C. and Parthasarathy, V. A., 1993, Heritability and correlation studies in China aster (*Callisthephus chinensis* [Ness.]). Indian J. Hort., **50**(1): 89-92.

Atia, M. M. M. and Tohamy, M. R. A., 2004. First record of alternaria leaf spot disease on okra in Egypt. Egypt J. Phytopathol., **32**: 139-140.

Bajwa, R., Mukhtar, I. and Mushtaq, S., 2010, New report of alternaria causing leaf spot of Aloe vera in Pakistan. Canadian J. Plant Pathol., **32**(4): 490-492.

Balasubramanyam, N. and Kolte, S. J., 1980a, Effect of different intensities of alternaria blight on yield and oil content of sunflower. J. Agric. Sci., **94**: 749-751.

Balasubramanyam, N. and Kolte, S. J., 1980b, Effect of alternaria blight on yield components, oil content and seed quality of sunflower. Indian J. Agric. Sci., **50**: 701-706.

Barigidad, H., Patil, A. A. and Nalawadi, U. G., 1992, Variability studies in chrysanthemum. Prog. Hort., **24**(1-2): 55-59.

Baskaran, V., Janakiram, T. and Jayanthi, R., 2004, Varietal evaluation in chrysanthemum. Karnataka J. Hort., **1**(1): 23-27.

Benagi, V, L., 1995, Epidemiology and management of late leaf spot of groundnut caused by *Phaeosariopsis personata* (Berk and Curt). Ph. D. Thesis, Univ. Agric, Sci., Dharwad, Karnataka (India).

Beura, S., Maharana, T. and Jagadev, P. N., 1995, Genetic variability and character association in dahlia. J. Tropical Agric., **33**: 20-22.

Bhaskaran, R. and Kandaswamy, T. K., 1978, Changes in ascorbic acid content in sunflower leaves due to *Alternaria helianthi* inoculation. The Madras Agricultural Journal, **65**: 419-420.

Bhat, H. A., Ahmad, K., Ahanger, R. A., Qazi, N. A., Dar, N. A. and Ganie, S. A., 2013, Status and symptomatology of alternaria leaf blight of Gerbera in Kashmir valley. Afr. J. Agric. Res., **8**(9): 819-823

Bhavani, U., Venkatasubbaiah, A., Rao, S. and Saigopal, D. V. R., 1998, Studies on mosaic disease of sunflower: Biochemical changes and growth parameters. Indian phyto. Patho. **51**: 357-358

Bindumathi, A. and Gulabrao, G., 1997, Cultivating China aster scientifically. Indian Hort., **41**: 30-44.

Borate, Y. S., 2002, Genetic characterization of ornamental germplasm through biotechnological approaches. Italus-Hort., **9**(5): 28- 33.

Burton, G. W. and Dewane, E. M., 1953, Estimating heritability from replicated clonal material. Agron. J., **45**: 478-481.

Carson, M. L., 1985, Epidemiology and yield losses associated with alternaria blight of sunflower. Phytopathology, **75**: 1151-1155.

Chaugule, B. B., 1985, Studies on genetic variability in chrysanthemum (*Chrysanthemum morifolium*). M. Sc. (Agri) Thesis, Mahatma Phule Agril. Univ., Rahuri.

Chezhiyan, N., Ponnuswami, V., Thamburaj, S., Khader, J. M. A., Nangan, K. and Gunashekaran, N., 1985, Evaluation of chrysanthemum cultivars. South Indian Hort., **33**: 279-282.

Choudhary, M. L., 1989, Genetic variability in dahlia. Prog. Hort., **19**(1-2): 58-60.

Dalal, S. R., Gonge, V. S., Mohatira, A. D. and Nuje, A. D., 2005, Performance of different varieties of gerbera under polyhouse conditions. Adv. Pl. Sci., **18**(1): 269- 272.

Dasgupta, M. K., 1998, Principles of Plant Pathology, Allied Publishers Private limited, India, p. 500.

David, J. C., 1998, *Alternaria zinnia*. IMI Descriptions of Fungi and Bacteria (108): Sheet 1007.

Desai, B. L., 1967, Flower description in China aster (*Callistephus chinensis*) in *Seasonal flowers*. ICAR Publication, New Delhi, pp. 53-56.

Dhal, N, K., Swain, N. C., Varshiney, J. L. and Biswal, G., 1997, Etiology of mycoflora causing blossom end rot of tomato. Indian Phytopathol., **50**: 587-592.

Dhane, R. A., 2003, Varietal performance of exotic cultivars of gerbera (*Gerbera jamesonii*) under naturally ventilated polyhouse conditions. M. Sc. Thesis, M.P.K.V., Rahuri, Maharashtra.

Dhiman, M. R., 2003, Assessment of chrysanthemum germplasm for commercial cultivation under Kullu-Valley condition. J. Orn. Hort., **6**(4): 394-396.

Eberhardt, M., 1982, New high yielding and long lasting gerbera varieties. Gartenbau., **29**(10): 314-316.

Ellis, M. B., 1998, *Alternaria chrysanthemi*. IMI Descriptions of Fungi and Bacteria, (17): Sheet 164.

Eswarappa, V., Vijaya Kumar, K. T. and Varsha rani, H., 2011, Inheritance study and identification of RAPD marker linked to alternaria blight resistance in sesame (*Sesamum indicum* L.). J. Current Biotica., **4**(4) : 453-457.

Gaikwad, A. M. and Patil, S. S., 2001, Evaluation of chrysanthemum germplasm for commercial cultivation under Kullu-Valley conditions. J. Orn. Hort., **6**(4): 95-97.

Guruprasad, G., 1999, Effect of time of planting on growth, flowering and vase life studies in China aster (*Callistephus chinensis* Nees.). M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad.

Hanson, W. D., 1963, Heritability. Symp. Statist. Genet. Pt. Br., Raleigh, Cardina, pp : 425-430.

Hegde, V, M., 1988, Studies on leaf blight of Chrysanthemum (*Chrysanthemum morifolium* Ramat) caused by *Alternaria tenuissima* (Fries) Wiltshire, M. Sc. (Agri), Thesis, Univ. Agric. Sci., Dharwad, India.

Hiremath, P, C., Kulkarni, M. S. and Lokesh, M. S., 1990, An Epiphytotic of alternaria leaf blight of sunflower in Karnataka. Karnataka J. Agri. Sci., **3**: 277-278.

Horn, W., Wricke, G. and Weber, W. E., 1974, Genotypic and environmental effects on characters expression in *Gerbera jamesonii*. Gareten bauwissenssenschaft, **39**(3): 289- 300.

Howe, T. K. and Waters, W. E., 1990, Evaluation of marigold cultivars as bedding plants, spring fall. Proceedings of the Florida State Horticultural Society, **103**: 332- 337.

Ishiba, C, Yokoyama, T and Tani, T., 1982, Black spot disease of stevia caused by *Alternaria steviae* Ann. Phytopath. Soc, Japan, **48**: 1, 44-51.

Janakiram, T. and Rao, T. M., 1991, Genetic improvement of marigold. In Floriculture Technology, Trade and Trends. Ed. Prakash, J and Bhandary, K. R., Oxford and IBH Company Private Limited, New Delhi, pp. 331-335.

Jawaharlal, M., Rajamani, K., Sundharam, S. K. and Balakrishnamurthy, G., 1998, Evaluation of gerbera genotypes for certain floral characters, flower yield and vaselife. S. Indian Hort., **46:** 291-293.

Johnson, H. W., Robinson, H. F. and Comstock, R. E., 1955, Estimates of genetic and environmental variability in soyabeans. Agron. J., **47**: 314-318.

Joshi, M., Verma, L. R. and Masu, M. M., 2009, Performance of different varieties of chrysanthemum in respect to growth, flowering and flower yield under north Gujarat condition., The Asian J. Hort., **4**(2): 292-294.

Kale, S. M. and Ajjappalavara, P. S., 2014, Evaluation of onion genotypes against purple blotch (*Alternaria porri*). Asian J. Hort., **9**(1): 274-275.

Kannan, M. and Ramdas, S., 1990, Variability and heritability studies in gerbera. Prog. Hort., **22**: 72-76.

Kanwar, P. S. and Saha, T. N., 2006, Genetic variability, heritability and genetic advance in French marigold (*Tagetes patula* L.). Indian J. Plant. Genet. Res., **19**(2): 206-208.

Karlatti, R. S and Hiremath, P. C., 1989, Seed borne nature of leaf and inflorescence blight in marigold and its host range. Curr. Res. **18**(12):180-181.

Kavitha, R and Anburani, A., 2010, Genetic variability in African marigold (*Tagetes erecta* L.). Asian. J. Hort., **5**(2): 344-346.

*Kolte, S. J. and Mukhopadhyay, A. N., 1973, Occurrence of some new sunflower disease in India. Pesticides Abstracts and News Summary, **19**: 392-396.

Kopaoki, M and Wagner, A., 2003, Health status of garden mums (*Dendranthema grandiflora* Tzvelev) in Lubin Region, Sodininkyste-ir-Darzininkyste., **22** (3): 83-90.

Kulkarni, B. S. and Reddy, B. S., 2004, Vegetative growth, flower yield and quality of different chrysanthemum cultivars. J. Orn. Hort., **7**(3-4): 32-36.

Kulkarni, B. S. and Reddy, B. S., 2006, Vegetative growth and flower yield as influenced by different cultivars of China aster. Haryana J. Hort. Sci., **35** (3-4): 269.

Kulkarni, B. S., 2003, Evaluation of varieties and effects of planting date and growth regulators on the performance of chrysanthemum (*Dendranthema indicum*). Ph. D. Thesis, Univ. Agric. Sci., Dharwad.

Kumar H. R. and Patil, V. S., 2003, Genetic variability and character association studies in China aster (*Callistephus chinensis*) genotypes. J. Orn. Hort., **6**(3): 222-228.

Laxmi, P., Pratap, M. and Reddy, S. A., 2008, Evaluation of yellow coloured chrysanthemum (*Dendranthema grandiflora* L.) cultivars for growth, flowering and yield. Orissa J. Hort., **36**(1): 116-119.

Lhoste, A., 2002, Cut gerbera: Varietal experiments in Mediterranean climate. PHM– Revue– Horticole, **435**: 24-27.

Li, Y., Zhang, D., Xu, W., Wu, Z., Guo, M. and Cao, A., 2011, *Alternaria tenuissima* causing leaf spot and fruit rot on pepper (*Capsicum annum*): first report in China. New Dis. Rep., **24**: 3.

Lipps, P. E. and Herr, L, J., 1986, Reaction of *Helianthus annuus* and *Helianthus tuberosus* plant introductions to *Alternaria helianthi*. Plant Disease, **70**: 831-835.

Madalagi, A, A., 2014, **S**tudies on leaf spot disease of chrysanthemum caused by *Alternaria alternata* (Keissler) and *Cercospora chrysanthemi* (Hd.wolf) M.Sc. (Hort.) Thesis, Uni. Hort. Sci., Bagalkot.

Magar, S. D., Warade, S. D., Nalge, N. A. and Nimbalkar, C. A., 2010, Performance of gerbera (*Gerbera jamesonii*) under naturally ventilated polyhouse condition. Int. J. Pl. Sci., **5**(2): 609-612.

Mallikarjun, G., 1996, Studies on *Alternria alternata* (Fr.) Keissler a causal agent of leaf blight of turmeric (*Curcuma longa* L.). M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India).

Mangala, U. N., Subbarao, M. and Ravindrababu, R., 2006, Host range and resistance to *Alternaria alternata* leaf blight on chilli. J. Mycol. Pl. Pathol., **36**(1): 84-85.

Mathad, G., Hegde, L., Reddy, B. S. and Mulge, R., 2003, Genetic variability, heritability and genetic advance in African marigold. The Karnataka. J. Hort., **1**(3): 37-42.

Mathur, S. J., Prasad, N., Agarwat, J. M. and Chipa, H. P., 1978, Estimation of losses due to alternaria blight of sunflower. Indian J. Mycol. Pl. Path., **8**: 15.

Mesta, R. K., Sunkad, G., Katti, P. and Shankergoud, I., 2005, Evaluation of sunflower germplasm against alternaria leaf blight and rust diseases. Agricultural Sciences Digest, **25**:221-222.

Mishra, R. L. and Saini, H. C., 1997, Genotypic and phenotypic variability in dahlia (*Dahlia variabilis*). Indian J. Hort., **17**: 148-152.

Mishra, R. L., Verma, T. S., Thakur, P. C. and Singh, H. B., 1987, Variability and correlation studies in dahlia. Indian J. Hort., **44**(3-4): 269-273.

Morris, J. B., Yang, S. M. and Wilson, L., 1983, Reaction of *Helianthus species* to *Alternaria helianthi*. Plant Disease, **67**: 539-540.

Mukewar, P. M., Lambat, A. K., Ramanath, Mujumbdar, R. A., Indra, R. and Jagadishchandra, K., 1974, Blight disease of sunflower caused by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara in India. Curr. Sci., **423**: 346-347.

Munikrishnappa, P. M., Patil, A. A., Patil, V. S., Patil, B. N., Channappagoudar, B. B. and Alloli, T**.** B., 2011, Studies on the growth and yield parameters of different genotypes of China aster (*Callistephus chinensis* Nees.), Karnataka J. Agric. Sci., **26** (1): 107-110.

Nagaraju, Janardhana, A., Puttarangaswamy, K. T. and Channakrishnaiah, K. M., 1994, Evaluation of sunflower population and hybrids against leafspots caused by *Alternaria helianthi.* Current Research, **23**: 115-116.

Nagrale, D. T., 2007, Studies on blight of gerbera (*Gerbera jamesonii* Hook.). M.Sc. (Agri.) Thesis, M.P.K.V., Rahuri.

Nagrale, D. T., Gaikwad, A. P., Goswami, S. and Sharma, L., 2012. Fungicidal management of *Alternaria alternata* (Fr.) Keissler causing blight of gerbera (*Gerbera jamesonii).* J. Appl. & Nat. Sci., **4**(2): 220-227.

Naik, B. H., Basavaraj, N. and Patil, V. S., 2004, Correlation studies in China aster (*Callisthephus chinensis* Ness.) genotypes. J. Orn. Hort., **7**(3-4) 81-86.

Naik, H. B., Chauhan, N., Patil, A. A., Patil, V. S. and Patil, B. C., 2006, Comparative performance of Gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) cultivars under naturally ventilated polyhouse. J. Orn. Hort., **9**(3): 204-207.

Nalawadi, U. G., 1982, Nutritional studies in some varieties of marigold (*Tagetes erecta* L.) *Ph D.* Thesis, Univ. Agric. Sci., Bengaluru.

Nalawadi, U. G., Narayanagouda, J. V., Ahmed, I. M. and Sulladamath, U. V., 1980, Vase life studies in some varieties of gerbera *(Gerbera jamsoni)*. Lal Baugh, **25**(4): 14-15.

Narain, A. and Saksena, H. K., 1973, Occurrence of alternaria leaf spot of sunflower in India. Indian J. Mycol. Pl. Path., **3**: 115 - 116.

Nargund, V. B. and Nazeer, A. N., 1994, Sunflower diseases and their management. National Training Courses on Sunflower Production Technology, Director of Extension, Govt. of India, New Delhi, pp.77-78.

Narsude, P. B., Kadam, A. S. and Patil, V. K., 2010, Studies on the growth and yield attributes of different African marigold genotypes under Marathwada conditions. The Asian J. Hort., **5**(2): 284-286.

Negi, S. S. and Janakiram. T., 1990, *Annual Report.* IIHR., Bengaluru.

Negi, S. S. and Raghava, S. P. S., 1982, Improvement of aster through breeding. *Annual Report.* IIHR., Bengaluru.

Negi, S. S. and Raghava, S. P. S., 1985, Improvement of chrysanthemum and China aster through breeding. Annual Report. IIHR., Bengaluru.

Negi, S. S., raghava, S. P. S., sharma, T. V. R. S. and Srinivasan, V. R., 1983, Studies on variability and correlation in China aster *(Callistephus chinensis* Nees.). Indian J. Hort., **40**: 102-106.

Pal, K. and Kumar, J., 2010, Study on genetic variability, heritability and genetic advance in African marigold (*Tagetes erecta* L.) under Meerut region. Prog. Hort., **10**(3): 144-149.

Panse, V. G. and Sukhatme, P. V., 1967, Statistical methods for agricultural workers, ICAR. New Delhi.

Paraneetha, S., 2006, Performance of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) genotypes at Shervaroy hills of Tamil Nadu. J. Orn. Hort., **9**(1): 55 57.

Parthasarathy, V. A. and Nagaraju, V., 2003, Evaluation of gerbera under mid hills of Meghalaya. J. Orn. Hort., **6**(4): 376-380.

Patil, S. S. D. and Rane, D. A., 1995, Studies on heritability estimates in China aster. J. Maharastra Agric. Univ., **20**(1): 137-138

Patil, V., Kulkarni, B. S., Reddy, B. S., Kerure, P. and Ingle, A., 2011, Yield and quality parameters as influenced by seasons and genotypes in marigold (*Tagetes erecta* L.). Res. J. Agric. Sci., **2**(2): 344-347.

Phapale, A. D., Solanky, K. U., Tayade, S. C. and Sapkale, P. R., 2010, Screening of fungicides against okra leaf spot under laboratory condition. Int. J. Plant Protec., **3**(2): 282-284.

Ponnuswami, V., Chezhiyan, N., Thambhuraj, S., Abdulkhadar, M. D. P. and Pangswami, P., 1985, Genetic variability in chrysanthemum. South Indian Hort., **33**(4): 211-213.

Poornima, G., Kumar, D. P., and Seetharamu, G. K., 2006, Evaluation of China aster (*Callestephus chinensis* (L.) nees) genotypes under hill zone of Karnataka. J. Orn. Hort., **9**(3): 208-211.

Rachappa, K., 2014, Studies on genetic variability and molecular characterization in China aster. M.Sc. (Hort.) Thesis, U. H. S., Bagalkot.

Raghava, S. P. S. and Negi, S. S., 1994, Genetic analysis of various quantitative traits in China aseter (*Callisthephus chinensis* Ness.). Indian J. Hort. **51**(1): 106-110.

Raghuvanshi, A. and Sharma, B. P., 2011, Varietal evaluation of French marigold (*Tagetes patula L.*) under mid-hill zone of Himachal Pradesh. Prog. Agric. **11** (1): 123-126.

Raja, P., Reddy, A. V. R. and Allam, U. S., 2005, First report of *Alternaria tenuissima* causing leaf spot and fruit rot on eggplant (*Solanum melongena*) in India. New Dis. Rep., **12**: 31.

Rajivkumar and Singh, S. B., 1996, Influence of weather factors on alternaria leaf spot development in sunflower. Indian Journal of Mycology and Plant Pathology, **26**: 196-198.

Rajivkumar, R., Yadav, D. S. and Roy, A. R., 2007, Performance of chrysanthemum (*Dendrathema grandiflora* Tzvelcv.) cultivars under subtropical midhills altitude of Meghalaya. Environ. Ecol., **255**(34): 941-944.

Ramjegathesh, R. and Ebenezar, E. G., 2012, Morphological and physiological character of *Alternaria alternata* causing leaf blight disease of onion. Int. J. Plant Pathol., **3**(2) : 34- 44.

Ranganatha, H. M., Shreekanth S. P., Manjula, S. M. and Arvindkumar, B. N., 2012, Genetic Variability Studies in Segregating Generation of Upland Cotton. Molecular Plant Breeding. **4**(10): 84-88.

Ranganatha, A. R. G., Reddy, A. V. V., Sujatha**,** M., Sudhakarbabu, S. N., Prayaga, L., Basappa, H., Rao, S. C. and Nagaraj, G., 2003. Diversification of parental base and development of elite lines, population, varieties and hybrids. DOR Annual Report 2002-03, Directorate of Oilseeds Research, Hyderabad, p. 8-11.

Rao, C. R. C., Veeranna, P., Reddy, M. R. and Padmaja, G., 2005, Screening of African marigold (*Tagetes erecta* L.) cultivars for flower yield and carotenoid pigments. Indian J. Hort., **62**(3): 276-279.

Rao, M. T. 1982, Studies on genetic variability and correlation in China aester (*Callisthephus chinensis* Ness.). M. Sc. (Hort.) Thesis Univ. Agril. Sci., Bangalore.

Rao, T. M. and Negi, S. S., 1990, Heritable components of biometric characters in China aster. Floriculture Technology, Trade and Trends, Ed. Prakash, J. and Bhandary, K. R., Oxford and 18H Co. Pvt. Ltd.. New Delhi, pp. 318-321.

Rao, T. M., Negi, S. S., Janakiram, T. and Raghava, S. P. S., 1996, 'Kamini'- A new China aster cultivar from IIHR, Flori. Today, pp. 40-41.

Rao, V. G., 1965, *Alternaria tenuis* Auct. in Bombay Maharastra Mycopath. Mycol. Appl., **27**: 257-264.

Ravikumar, 2002, Evaluation of China aster (*Callistephus chinesis* (L.) Nees) genotypes under transitional zone of north Karnataka. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad.

Ravikumar, R. L., Doddamani, I. K., and Kulakarni, M. S., 1995, Reaction of selected germplasm lines and *Helianthus tuberosus* derived introductions to *Alternaria helianthi*. Helia, **18**: 67-72.

Reddy, C. V. C. M., Reddy, A. V. V., Sinha, B. and Shantha Lakshmi, M., 2006, Screening of sunflower genotypes for resistance to against alternaria blight. Asian J. of Plant Sci., **5(**3): 511-515.

Robinson, H. F., Comstock, R. E. and Harvey, P. M., 1949, Estimates of heritability and degree of dominance in corn. Agron. J., **41**: 353-359.

Rohringer, R. and Samborski, D. J., 1967, Aromatic compounds in the host parasite interaction. Annual Review of Phytopathology, **5**: 77-86.

Sackston, W. E., 1988, First report of *Alternaria helianthi* on sunflower in Canada**.** Pl. Dis, **72**: 801.

*Saini, R. S., Arora, Y. K., Chawala, H. K. L. and Wagle, D. S., 1988, Total phenols and sugar content in wheat cultivars resistant and susceptible to *Ustilago nuda* (Jens.) Rostrup. Biochemi and Physiologie der Pflanzen, **183**: 89-93.

*Schmidt, 1965, A fungal leaf spot disease of Chrysanthemum caused by *Alternaria chrysanthemi* sp. nov. P. flanzenchutz. **21**: 13-20.

Shahi, H. P. S. and Shyam, K. R., 1993, Occurrence of alternaria leaf spot on tomato in Himachala Pradesh a new record. Plant Dis. Res., **8**: 140-141.

Shane, W. W., Baumer, J. S. and Sederstrom, S. G., 1981, *Alternaria helianthi*, A pathogen of sunflower new to Minnesota. Pl. Dis, **64**: 269-271.

Shashikala, B., Maharana, T. and Jagadev, P. N., 1995, Genetic variability and character association in dahlia. J. Trop. Agril., **33**(1): 20-25.

Shin, H. K., Kim, J. Y., Shin, R. W. and Ko, J. Y., 1994, Seasonal fluctuation on yield and quality of cut flowers in gerbera hybrids. RDA J. Agric. Sci., **36**: 444-452.

Shivakumar, 2014, Evaluation of marigold (*Tagetes erecta* L.) genotypes under hill zone of Karnataka. M. Sc. (Hort.) Thesis, Univ. Agric. Hort. Sci., Shivamogga.

Shivakumar, M. 2008, Evaluation of segregating population for productivity and rust resistance in soyabean. M. Sc. (Hort.) Thesis, Uni. Agri. Sci., Dharwad.

Shivasubramanian, S. and Menon, N., 1973, Heterosis and inbreeding depression in rice. Madras Agric. J., **60**: 1139-1144.

Singh and Sen, N. L., 2000, Genetic variability, heritability and genetic advance in marigold. J. Orn. Hort., (New series), **3**(2): 75-78.

Singh, B. and Srivastava, R., 2008, Varietal evaluation of gerbera as influenced by growing conditions. J. Orn. Hort., **11**(2): 143-147.

Singh, D. and Singh, A. K., 2005, Correlation and path coefficient analysis in marigold (*Tagetes spp*). Prog. Hort., **37**(2): 385–388.

Singh, D. and Singh, A. K., 2006, Characterization of African marigold (*Tagetes erecta* L.) genotypes using morphological characters. J. Orn. Hort., **9**(1): 40-42.

Singh, D., Kumar, S., Singh, A. K. and Kumar P., 2008, Assessment of African marigold (*Tagetes erecta*) genotypes in Uttarakhand. J. Orn. Hort., **11**(2): 112-117.

Singh, K. P. and Saha, T. N., 2006, Genetic variability, heritability and genetic advance in French marigold (*Tagetes patula* L.). Ind J. Pla. Gen. Res., **19**(2): 42-43.

Singh, K. P. and Sangama, 2002, Influence of cultivars and flower stalk length on vase life of gerbera. Floriculture research trend in India. Proceedings of the national symposium on Indian floriculture in the new millennium, Lalbagh, Bengaluru, 25-27 Feb, 324-325.

Singh, R. K., 2003, Variability studies in dahlia for some quantitative traits. J. Orn. Hort., **7**(1): 58-60.

Singh, S., Rameshkumar and Poonam, 2008, Evaluation of chrysanthemum open pollinated seedlings for vegetative and floral characters. J. Orn. Hort., **11**(4): 271-274.

Siroshi, P. T. and Behera T. K., 2000, Genetic variability in chrysanthemum. J. Orn. Hort., (New series), **3**(1): 34-36.

Smita, R., Jha, A. K., Lal, H. C. and Ojha, K. L., 1998, Reaction of different cultivars of sunflower and hosts against *Alternaria alternata.* J. App. Biol., **8**(2): 43-45.

*Sobers, E. K., 1965, *Alternaria chrysanthemi* Simmons and Crosier in Florida. Proc. Fla. Sta. Hort. Soc., **78**: 419-422.

Sreenivasulu, G. B., Kulkarni, B. S., Reddy, B. S., Adiga, J. D. and Thammaiah, N., 2004, Evaluation of China aster genotypes against alternaria leaf spot under field conditions. J. Orn. Hort., **7**(3-4): 345-346.

Srinath, K. V. and Sarwar, M., 1965, alternaria blight of pyrethrum. Curr. Sci., **34**: 295.

Srinivas, P. T. and Narayanagowda, J. V., 1995, Genetic variability in dahlia. Crops Res., **9**(3): 358-362.

Tabuki, K. and Nishihara, N., 1969, *Alternaria helianthi* (Hansf.) Comb. nov. Trans. Br. Mycol. Soc, **53**: 147-149.

Taj, A., 2012, Performance of gerbera (*Gerbera jamesonii* Hook.) genotypes under protected cultivation. M. Sc. (Hort.) Thesis, Univ. Hort. Sci., Bagalkot.

Talukdar, M. C., Mahanta, S., Sharma, B. and Das, S., 2003, Extent of genetic variation for growth and floral characters in chrysanthemum cultivars under Assam condition. J. Orn. Hort., **6**(3): 201-211.

Thammaiah. N., Kulkarni, B. S., Sathyanarayana Reddy, B. and Kulkarni, M. S., 2004, Screening of chrysanthemum cultivars against alternaria leaf spot disease under natural conditions. J. Orn. Hort., **7**(3-4): 345-346.

Thangaraj, T., Rajamani, K. and Thamburaj, S., 1990, A study on the vase life of gerbera (*Gerbera jamesonii* Bolur). S. Indian Hort., **38**: 265-267.

Theerthaprasad, D. and Shambulingappa, K. G., 1986, Biochemical factors in *Helianthus annus* L. in relation to rust (*Puccinia helianthi*) resistance. Journal of Oilseeds Research, **3**: 268-269.

Thomas, C. E., McCreight, J. D. and Jourdain, E. L.,1990, Inheritance of Resistance to *Alternaria cucumerina* in *cucumis melo* Line MR-1. Plant Dis. **74**: 868-870.

Tirakannanavar, S., Chavan, M., Devappa, V., Reddy, B. S. and Laxman Kukanoor, 2004, A study on seed quality parameters in different genotypes of China aster (*Callistephus chinensis* L. Nees). J. Orn. Hort., **7**(3-4): 125- 127.

Tryphone, G. M., Chilagane, L. A., Kusolwa, P. M., and Msolla, S. N., 2012, Inheritance of angular leaf spot resistance in common bean population developed from Kablanketi × Mexico 54. J. Agric. Sci. & Tech., **2**: 856-862.

Tsukamoto, Y., Imanishi, H. and Yakara, H., 1971, Studies on flowering in marigold II. Interaction among day length, temperature, light intensity and growth regulators. J. Japanese Society Hort. Sci., **40**(4): 401-406.

Vasudevan, V. and Rao, V. K., 2010, Evaluation of gerbera *(Gerbera jamesonii* Bolus ex Hooker F.) genotypes under mid hill conditions of Garhwal Himalaya. Abstract published in National symposium on lifestyle floriculture: challenges and opportunities held at the Dr. Y.S. Paramar University of Horticulture and Forestry, Nauni, Solan. pp: 19.

*Velanzhahan, R. and Narayanaswamy, P., 1994, Resistance in sunflower genotypes to rust and leafspot. The Madras Agricultural Journal, **81**: 43-44.

Velanzhahan, R., Narayanaswamy, P. and Jeyarajan, R., 1991, Evaluation of sunflower germplasm for field resistance to *Alternaria helianthi*. The Madras Agricultural Journal, **78:** 143-144.

Vergora, J., 1984, Study of gerbera varieties in the American sand culture system under cover. Boletin Informativo Centro de Investigation of Disarollo Hortico, **8:** 69-77.

Vijayalaxmi, P., 1998, Evaluation of dwarf marigold *(Tagetes patula* L.) varieties under northern transitional tract of Karnataka. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad.

Vikas, H. M., Patil, V. S., Agasimani, A. D and Parveenkumar, D. A., 2011, studies on genetic variability in dahlia (*Dahlia variabilis* L.). Int. J. Sci. Nature., **2**(2): 372-375.

Waals, J. E. V., Pitsi, B. E., Marais, C. and Wairuri, C. K., 2011, First report of *Alternaria alternata* causing leaf blight of potatoes in South Africa. American Phytopathol. Soc., **95**(3): 363.

*Wheeler, B. E. J., 1969, An Introduction to Plant Diseases. John willey and Sons Ltd., London, pp: 301.

Yadav, O. P., Dabbas, M. R. and Gaur, L. B., 2014, Screening of tomato advancedlines, genotypes against *Alternaria solani*. J. Plant Archives., **14**(1): 553-555.

Zimmer, K., 1989, Photoperiodic response of petunias and *Tagetes*. Deutscher Gartenbau. **4**(15): 961-963.

Zosiamliana, J. H., Reddy, G. S. N. and Rymbai, H., 2012, Growth, flowering andyield characters of some cultivars of China aster (*Callistephus chinensis* Nees.). J. Nat. Prod. Plant Resour., **2**(2): 302-305.

* Originals not seen

Appendix I. Meteorological data as recorded during the period of January, 2015 to December, 2015 at Agricultural Research Station, Arabhavi

Month	Temperature ^{0}C		RH%	Rainfall (mm)	No. of Rainy days	Evaporation (mm)
	Maximum	Minimum				
January	28.45	18.85	88.50	0.00	0.00	4.20
February	31.90	18.10	87.50	0.00	0.00	4.20
March	34.10	18.05	95.00	2.00	2.00	3.30
April	36.80	20.20	82.10	22.00	1.00	3.40
May	38.00	22.70	85.50	108.80	3.00	4.60
June	31.40	21.20	85.50	69.50	6.00	3.90
July	31.10	20.70	84.50	7.90	1.00	4.30
August	30.90	19.90	88.30	33.70	4.00	7.40
September	31.90	18.90	89.40	53.70	3.00	4.60
October	34.60	18.30	89.90	53.30	4.00	3.90
November	30.90	14.30	87.00	30.90	1.00	4.20
December	28.00	19.00	90.00	28.00	2.00	3.00
Total	**388.05**	**230.2**	**1053.2**	**409.8**	**27.00**	**51.00**

Appendix II. Values of 22 characters in F_2 population of AAC-1 x Arka Kamini

Plant No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	45.65	15	154	1.25	4520.8	20.6	28.3	18	25.3	6.5	2.5	4	50	61	76	32	4.2	42	75.6	8.39	55.75	7
2	38.36	12	127	1.15	3580.85	17.5	25.6	12	23.2	6	2.8	3.2	49	55	76	30	5.2	52	62.4	6.93	20.8	9
3	44.35	15	138	1.24	3980.85	21.8	22.8	17	21.5	4	2	2	52	59	78	33	3.2	32	54.4	6.04	24.8	7
4	58.65	17	212	1.52	5820.25	26.5	30.2	28	32.8	5.4	2.1	3.3	48	54	74	29	4.5	45	126	13.99	22.6	8
5	59.86	20	225	1.6	6282.84	25.8	38.1	30	32.6	7	1.8	5.2	54	61	81	31	3.6	36	108	11.99	17.5	7
6	61.5	23	231	1.62	6853.4	27.8	34.3	29	35.8	5.5	1.7	3.8	42	53	79	29	4.9	49	142.1	15.78	37.8	6
7	45.49	12	153	1.42	4525.25	18.1	25.2	15	20.1	6	2.1	3.9	54	62	81	33	3.8	38	57	6.33	9.28	7
8	52.53	20	198	1.53	5280.65	21.6	32.8	17	32.8	5.5	2.51	2.99	51	60	80	32	4.2	42	71.4	7.93	18.24	9
9	50.53	18	170	1.5	5025.52	19.53	28.6	16	27.4	5.8	2.2	3.6	48	57	81	28	5.3	53	84.8	9.42	21.23	5
10	46.15	13	159	1.4	4625.25	17.8	28.1	15	25.8	4.5	2.5	2	51	61	82	30	4.5	45	67.5	7.49	39.2	6
11	55.32	22	198	1.52	5352.55	23.6	31.7	25	32.2	5	2.1	2.9	52	62	80	32	5.8	58	145	16.1	24.2	7
12	60.7	25	200	1.63	6073.2	25.43	35.2	28	38.3	6	2.4	3.6	46	52	78	29	4.8	48	134.4	14.93	19.7	5
13	57.53	12	216	1.45	5750.5	22.5	33.8	23	36.5	3.5	1.6	1.9	55	60	81	33	4.5	45	103.5	11.49	20.1	6
14	41.8	11	135	1.21	4180.81	19.4	25.2	18	25.2	4.8	1.8	3	47	57	79	28	5.12	51.2	92.16	10.23	52.5	8
15	46.5	14	162	1.2	4620.25	18.8	30.8	20	26.7	5.1	2.2	2.9	49	52	75	30	5.8	58	116	12.88	22.5	7
16	53.62	17	195	1.35	5280.82	23.5	32.7	22	32.5	5.3	2.3	3	51	60	81	32	5.2	52	114.4	12.71	23.5	8
17	56.43	12	203	1.4	5670.78	26.3	36.1	32	34.7	5.8	2.4	3.4	53	63	75	33	5.5	55	176	19.55	20.1	7
18	48.85	15	172	1.15	4870.72	20.2	25.4	18	25.3	4.3	1.8	2.5	48	57	77	31	4.9	49	88.2	9.79	17.2	6
19	40.62	13	132	1.02	3880.87	17.3	24.9	15	22.5	5.3	2.5	2.8	49	55	79	29	4.6	46	69	7.66	19.2	7
20	44.86	12	140	1.18	4475.75	19.5	26.2	13	24.86	6	2.2	3.8	51	62	80	30	5.9	59	76.7	8.52	54.8	9
21	55.36	20	209	1.75	5580.85	25.8	35.5	20	38.2	7.2	2.7	4.5	47	59	75	35	4.6	46	92	10.22	21.2	7
22	59.7	22	229	1.81	6820.25	27.5	32.8	25	37.5	6.2	2.1	4.1	46	55	78	27	3.42	34.2	85.5	9.49	14.27	8
23	51.85	18	192	1.75	6225.85	23.1	35.1	20	31.8	6.1	1.9	4.2	49	55	80	32	4.36	43.6	87.2	9.68	20.54	7
24	47.58	15	160	1.79	5850.25	17.5	28.2	23	27.5	4.2	2.3	1.9	50	51	72	30	3.78	37.8	86.94	9.65	22.1	6
25	56.3	19	196	1.65	5635.45	23.5	31.8	20	32.6	5.1	2.1	3	48	54	75	29	5.8	58	116	12.88	45.9	7
26	45.7	11	142	1.3	4230.5	18.4	27.4	17	26.7	6.5	1.8	4.7	51	59	79	31	4.5	45	76.5	8.49	18.9	6
27	54.5	20	220	1.8	6380.85	21.2	34.1	22	25	5.7	1.7	4	49	58	81	29	5.6	56	123.2	13.68	54.3	8
28	56.8	24	218	1.32	5680.75	22.54	35.2	20	30.5	5.5	2.5	3	45	55	79	35	4.8	48	96	10.66	22.8	7
29	52.2	18	196	1.79	7520.85	18.8	35.8	32	27.5	6	2.3	3.7	47	54	79	30	5.2	52	166.4	18.48	23.7	7
30	55.75	21	205	1.3	5580.85	25.3	33.52	22	32.7	5.9	2.1	3.8	55	57	75	28	4.4	44	96.8	10.75	23.7	8

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
31	54.4	18	198	1.25	5420.35	22.1	34.89	20	33.8	6.28	2.5	3.78	51	60	79	29	5.5	55	110	12.22	19.2	7
32	39.6	10	132	1.02	3950.58	17.4	25.6	19	22.6	7	1.98	5.02	51	59	78	31	4.62	46.2	87.78	9.75	32.5	6
33	44.9	12	153	1.1	4480.85	18.5	22.1	18	28.36	6.15	2.3	3.85	42	50	71	32	4.2	42	75.6	8.39	17.7	7
34	52.2	17	175	1.2	5280.85	22.8	32.7	21	35.7	5.78	2.7	3.08	48	52	73	35	3.6	36	75.6	8.39	18.7	9
35	58.7	21	196	1.45	5520.2	26.5	29.7	25	38.5	6.12	2.4	3.72	49	60	75	30	4.6	46	115	12.77	15.8	8
36	41.1	12	143	1.15	3046.8	18.9	25.3	10	25.3	5.29	2.6	2.69	44	52	70	28	4.7	47	47	5.22	48.2	7
37	58.3	18	210	1.7	6058.3	27.3	32.3	23	27.8	6.1	1.8	4.3	42	52	73	31	5.4	54	124.2	13.79	18.3	6
38	43.8	13	154	1.4	4352.4	18.4	28	18	28.5	6.2	3	3.2	42	51	78	32	4.9	49	88.2	9.79	43.2	8
39	48.4	15	176	1.2	4850.5	20.5	30.2	17	30.2	6.5	2.5	4	48	55	75	33	5.2	52	88.4	9.82	20.6	7
40	53.32	20	195	1.42	5320.52	21.7	32.8	29	36.6	7	1.9	5.1	49	57	82	27	5.1	51	147.9	16.43	18.2	7
41	44.53	11	164	1.21	4481.82	18.5	20.5	15	25.5	5.2	3.1	2.1	45	55	78	30	5.9	59	88.5	9.83	22.8	8
42	45.2	14	135	1.1	3872.75	20	23.7	18	24.3	5.3	2.6	2.7	48	55	77	29	4.3	43	77.4	8.59	20.5	7
43	43.25	13	130	1.05	3078.78	17.2	20.1	15	26.2	6.5	2.2	4.3	48	53	74	28	3.6	36	54	5.99	22.5	6
44	47.7	14	135	1.21	3952.82	18.5	24.3	12	32.7	6.3	2.8	3.5	49	59	75	31	5.6	56	67.2	7.46	18.9	7
45	42.5	15	122	1.32	4250.5	18.5	22.8	18	25.76	6.7	1.8	4.9	45	55	79	33	3.2	32	57.6	6.39	37.28	9
46	55.6	20	201	1.52	5850.58	19.6	28.2	23	33.7	5.2	2.3	2.9	43	53	82	29	4.2	42	96.6	10.73	20.8	7
47	45.9	15	136	1.45	4520.52	16.4	22.7	15	29.5	5.5	2.5	3	45	57	78	30	4.7	47	70.5	7.83	24.9	9
48	52.5	20	196	1.62	5270.75	25.8	35.2	21	32.5	6.2	2.8	3.4	48	58	78	31	4.1	41	86.1	9.56	12.3	7
49	43.8	12	135	1.02	4358.95	19.5	27.2	17	26.3	6	1.9	4.1	48	55	76	28	5.4	54	91.8	10.19	34.5	8
50	41.6	11	128	1.12	3670.89	17.5	21.7	20	23.5	5.8	2.1	3.7	45	56	78	30	4.8	48	96	10.66	20.8	7
51	42.5	14	132	1.14	3845.8	18.9	26.2	13	20.6	5.6	2.8	2.8	49	59	82	32	4.5	45	58.5	6.49	37.5	6
52	45.7	16	145	1.02	4520.52	20.8	27.8	18	22.6	5.8	2.3	3.5	45	55	82	35	3.9	39	70.2	7.79	23.9	7
53	53.2	22	193	1.52	5350.45	24.5	36.2	22	38.5	4.5	1.8	2.7	48	58	80	33	4.7	47	103.4	11.48	19.8	9
54	41.3	12	125	1.25	2640.2	19.8	22.1	21	26	5.1	2.1	3	47	58	78	35	5.2	52	109.2	12.13	18.6	6
55	47.6	17	164	1.23	3870.72	20.8	29.6	15	27.5	6.2	2.7	3.5	48	55	73	26	4.1	41	61.5	6.83	21.8	8
56	49.3	19	171	1.1	4920.5	21.2	30	19	23.5	4.8	3.1	1.7	45	52	72	28	4.8	48	91.2	10.13	20.1	6
57	46.1	18	165	1.05	4620.8	20.2	23.6	17	23.8	5.5	2.4	3.1	55	61	75	31	5.3	53	90.1	10.01	37.4	7
58	50.4	20	189	1.5	5058.2	23.2	33	21	36.3	6.2	2.7	3.5	47	58	79	29	5.5	55	115.5	12.83	23.8	5
59	59.3	25	215	1.62	6352.8	27.2	35.4	23	35.2	5.8	2.2	3.6	53	53	82	30	4.9	49	112.7	12.52	19.2	6

Plant no	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
60	51.2	20	198	1.65	6210.5	21.6	32.8	25	32.5	6.5	1.9	4.6	50	58	71	33	5.5	55	137.5	15.27	45.69	8
61	57.3	22	235	1.85	5320.8	24.7	35.2	21	35.8	7.1	2.9	4.2	45	57	77	31	4.6	46	96.6	10.73	16.2	7
62	53.8	20	195	1.3	6570.8	22.8	31.3	20	34.6	6.3	2.5	3.8	48	59	78	35	5.8	58	116	12.88	24.9	7
63	48.3	18	146	1.15	4850.8	20.6	28.9	18	23.7	5.8	2.3	3.5	50	58	75	33	4.3	43	77.4	8.59	22.5	8
64	53.2	20	198	1.2	3450.8	23.2	23.2	15	32.8	4.8	2.7	2.1	49	57	77	31	5.8	58	87	9.66	32.54	7
65	45.8	15	125	1.12	4540.45	18.5	22.9	18	22.7	6.2	2.25	3.95	45	55	76	32	4.8	48	86.4	9.59	22.8	6
66	49.3	19	131	1.15	4925.45	20.3	32.1	16	25.6	5.8	1.9	3.9	49	57	79	28	5.46	54.6	87.36	9.70	16.9	7
67	45.7	14	125	1.09	4525.5	18.9	33.7	19	23.6	5.2	2	3.2	52	62	80	30	5.65	56.5	107.35	11.92	29.5	9
68	42.5	12	138	1.12	3258.82	17.6	28.8	12	25.3	4.9	2.1	2.8	53	62	82	32	4.7	47	56.4	6.26	22.1	7
69	40.2	11	120	1.12	2890.42	18	26.1	13	23.5	5.2	2.5	2.7	50	59	78	29	3.9	39	50.7	5.63	23.9	8
70	50.3	20	210	1.5	5045.48	20.7	33.1	12	35	6	1.8	4.2	49	59	81	30	5.4	54	64.8	7.19	27.54	7
71	42.5	15	128	1.32	4245.85	20.2	32	23	25.7	6.2	2.9	3.3	49	57	83	32	4.64	46.4	106.72	11.85	35.26	6
72	54.2	21	195	1.05	3648.8	22.6	26	18	27.6	5.9	2.4	3.5	45	57	75	31	3.5	35	63	6.99	23.8	5
73	47.7	15	126	1.2	4742.8	19.4	32.5	12	22.8	6.2	2.1	4.1	54	64	83	29	4.37	43.7	52.44	5.82	53.4	7
74	52.3	20	195	1.8	5289.89	20.8	36.8	22	26.5	6.9	2	4.9	43	51	72	28	4.1	41	90.2	10.02	20.5	9
75	42.5	12	128	1.08	3545.92	17.8	23.6	18	20.5	5.7	2.3	3.4	49	57	78	25	5.43	54.3	97.74	10.85	19.2	7
76	49.7	18	132	1.25	4958.2	19.3	28.9	15	22.5	5.2	2.5	2.7	42	51	73	32	4.53	45.3	67.95	7.54	22.1	8
77	45.2	10	130	1.2	4520.5	20.1	20.3	17	21.5	7	2.9	4.1	45	54	79	25	5.2	52	88.4	9.82	22.5	7
78	52.7	20	215	1.3	5240.2	22.8	29.7	32	31.6	6.5	2.5	4	42	52	76	23	4.5	45	144	15.99	41.2	6
79	50.4	18	205	1.45	5029.59	19.2	28.5	29	33.5	6.25	2.9	3.35	43	53	80	30	5.83	58.3	169.07	18.78	20.8	7
80	46.6	12	145	1.35	4625.52	17.8	26.5	18	27.3	5.8	2.4	3.4	49	59	78	28	3.8	38	68.4	7.59	54.25	7
81	45.3	11	130	1.05	3650.82	17.5	28.2	15	22.5	5.9	1.9	4	46	60	80	31	4.14	41.4	62.1	6.89	18.9	8
82	55.9	25	225	1.6	5532.52	20.8	32.5	35	25.6	6.1	2.5	3.6	40	48	70	32	4.98	49.8	174.3	19.36	44.58	7
83	47.6	15	155	1.42	4782.62	18.6	23.7	15	22.5	6	2.8	3.2	47	58	80	29	5.28	52.8	79.2	8.79	18.53	6
84	48.2	17	168	1.32	3650.8	20	20.45	19	28.2	5.8	2.9	2.9	45	55	81	30	5.1	51	96.9	10.76	21.7	7
85	42.5	15	125	1.45	4280.8	21.5	32	18	21.5	6.2	3	3.2	49	59	79	29	4.2	42	75.6	8.39	19.6	9
86	50.4	20	205	1.5	5032.8	24.7	33	30	32.8	6.3	2.5	3.8	43	53	80	33	5.38	53.8	161.4	17.93	22.8	7
87	40.2	14	135	1.1	2840.52	20	21	20	22.8	6	2.8	3.2	49	59	78	30	4.32	43.2	86.4	9.59	35.2	8
88	49.3	16	186	1.02	3250.8	23.8	21	11	24.6	5.9	2.5	3.4	40	50	62	28	4.83	48.3	53.13	5.90	21.4	7
89	44.4	13	152	1.32	4472.82	19.8	32	15	21.5	5.8	2.6	3.2	48	55	78	25	5.12	51.2	76.8	8.53	17.5	6
90	47.2	17	158	1.37	4782.52	22.8	30	18	23.5	6.2	1.9	4.3	42	52	75	29	4.8	48	86.4	9.59	18.7	6

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
91	43.8	11	128	1.05	3250.8	20	25	12	22.8	6.1	2.8	3.3	40	59	80	30	5.98	59.8	71.76	7.97	20.2	8
92	50.1	18	175	1.4	4820.5	25.3	32	17	32	6	2.9	3.1	49	56	81	32	4.35	43.5	73.95	8.21	24.7	7
93	49.2	14	146	1.52	6150.2	20.1	35	28	25.5	5.9	2.8	3.1	42	52	76	31	3.22	32.2	90.16	10.01	19.9	9
94	55.28	21	183	1.45	5950.25	26.3	28	25	28.2	4.9	2.5	2.4	45	57	77	28	4.35	43.5	108.75	12.08	18.2	7
95	52.7	20	171	1.58	6320.85	21.7	36	38	30.5	5.2	1.9	3.3	48	59	75	32	5.1	51	193.8	21.53	15.8	8
96	49.5	18	145	1.6	6480.85	19.2	33	26	27.2	5.5	2.4	3.1	32	42	56	30	4.8	48	124.8	13.86	36.4	7
97	50.1	18	195	1.45	5048.55	20.5	32	25	22	4.8	2.5	2.3	35	45	55	29	3.2	32	80	8.88	24.5	5
98	39.8	13	135	1.02	3942.82	17.8	20	16	21.5	6.5	2.6	3.9	38	48	60	31	4.8	48	76.8	8.53	21.8	7
99	30.6	10	128	1.2	3045.54	20	22	11	20.8	6	2.8	3.2	49	59	80	33	3.98	39.8	43.78	4.86	19.8	9
100	51.3	18	210	1.45	5120.45	23.5	32	22	32.7	6.4	1.9	4.5	45	54	82	32	4.76	47.6	104.72	11.63	11.28	7
101	48.5	13	157	1.32	4482.15	18.4	33	16	22.7	6.2	2.4	3.8	41	51	71	28	4.1	41	65.6	7.28	23.4	8
102	46.2	12	146	1.29	4230.5	19.3	28	18	20.5	6.3	2.5	3.8	47	57	78	30	4.96	49.6	89.28	9.91	24.7	7
103	46.2	11	130	1.12	3632.8	20	25	15	22.7	6	3	3	45	52	80	32	3.93	39.3	58.95	6.54	19.5	6
104	40.8	10	125	1.08	3480.82	22	27	12	25.6	5.2	2	3.2	47	54	79	33	5.1	51	61.2	6.79	54.3	7
105	45.3	13	130	1.28	4542.8	23.8	30	15	27	5.7	2.4	3.3	45	56	78	29	4.9	49	73.5	8.16	22.9	9
106	50.4	22	195	1.32	5050.82	24.3	32	20	30.5	4.8	2.8	2	42	52	79	24	4.34	43.4	86.8	9.64	21.8	7
107	57.7	25	217	1.52	5782.82	26.9	35	22	32.6	5.2	2.5	2.7	46	52	72	32	4.5	45	99	10.99	21.9	8
108	42.2	18	145	1.35	4280.85	19.5	28	12	22	6.2	2.6	3.6	44	51	67	30	5.1	51	61.2	6.79	38.2	7
109	45.8	13	152	1.2	3728.85	20.2	28	16	25.3	6.5	2.2	4.3	42	53	72	29	4.3	43	68.8	7.64	20.4	6
110	40.6	10	127	1.15	3057.85	17.5	28	14	20.5	6.6	1.9	4.7	49	57	80	31	4.3	43	60.2	6.68	46.3	7
111	45.1	17	138	1.45	4254.88	18.2	32	15	22.5	7.1	2.1	5	40	51	62	30	3.78	37.8	56.7	6.29	18.2	5
112	42.3	12	129	1.37	3815.15	17.9	26	15	23.5	5.2	2.2	3	49	52	78	29	4.1	41	61.5	6.83	15.8	6
113	52.8	22	195	1.52	5215.15	23.5	35	22	34.5	5.4	2.4	3	45	55	65	31	3.7	37	81.4	9.04	20.3	8
114	47.5	18	148	1.3	4720.5	18.2	35	18	20.5	5	2.5	2.5	47	57	67	25	4.1	41	73.8	8.19	22.8	7
115	45.7	16	131	1.07	3750.15	19.2	30	13	22.5	5.8	2.8	3	48	58	76	25	3.7	37	48.1	5.34	21.9	7
116	58.3	22	209	1.45	5810.22	23.7	32	22	36.5	6.1	2.3	3.8	47	55	65	30	4.2	42	92.4	10.26	48.2	9
117	52.75	18	196	1.38	5212.8	20.3	30	20	27.1	6.2	1.8	4.4	44	53	73	29	4.3	43	86	9.55	22.7	7
118	44.64	12	137	1.29	4421.8	18.8	28	15	20.2	6	2.1	3.9	48	57	79	28	3.9	39	58.5	6.49	61.2	8
119	39.6	11	126	1.19	3945.62	17.5	24	16	21.6	5.9	2.9	3	50	59	71	31	4.2	42	67.2	7.46	19.2	7
120	52.3	22	204	1.38	5215.4	21.8	35	23	32.5	5.7	3.1	2.6	47	58	68	28	3.5	35	80.5	8.94	44.53	6

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
121	55.1	25	208	1.42	5520.52	22.6	38	21	35.4	4.9	2.1	2.8	39	45	56	27	4.2	42	88.2	9.80	22.8	7
122	58.2	24	220	1.55	6245.8	24.3	35.6	25	27.6	5.8	2.5	3.3	47	62	71	30	3.3	33	82.5	9.17	38.58	9
123	56.4	22	212	1.4	5672.8	22.1	32	28	21.5	6.2	2.2	4	48	60	70	29	3.8	38	106.4	11.82	18.2	7
124	52.53	20	198	1.58	6480.25	20.5	38	30	22.5	6	2.2	3.8	42	51	62	32	4.1	41	123	13.67	19.8	8
125	45.7	15	137	1.2	4580.2	18.3	22	15	22.4	4.9	2.5	2.4	46	57	67	33	4.3	43	64.5	7.17	21.8	7
126	59.4	20	215	1.45	5980.8	21.6	33	28	35.8	5	2.5	2.5	40	60	70	35	4.12	41.2	115.36	12.82	20.2	7
127	48.9	17	167	1.48	6029.52	20.4	33	25	22.1	6.1	2.1	4	45	62	72	33	4.6	46	115	12.78	23.5	5
128	59.2	25	196	1.52	6152.82	24.9	34.2	26	33.5	6.2	1.8	4.4	49	61	71	29	3.7	37	96.2	10.69	45.3	6
129	49.2	17	148	1.58	6720.52	21.8	32	28	25.1	6.5	2.2	4.3	39	49	59	28	4.12	41.2	115.36	12.82	20.8	8
130	54.5	20	205	1.45	5420.52	23.1	30	20	22.5	6.8	2.5	4.3	40	50	60	31	3.5	35	70	7.78	14.2	7
131	43.7	15	132	1.23	4380.9	18.5	30	18	22.5	7	2	5	42	52	62	32	4.97	49.7	89.46	9.94	66.3	6
132	48.5	17	128	1.16	3780.9	20	25	12	25.7	5.8	2.9	2.9	41	50	59	25	4.56	45.6	54.72	6.08	21.9	7
133	55	20	212	1.52	5820.8	25.8	30	28	25	6.1	2.5	3.6	45	55	62	27	3.96	39.6	110.88	12.32	17.4	9
134	47	15	143	1.2	4780.88	20.2	20	19	22.5	6.8	2.1	4.7	46	55	65	30	5.3	53	100.7	11.19	56.3	7
135	55.4	22	215	1.45	5598.2	22.8	35	20	33.5	5.2	2.5	2.7	42	51	62	29	5.25	52.5	105	11.67	22.9	8
136	51.6	21	195	1.39	5130.8	20.5	32	18	21	5.8	1.9	3.9	45	50	60	32	4.67	46.7	84.06	9.34	16.8	7
137	45.2	18	138	1.25	4520.89	18.2	30	15	22.5	4.9	3	1.9	49	62	70	28	5.29	52.9	79.35	8.82	23.4	6
138	40.3	15	125	1.05	4015.35	17.5	28	15	23.5	5.3	2.8	2.5	45	52	67	30	4.67	46.7	70.05	7.78	54.3	7
139	56.1	22	216	1.25	5625.82	22.8	38	25	35.7	5.4	2.7	2.7	41	51	61	32	4.29	42.9	107.25	11.92	17.3	6
140	59.3	25	225	1.45	5932.85	25.2	36	23	31.5	6	2.5	3.5	39	47	57	29	5.3	53	121.9	13.54	22.8	6
141	53.25	21	210	1.48	5325.85	21.8	32	20	32.5	6.7	2.6	4.1	42	51	71	30	3.9	39	78	8.67	20.9	8
142	46.5	18	136	1.25	4632.82	18.2	26	18	20.4	6.3	2.1	4.2	44	54	79	32	4.23	42.3	76.14	8.46	19.5	9
143	50.4	22	185	1.45	5215.45	21.98	28	22	30.4	5.6	2.4	3.2	47	55	76	29	5.2	52	114.4	12.71	45.2	6
144	52.7	23	205	1.47	5420.42	22.8	32	21	32.5	6.2	2.7	3.5	39	47	78	31	5.1	51	107.1	11.90	11.27	7
145	44.4	18	126	1.2	4420.8	18.2	26	18	20.2	4.9	2	2.9	40	52	80	27	5.39	53.9	97.02	10.78	20.2	5
146	57.6	24	205	1.7	6720.72	27.3	31.8	22	31.2	6	1.8	4.2	38	48	82	30	4.28	42.8	94.16	10.46	37.2	7
147	51.6	21	195	1.57	5125.25	25.4	32	21	32.6	6.2	2.9	3.3	49	59	78	29	4.36	43.6	91.56	10.17	23.8	5
148	59.4	25	207	1.75	6152.52	27.2	32.6	25	36.5	5.2	2.5	2.7	43	53	81	31	5.39	53.9	134.75	14.97	42.7	6
149	57.5	23	223	1.48	5721.57	26.5	37.4	20	35.2	5.7	1.9	3.8	49	59	78	28	3.9	39	78	8.67	21.8	8

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
150	40.3	15	143	1.2	4072.8	17.6	26.2	18	20.8	4.9	2.3	2.6	48	58	77	30	4.5	45	81	9.00	18.96	7
151	47.9	19	158	1.32	4715.8	19.8	28.4	17	28.5	7.1	2.5	4.6	45	51	80	31	3.62	36.2	61.54	6.84	13.2	6
152	45.6	17	149	1.25	4521.85	17.5	27.5	15	25.6	5.9	2.5	3.4	49	55	75	27	5.87	58.7	88.05	9.78	56.9	6
153	48.3	15	145	1.25	4815.2	18.8	30.8	18	20.1	5.65	2.4	3.25	52	62	80	25	4.8	48	86.4	9.60	19.5	8
154	47.5	13	152	1.4	3520.8	17.2	25.4	14	22.5	6.5	2.3	4.2	45	53	75	32	5.1	51	71.4	7.93	21.9	9
155	58.4	23	218	1.62	5820.8	27.2	30.8	21	25.5	6.2	2.2	4	48	58	73	35	5.85	58.5	122.85	13.65	28.1	6
156	53.7	21	204	1.58	5320.48	24.8	32.1	20	21.1	6.6	1.9	4.7	47	58	78	30	4.6	46	92	10.22	19.6	7
157	43.53	18	135	1.43	4325.82	19.2	28.1	18	20.5	5.9	2.5	3.4	51	61	73	29	4.2	42	75.6	8.40	42.5	5
158	40.8	15	127	1.35	4052.72	17.4	26.8	15	23.5	5.2	2	3.2	48	58	68	31	5.38	53.8	80.7	8.97	20.7	7
159	50.7	20	189	1.5	5132.52	22.8	32.3	23	32.5	6	2.2	3.8	52	62	71	26	5.05	50.5	116.15	12.91	18.4	9
160	41.6	19	135	1.52	5752.15	18.2	23.7	25	22.5	6.2	2	4.2	39	63	73	30	4.3	43	107.5	11.94	22.8	7
161	57.6	23	200	1.58	6025.82	25.3	33.7	28	20.1	5	1.8	3.2	49	59	69	28	4.2	42	117.6	13.07	19.2	8
162	54.4	22	186	1.48	5425.52	20.4	35.3	25	23.5	4.9	2.2	2.7	43	53	71	31	4.5	45	112.5	12.50	19.8	7
163	60.2	25	215	1.5	6045.82	23.8	31.8	28	20.6	5.1	2.3	2.8	45	55	72	27	5.2	52	145.6	16.18	35.4	6
164	42.4	17	126	1.42	4215.15	19.5	32.4	17	21.2	6.2	2.5	3.7	47	57	76	32	6.36	63.6	108.12	12.01	22.5	7
165	56.7	21	180	1.52	5672.82	21.5	32.9	20	21.8	6	2.4	3.6	46	57	77	30	3.8	38	76	8.44	36.4	6
166	54.84	20	164	1.54	5428.52	22.8	33	18	20.2	6.5	2.3	4.2	48	58	65	29	5.3	53	95.4	10.60	19.5	6
167	60.75	25	214	1.8	6072.8	24.5	31.5	22	23.5	6.3	2.2	4.1	43	53	71	28	4.16	41.6	91.52	10.17	14.35	8
168	58.46	23	206	1.85	6720.8	25.3	32.1	25	26.5	5	2.8	2.2	46	57	65	31	3.4	34	85	9.44	20.6	9
169	51.53	21	187	1.45	5120.45	24.7	35.6	20	32	5.2	1.9	3.3	40	48	64	32	4.3	43	86	9.56	18.5	6
170	42.65	12	128	1.35	4230.45	19.4	25.2	18	26	6.1	2.1	4	49	57	68	29	5.12	51.2	92.16	10.24	54.3	7
171	54.72	22	173	1.52	5432.51	25.8	35.8	21	28	5.8	2.2	3.6	45	59	69	27	4.28	42.8	89.88	9.99	17.2	5
172	40.54	12	129	1.2	3250.81	18.5	28.2	17	22	5	1.9	3.1	42	52	70	30	5.2	52	88.4	9.82	35.7	8
173	52.17	23	205	1.55	5582.8	24.8	35.8	22	23.2	4.9	2.8	2.1	48	58	68	31	4.28	42.8	94.16	10.46	15.8	6
174	47.65	17	159	1.42	4782.81	18.9	28.2	18	24.5	6	2.7	3.3	47	60	70	35	3.35	33.5	60.3	6.70	18.3	7
175	51.87	20	214	1.25	5152.15	25	38.3	20	22.2	6.7	2.2	4.5	49	58	69	33	4.12	41.2	82.4	9.16	20.8	5
176	44.74	15	142	1.15	4458.81	19.5	30.2	17	21	6.1	1.9	4.2	48	61	71	32	4.2	42	71.4	7.93	24.8	6
177	47.58	18	157	1.2	4781.82	22	28.1	18	23	6.5	3.1	3.4	48	59	70	30	5.2	52	93.6	10.40	32.5	8
178	40.27	13	136	1.05	4092.35	18.1	22.8	16	22.5	7	2	5	41	51	72	27	5.28	52.8	84.48	9.39	20.8	7

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
179	52.85	20	202	1.02	5731.82	20.6	36.1	22	35	4.9	2.7	2.2	48	57	67	29	4.97	49.7	109.34	12.15	19.5	9
180	60.76	23	213	1.85	6132.82	25.4	31.2	25	34.8	5.2	2.4	2.8	46	53	72	32	5.8	58	145	16.11	21.8	7
181	54.73	19	200	1.25	5428.81	23.5	35.6	21	32.8	5	2.5	2.5	48	51	61	31	4.2	42	88.2	9.80	18.2	6
182	46.64	15	175	1.15	4732.12	17.8	30.1	17	21.5	5.6	2.3	3.3	45	55	68	30	3.5	35	59.5	6.61	52.38	6
183	52.65	22	215	1.52	5215.9	19.2	34.8	22	24	5.8	2.5	3.3	48	53	63	25	5.18	51.8	113.96	12.66	20.5	8
184	57.54	25	217	1.56	5750.82	23.6	35.2	25	25	5.4	2.1	3.3	38	48	56	29	4.12	41.2	103	11.44	38.3	9
185	51.34	20	195	1.49	5125.8	21.9	30.79	20	24.4	5	2.2	2.8	46	52	73	31	4.35	43.5	87	9.67	22.6	6
186	45.85	19	129	1.3	4525.35	17.3	20.8	18	22.5	5.6	2.5	3.1	50	57	79	32	5.2	52	93.6	10.40	21.2	7
187	54.54	20	215	1.49	5488.2	20.5	31.8	19	21.6	5.7	2.3	3.4	48	60	82	33	5.2	52	98.8	10.98	35.2	5
188	59.5	25	225	1.5	5982.2	24.6	35.8	18	22.5	5.2	2.2	3	39	49	55	29	4.3	43	77.4	8.60	17.9	6
189	58.3	22	214	1.32	5825.8	25.3	32.6	21	21.8	6	2.5	3.5	39	45	56	30	5.2	52	109.2	12.13	20.7	8
190	42.86	15	128	1.28	4253.35	17.5	20.7	15	21.8	6.2	1.9	4.3	42	57	65	31	6.2	62	93	10.33	45.2	7
191	45.64	10	135	1.21	4480.2	18	22.2	17	20.2	5.6	2.5	3.1	48	58	67	32	5.3	53	90.1	10.01	23.8	5
192	50.82	15	147	1.25	5035.5	21.2	35.3	22	25.7	6.1	2	4.1	41	62	71	30	5.9	59	129.8	14.42	17.2	6
193	40.5	12	133	1.14	3942.8	19.5	20.9	12	20.3	6	2.3	3.7	47	59	68	29	4.2	42	50.4	5.60	29.8	7
194	48.2	15	138	1.1	4820.82	20.4	32.1	18	25.3	5.8	2.5	3.3	35	45	55	31	6.2	62	111.6	12.40	23.8	9
195	50.6	12	189	1.02	4525.51	25	28.6	15	20.2	5.9	2	3.9	48	59	67	27	5.1	51	76.5	8.50	32.35	7
196	42.8	14	165	1.15	3942.5	17.9	28.2	17	22.5	4.8	2.3	2.5	48	58	72	29	4.1	41	69.7	7.74	24.8	8
197	41.54	12	125	1.24	4825.82	18.4	25.8	14	21.5	5.1	2.25	2.85	38	48	58	30	3.15	31.5	44.1	4.90	20.8	7
198	48.22	13	135	1.15	4529.92	20.3	23.5	15	24.6	6.5	1.9	4.6	46	55	66	28	4.5	45	67.5	7.50	13.2	6
199	39.8	11	133	1.4	3215.82	17.9	20.4	11	20.5	6	2	4	48	56	67	31	5.2	52	57.2	6.36	53.29	7
200	42.8	13	126	1.13	4725.25	18.2	25.2	15	22.6	5.8	2.5	3.3	35	42	53	30	6.13	61.3	91.95	10.22	27.8	9

1) Plat height 2) No. of branches 3) No. of leaves 4) Stem girth 5.) Leaf area 6) Plant spread (N-S) 7) Plant spred (E-W) 8) No. of flowers 9) Stalk length 10) Flower diameter 11) .Disc diameter 12) Ray florets length 13) Days for first bud initiation 14) Days for first flowering 15) Days for 50 per cent flowering 16.) Duration of flowering 17) Individual flower weight 18) Ten flower weight 19) Yield per plant 20) Yield per hectare 21) Percent disease intensity 22) Vase life

Appendix III. Values of 22 characters in F_2 population of PG Purple x AAC-1

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	43.8	15	110	1.53	5051.38	28.2	22.5	31	21.2	6.5	2.5	4	46	55	66	32	5.3	53	164.3	18.25	22.8	6
2	58.2	18	202	1.33	4382.66	21.6	26.8	30	30.8	6	3	3	45	53	69	27	6.7	67	201	22.33	16.8	7
3	39.4	12	185	1.82	4633.9	21.9	20.8	20	20.1	4	1.5	2.5	49	54	63	30	8.3	83	166	18.44	58.28	10
4	48.5	15	122	1.8	5765.68	23.5	23.5	25	24.9	3.4	1.8	1.6	48	55	70	29	6.2	62	155	17.22	20.8	7
5	47.3	17	117	1.62	6248.23	25.3	29.8	22	22.2	7	3.5	3.5	51	58	65	28	5.26	52.6	115.72	12.85	17.5	9
6	44.7	13	118	1.2	4720.82	28.5	21.1	25	21.8	3.5	2	1.5	42	50	61	30	5.2	52	130	14.44	38.29	5
7	39.5	14	125	1.3	5329.25	25.3	25.2	29	20.3	6	2.5	3.5	50	58	68	33	5.76	57.6	167.04	18.55	23.1	6
8	44.8	12	118	1.35	3969.97	22.8	29.4	36	32.5	5.5	2.5	3	46	55	72	31	4.92	49.2	177.12	19.67	12.6	10
9	47.2	16	123	1.25	7295.29	25.2	20.5	40	26.8	5.8	2.1	3.7	48	57	77	29	4.5	45	180	19.99	30.2	6
10	48.2	23	213	1.35	4867.3	18.2	21.4	42	25.8	4.5	1.2	3.3	51	58	73	30	3.9	39	163.8	18.19	19.8	8
11	50.2	15	124	1.45	5300.6	26.2	24.5	32	31.3	5	2.2	2.8	49	58	75	32	3.98	39.8	127.36	14.15	24.2	11
12	48.3	20	202	1.28	4633.9	27.8	26.8	40	27.9	6	2.1	3.9	46	56	78	28	4.5	45	180	19.99	37.2	5
13	48.2	13	123	1.3	4810.53	22.2	19.3	25	19.6	5.5	2.3	3.2	50	57	77	31	5.41	54.1	135.25	15.02	19.2	6
14	45.2	12	112	1.45	5043.77	25.7	28.2	28	30.2	4.8	2.51	2.29	47	59	79	29	4.85	48.5	135.8	15.08	22.8	8
15	50.6	14	120	1.52	6142.58	21.8	25.8	22	28.2	5.1	1.8	3.3	49	52	72	30	4.35	43.5	95.7	10.63	55.2	7
16	49.5	19	130	1.5	7045.28	20.5	22.5	35	27.8	5.3	2.15	3.15	51	58	78	32	5.51	55.1	192.85	21.42	23.5	8
17	51.5	20	140	1.7	4030.59	22.9	29.5	32	30.3	3.8	2.1	1.7	45	52	70	30	5.12	51.2	163.84	18.20	22.9	6
18	46.2	12	115	1.82	4778.29	19.5	23.8	28	29.6	4.8	2.8	2	48	57	74	29	4.52	45.2	126.56	14.06	14.2	7
19	44.8	12	125	1.3	4590.58	20.5	29.2	22	24.2	5.2	1.8	3.4	49	57	79	30	5.12	51.2	112.64	12.51	58.25	6
20	39.5	15	112	1.45	5765.68	21.8	25.7	15	20.6	6	2.5	3.5	52	60	79	27	3.92	39.2	58.8	6.53	24.9	7
21	48.3	13	120	1.23	4582.18	22.8	24.5	20	22.1	7.1	3.7	3.4	47	55	75	30	4.25	42.5	85	9.44	19.5	9
22	42.8	12	117	1.25	4633.9	25.5	28.3	30	28.9	6.2	2.2	4	35	42	57	28	4.3	43	129	14.33	54.2	5
23	50.9	17	118	1.3	7217.23	28.3	25.2	31	25.2	6.1	2.4	3.7	49	55	76	31	4.4	44	136.4	15.15	20.54	8
24	46.2	15	120	1.5	7668.661	25.8	20.8	21	23.7	5.2	1.8	3.4	42	50	79	33	6.52	65.2	136.92	15.21	44.3	6
25	41.6	18	123	1.45	6253.82	21.5	23	19	21.8	5.1	1.1	4	48	54	75	29	4.92	49.2	93.48	10.38	23.8	10
26	52.9	12	118	1.25	4590.564	22.8	25.7	27	32.9	6.2	2.8	3.4	47	51	71	32	4.3	43	116.1	12.89	19.7	6
27	49.2	21	124	1.3	5480.29	25.3	27.8	31	34.2	5.8	1.7	4.1	49	56	78	31	5.82	58.2	180.42	20.04	20.7	8
28	48.3	17	118	1.42	6251.29	21.8	20.6	25	30.5	5.2	3.2	2	45	56	76	29	5.5	55	137.5	15.27	21.8	11
29	46.9	12	126	1.35	4525.31	22.3	19.8	19	27.3	6.2	2.4	3.8	47	54	79	30	5.2	52	98.8	10.97	23.7	5

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
30	50.1	13	132	1.36	5025.35	20.6	26.8	21	32.4	6	2.5	3.5	49	57	67	32	5.4	54	113.4	12.59	55.2	6
31	52.5	12	122	1.2	5028.85	19.8	28.1	23	34.1	5.89	1.7	4.19	48	59	79	29	4.9	49	112.7	12.52	22.9	8
32	45.9	17	128	1.5	4023.58	21.2	22.5	18	22.8	6.28	3.1	3.18	51	59	80	30	6.1	61	109.8	12.19	13.2	7
33	52.7	20	135	1.3	6280.98	22.6	26.2	31	32.1	7	2.4	4.6	42	50	70	31	5.8	58	179.8	19.97	45.27	8
34	51.8	21	129	1.3	6324.58	23.5	24.8	29	25.8	6.15	1.8	4.35	48	52	78	28	5.95	59.5	172.55	19.17	22.9	6
35	48.2	19	111	1.45	5823.42	24.6	20.5	23	28.2	5.12	3.1	2.02	49	57	75	30	4.29	42.9	98.67	10.96	19.8	7
36	39.8	13	122	1.4	4051.25	21	22	15	23.2	4.9	2.9	2	44	52	80	29	5.1	51	76.5	8.49	17.8	6
37	40.2	12	132	1.25	3570.32	20.6	19.5	16	21.8	5.1	2.3	2.8	42	52	74	30	4.35	43.5	69.6	7.73	18.3	7
38	45	14	120	1.2	4580.42	19.5	21.5	19	19	6.1	2.4	3.7	42	51	78	31	4.37	43.7	83.03	9.22	43.2	9
39	47.2	12	128	1.52	4078.32	23.8	23.5	25	21.3	5.8	2.4	3.4	48	55	75	30	5.9	59	147.5	16.38	19.2	10
40	40.8	14	145	1.4	3970.23	22.5	20.5	18	20.5	6.1	2	4.1	49	58	80	27	4.2	42	75.6	8.39	25.8	6
41	50.4	12	120	1.3	5612.21	26.3	23.9	28	32.1	6.28	1.4	4.88	48	59	78	29	6.8	68	190.4	21.15	24.3	7
42	48.8	12	142	1.45	4251.43	20.3	21.5	20	18.7	5.9	2	3.9	48	55	76	31	5.02	50.2	100.4	11.15	18.2	9
43	39.3	12	125	1.2	3780.45	18.5	20.2	15	25.5	5.1	2.1	3	48	53	74	28	5.8	58	87	9.66	22.5	7
44	43.2	15	136	1.3	4319.63	19.5	22.1	18	23.3	5.28	3.1	2.18	49	59	80	30	5.67	56.7	102.06	11.33	38.3	8
45	49.7	12	110	1.35	4925.62	21.7	23.9	20	25.4	6.28	2.6	3.68	49	55	73	32	4.1	41	82	9.11	18.2	7
46	39.8	13	132	1.4	3029.64	20	19.8	17	23.5	4.31	1.8	2.51	53	62	75	29	2.85	28.5	48.45	5.38	20.1	6
47	40.5	15	125	1.5	3259.67	19.8	20.2	15	18.2	4.81	2.4	2.41	45	52	78	31	5.06	50.6	75.9	8.43	32.1	7
48	45.1	12	130	1.25	4025.53	22.5	22.6	18	20.3	5.2	2.3	2.9	45	53	75	30	4.64	46.4	83.52	9.27	11.4	9
49	48.6	13	142	1.44	4823.63	23.8	23.8	16	22.1	5.3	2.2	3.1	48	55	76	32	3.28	32.8	52.48	5.83	23.2	5
50	45.3	13	135	1.35	4563.72	20.8	20.8	18	23.7	5	3.1	1.9	45	56	74	28	4.98	49.8	89.64	9.95	36.6	6
51	43.2	14	120	1.4	3023.12	19.5	19.5	15	27.2	4.8	2.5	2.3	49	57	77	29	5.84	58.4	87.6	9.73	19.2	7
52	47.8	13	110	1.39	4789.64	20.5	21.3	17	30.2	6.1	1.7	4.4	50	59	79	30	4.2	42	71.4	7.93	21.9	5
53	50.1	16	150	1.42	3230.68	23.5	23.6	23	23.9	6	2.8	3.2	43	50	75	31	3.9	39	89.7	9.96	17.8	6
54	49.5	20	132	1.3	6250.26	19.8	20.1	25	30.7	6.5	2.3	4.2	47	58	78	32	4.65	46.5	116.25	12.91	19.8	8
55	52.4	23	185	1.25	6530.82	20.6	23.2	28	28.6	6.2	1.7	4.5	48	55	78	27	5.3	53	148.4	16.48	22.8	7
56	48.9	21	172	1.27	6850.23	22.8	25.7	30	26.7	5.8	2.6	3.2	45	52	75	28	6.1	61	183	20.33	23.2	8
57	49.8	18	125	1.3	4950.41	20.6	21.5	17	20.5	5	2.2	2.8	40	51	72	29	5.1	51	86.7	9.63	37.4	7
58	45.3	17	120	1.25	4520.62	19.6	19.8	16	21.3	5.2	2.4	2.8	47	57	78	30	4.2	42	67.2	7.46	23.8	6

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
59	48.9	17	152	1.37	4835.72	21.5	22.5	17	22.7	5.4	2.2	3.2	46	55	75	32	3.6	36	61.2	6.79	19.8	7
60	39.6	15	148	1.38	3825.83	20	18.2	15	21.5	5	2.7	2.3	50	58	70	28	5.2	52	78	8.66	21.9	9
61	40.3	17	152	1.4	2590.55	20.8	21.6	17	20.2	4.8	1.8	3	45	52	73	31	6.2	62	105.4	11.71	20.5	7
62	49.8	13	143	1.2	5240.73	23.6	23.8	22	23.45	6.9	2.7	4.2	48	55	78	29	5	50	110	12.22	19.8	8
63	45.4	12	118	1.22	4535.53	25.4	24.1	15	20.5	6.2	2.6	3.6	50	58	75	30	5.1	51	76.5	8.49	22.5	7
64	39.6	13	132	1.3	3570.72	22.6	19.8	17	19.2	5.9	2.1	3.8	49	57	68	32	4.8	48	81.6	9.06	32.54	6
65	41.7	15	110	1.32	4058.15	23.5	22.2	15	21.8	5.5	1.9	3.6	45	52	72	29	6.2	62	93	10.33	23.8	7
66	43.8	13	121	1.25	4321.42	19.2	25.8	22	20.56	6.5	2.4	4.1	49	57	75	28	5.1	51	112.2	12.46	43.68	6
67	51.2	15	130	1.23	5023.53	23.5	28.2	24	22.13	6.9	2.8	4.1	38	47	65	30	5.8	58	139.2	15.46	24.3	8
68	44.8	12	135	1.3	4042.77	18.9	21.8	18	18.18	6.2	2.5	3.7	44	52	73	31	6.1	61	109.8	12.19	18.9	7
69	50.7	14	165	1.32	5231.34	25.8	23.8	25	25.35	5.9	2.5	3.4	50	59	78	29	5.3	53	132.5	14.72	19.7	7
70	41.3	13	123	1.29	4252.62	20.8	20.5	19	20.2	5.1	2.3	2.8	49	59	75	30	5.42	54.2	102.98	11.44	20.6	8
71	39.7	12	112	1.28	3862.45	19.5	19.5	16	19.5	5.2	2.4	2.8	49	57	75	32	6	60	96	10.66	14.8	7
72	40.2	15	115	1.3	3042.31	20	21	20	18.2	4.8	2.9	1.9	45	52	73	28	5.5	55	110	12.22	52.3	10
73	46.3	14	120	1.32	4123.43	22.6	23.2	16	22.8	4.5	2.1	2.4	49	50	70	30	6.12	61.2	97.92	10.87	21.8	7
74	42.8	13	125	1.3	4289.76	20.5	21.5	19	20.5	5.1	2.7	2.4	43	51	71	31	4.5	45	85.5	9.49	23.9	9
75	53.2	15	150	1.29	5359.82	23.8	25.2	25	20.9	5.8	2.4	3.4	49	57	77	32	5.9	59	147.5	16.38	48.3	8
76	48.7	12	132	1.28	4238.45	19.8	19.8	15	18.58	5.5	2.5	3	56	61	80	28	4.8	48	72	7.99	19.8	7
77	48.2	12	152	1.53	4895.3	20.8	20.2	22	21.5	6.5	2.9	3.6	48	59	79	31	6.7	67	147.4	16.37	20.8	6
78	53.1	15	150	1.8	5032.25	22.7	25.2	28	25.8	6.8	2.6	4.2	39	50	63	30	5.3	53	148.4	16.48	21.8	8
79	39.5	14	121	1.2	4057.52	18.25	20.2	18	18.5	5.3	2	3.3	50	58	78	29	7.1	71	127.8	14.19	44.3	7
80	42.8	13	110	1.52	4235.55	19.2	21.8	17	21.8	6.3	2.8	3.5	49	59	76	30	6.2	62	105.4	11.71	18.3	7
81	39.8	12	120	1.5	2975.5	17.2	19.8	13	20.5	5.4	2	3.4	50	59	79	29	5.5	55	71.5	7.94	24.8	8
82	45.3	15	118	1.23	3289.5	20.2	21.5	18	19.8	5.8	2.1	3.7	40	48	65	27	6.98	69.8	125.64	13.95	23.9	7
83	41.9	16	120	1.42	4150.5	18.2	20.6	20	21.8	6.1	3.1	3	50	58	75	28	5.42	54.2	108.4	12.04	19.8	6
84	50.7	15	131	1.85	5825.8	21.6	25.8	25	20.5	7.1	3	4.1	47	58	78	30	5.4	54	135	14.99	32.4	7
85	51.2	19	118	1.78	5180.5	23.8	22.8	22	25.6	6.5	2.8	3.7	49	59	79	28	2.9	29	63.8	7.08	19.6	9
86	44.8	12	116	1.45	4480.4	18.2	20.1	18	21.7	6.1	2	4.1	51	60	80	29	3.21	32.1	57.78	6.41	24.9	7
87	39.8	13	120	1.2	3550.8	18	18.3	16	20.8	5.2	2.2	3	49	59	79	30	5.2	52	83.2	9.24	35.2	9

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
88	40.3	15	121	1.21	3780.85	19.8	21.8	12	23.2	5.4	2.1	3.3	50	59	78	31	4.3	43	51.6	5.73	21.4	7
89	43.7	14	115	1.4	4320.25	20.2	23.5	15	20.5	5.5	2.2	3.3	48	55	85	32	5.6	56	84	9.33	23.9	8
90	45.1	15	120	1.42	5250.58	21.2	22.8	16	22.5	5.8	1.8	4	45	54	74	29	3.5	35	56	6.22	24.3	7
91	52.7	18	123	1.52	2938.8	22.5	25.8	21	30.6	6.5	2	4.5	48	59	79	28	6.1	61	128.1	14.23	39.2	6
92	42.5	13	112	1.3	3825.52	20	20.8	14	21.8	4.8	1.95	2.85	42	53	75	30	5.1	51	71.4	7.93	19.7	7
93	40.8	12	118	1.2	4950.5	19.8	19.5	15	20.8	5.1	2.4	2.7	39	50	72	27	4.2	42	63	6.9	13.5	9
94	49.2	16	126	1.32	6820.58	21.8	23.8	18	19.9	6.5	2.5	4	45	57	76	31	5.5	55	99	10.99	21.8	6
95	50.3	18	132	1.85	6240.42	23.6	24.5	26	30.5	6.9	2.8	4.1	48	59	79	28	6.1	61	158.6	17.62	19.8	8
96	55.3	20	128	1.78	6048.28	24.2	25.8	20	29.9	6.7	2	4.7	45	53	71	29	5.5	55	110	12.22	22.8	6
97	52.8	17	140	1.6	5805.05	21.2	20.1	21	28.5	6.1	2.9	3.2	53	59	75	30	5.1	51	107.1	11.89	18.5	7
98	50.1	21	135	1.72	6058.25	19.2	19.8	25	24.5	5.7	2.1	3.6	45	52	70	31	4.2	42	105	11.66	20.8	5
99	47.7	15	110	1.5	4745.25	18.3	20	17	23.5	5.1	2.3	2.8	49	59	75	32	3.9	39	66.3	7.36	22.8	6
100	39.2	13	122	1.21	3350.3	18	22.9	14	20.2	5.2	2.3	2.9	43	52	71	29	5.55	55.5	77.7	8.63	36.3	8
101	48.5	17	118	1.25	4880.43	23.2	20.5	17	25.6	5.9	2.5	3.4	41	49	69	28	4.8	48	81.6	9.06	24.2	7
102	45.3	15	120	1.23	4520.52	21.5	19.2	15	23.9	5.2	2.4	2.8	47	57	77	30	6.2	62	93	10.33	53.2	7
103	43.6	15	128	1.2	3925.81	20	20.5	19	21.8	5	2.5	2.5	49	55	75	31	4.6	46	87.4	9.71	19.5	8
104	40.2	13	132	1.3	3565.32	19.2	19.5	15	20.5	4.7	2.1	2.6	45	55	68	32	5.22	52.2	78.3	8.60	20.8	7
105	49.5	12	121	1.25	5036.52	22.3	20.8	19	20.4	6.2	2.8	3.4	40	50	62	29	5.22	52.2	99.18	11.01	20.8	6
106	43.9	15	115	1.2	4526.72	24.3	18.5	20	21.2	6	2.9	3.1	39	49	60	29	3.8	38	76	8.44	17.2	7
107	45.5	14	125	1.6	3735.63	20	20.1	15	18.5	5.8	2	3.8	46	52	74	32	5.5	55	82.5	9.16	22.8	9
108	48.1	18	115	1.28	4826.32	22.3	22.7	18	20.6	6.5	2.7	3.8	44	51	71	31	4.26	42.6	76.68	8.51	38.2	7
109	50.4	21	130	1.35	5625.43	24.2	25.2	21	21.5	6.9	3.1	3.8	42	53	73	26	6.1	61	128.1	14.23	20.4	8
110	39.8	13	119	1.3	3732.12	18.2	19.2	18	20.5	5.2	2.8	2.4	49	56	76	25	5.2	52	93.6	10.39	19.8	7
111	47.2	15	128	1.2	4756.92	18.5	20.1	16	20.8	5.5	2.4	3.1	39	49	62	28	4.8	48	76.8	8.53	17.2	6
112	51.8	21	117	1.58	5132.5	19.8	22	20	28.8	6.7	2.9	3.8	49	52	78	27	5.3	53	106	11.77	42.6	5
113	53.2	19	123	1.85	5350.72	23.8	24.2	19	22.5	6.2	2.8	3.4	45	55	68	28	4.8	48	91.2	10.13	20.3	7
114	48.7	16	112	1.25	4850.12	21.5	20.1	15	18.5	6	2.4	3.6	49	59	79	29	5.2	52	78	8.66	22.8	9
115	50.2	20	130	1.67	5058.42	24.8	22.5	25	21.5	6	2.5	3.5	48	58	78	30	4.8	48	120	13.33	19.2	7
116	45.6	16	121	1.52	4525.6	20	19.4	18	25.5	5.5	2.4	3.1	38	55	75	25	5.1	51	91.8	10.19	21.8	10

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
117	48.2	15	127	1.53	4850.24	20.5	21.2	20	18.5	5.8	2.1	3.7	44	53	63	29	4.8	48	96	10.66	23.8	6
118	39.9	14	132	1.4	3980.85	18.6	20.3	15	20.8	4.8	1.8	3	39	45	65	30	5.3	53	79.5	8.83	9.2	8
119	52.5	19	155	1.82	5825.4	22.6	22.6	20	25.8	6.5	3.5	3	40	50	79	31	5.6	56	112	12.44	43.2	9
120	50.3	22	180	1.9	6230.3	20.5	21.2	28	22.5	7	2.51	4.49	47	58	75	28	3.8	38	106.4	11.82	19.8	7
121	52.5	20	120	1.39	5245.22	21.8	25.2	20	20.5	6.4	3.1	3.3	45	54	65	29	4.6	46	92	10.22	20.8	7
122	50.2	18	200	1.32	6858.2	20.8	24.8	25	30.1	6.8	3.8	3	42	52	66	31	6.2	62	155	17.22	20.12	8
123	45.8	12	123	1.35	4580.2	19.2	21.8	16	25.2	5.2	2.3	2.9	45	55	78	30	5.1	51	81.6	9.06	18.2	6
124	52.4	22	118	1.4	5280.8	24.6	25.1	18	23.5	5.8	2.1	3.7	49	56	76	28	4.7	47	84.6	9.39	48.2	8
125	50.2	20	115	1.42	5025.52	25	23.8	19	24.6	5.4	2.15	3.25	46	52	79	30	5.501	55.01	104.519	11.61	21.9	6
126	46.8	13	121	1.38	4628.82	22.1	20.5	15	28.5	5.3	2.31	2.99	49	55	75	31	5.3	53	79.5	8.83	17.9	10
127	52.6	21	123	1.45	5553.32	24.2	22.5	18	30.2	6	1.8	4.2	39	48	68	29	4.52	45.2	81.36	9.03	23.5	6
128	50.1	23	140	1.6	6045.25	23.8	24.8	21	28.2	6.3	2.1	4.2	49	58	78	27	5.521	55.21	115.941	12.88	21.8	8
129	49.3	20	132	1.58	5752.25	21.8	21.2	22	19.21	5.7	2.7	3	48	55	72	28	4.9	49	107.8	11.97	20.8	11
130	41.8	12	128	1.4	4152.25	20.1	18.5	18	21.5	5	2.6	2.4	42	59	70	25	5.8	58	104.4	11.59	24.8	5
131	46.3	15	125	1.48	4672.5	20.2	24.2	20	20.2	5.4	2.2	3.2	50	58	68	28	6.2	62	124	13.77	19.5	6
132	50.1	18	122	1.52	5250.25	25.8	26.8	23	25.5	6	1.8	4.2	45	52	65	30	5.1	51	117.3	13.03	54.3	8
133	48.3	17	131	1.58	5630.48	22.6	19.5	24	23.5	6.5	2.7	3.8	45	55	68	31	4.82	48.2	115.68	12.85	17.4	7
134	48.1	15	118	1.5	4825.5	23.5	20.15	18	22.3	5.9	2.8	3.1	46	55	65	22	5.76	57.6	103.68	11.51	22.9	8
135	39.9	14	146	1.4	3820.8	20	19.8	15	20.2	4.9	2.5	2.4	48	56	67	28	5.22	52.2	78.3	8.69	46.3	6
136	44.2	12	152	1.32	4450.5	20.7	20.5	17	18.5	6	2.6	3.4	42	50	65	30	5.8	58	98.6	10.95	24.8	7
137	51.9	18	125	1.53	5505.5	25.2	23.1	21	23.5	6.5	2.3	4.2	37	45	62	31	5.1	51	107.1	11.89	23.4	6
138	48.5	20	158	1.62	6825.52	22.7	20.5	25	29.2	7	2.15	4.85	39	49	61	29	4.8	48	120	13.33	54.3	7
139	50.8	19	142	1.65	6280.8	20.5	22.8	22	27.5	5.8	2.7	3.1	41	52	62	28	3.7	37	81.4	9.04	17.3	9
140	51.6	22	133	1.57	5780.5	21.8	23.5	19	20.6	5.1	1.8	3.3	36	47	68	32	3.52	35.2	66.88	7.43	23.8	7
141	47.6	20	129	1.52	5825.52	20.2	19.25	20	22.5	6	2.6	3.4	48	56	78	30	4.1	41	82	9.11	19.6	8
142	45.8	18	152	1.42	4632.25	19.5	20.8	18	28.6	5.4	2	3.4	45	52	72	33	5.2	52	93.6	10.39	21.9	7
143	52.3	20	130	1.62	6425.52	22.5	23.7	26	24.5	6.8	2.4	4.4	47	53	73	29	4.6	46	119.6	13.28	63.2	6
144	46.8	21	125	1.55	5620.32	20.5	21.2	24	22.6	6.1	2.1	4	45	57	67	30	3.2	32	76.8	8.53	18.6	7
145	50.2	22	142	1.65	6502.2	21.8	24.8	30	28.4	7.5	2.55	4.95	46	59	69	29	5.75	57.5	172.5	19.16	20.2	9

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
146	48.6	20	118	1.58	5528.82	20.5	22.5	23	22.5	6	2.51	3.49	45	59	70	27	4.2	42	96.6	10.73	37.2	5
147	50.2	17	115	1.5	5432.85	22.3	20.8	19	20.6	6.5	2.4	4.1	49	59	76	28	3.5	35	66.5	7.38	19.2	6
148	39.9	17	120	1.5	3958.82	20	19.7	13	18.5	5.4	2.8	2.6	44	49	62	30	5.1	51	66.3	7.36	21.8	7
149	44.2	14	126	1.3	4432.82	22.6	22.8	18	20.7	5.8	2.6	3.2	49	59	72	32	4.56	45.6	82.08	9.11	20.8	10
150	47.3	16	125	1.52	5250.45	21.7	24.7	20	21.5	6.5	2	4.5	38	49	59	23	4.2	42	84	9.33	21.9	8
151	50.2	19	128	1.48	5850.5	23.8	27.2	22	26.3	6.8	2.4	4.4	45	51	65	32	4.512	45.12	99.264	11.02	13.2	6
152	39.3	14	120	1.4	3540.8	20	18.5	13	21.6	5.9	2.1	3.8	39	52	65	28	5.212	52.12	67.756	7.52	45.9	10
153	41.8	13	118	1.6	4150.45	20.5	19.2	16	20.2	5.5	2.5	3	40	49	59	28	6.1	61	97.6	10.84	20.2	9
154	47.2	18	140	1.5	5720.3	19.8	21.5	25	23.6	6	2	4	45	53	63	30	5.1	51	127.5	14.16	24.9	7
155	52.1	20	156	1.61	6020.2	22.5	24.2	32	30.5	6.5	2.1	4.4	48	58	68	29	4.35	43.5	139.2	15.46	28.1	6
156	49.2	16	135	1.52	5530.5	21.7	21.9	22	26.4	5.8	2.8	3	35	45	58	27	4.6	46	101.2	11.24	39.2	7
157	46.2	12	125	1.4	4672.5	18.3	20.8	19	19.5	5	2.9	2.1	38	49	59	29	5.32	53.2	101.08	11.23	19.8	9
158	50.5	19	111	1.52	5220.5	22.5	22.5	21	25.5	6	2.5	3.5	40	51	61	30	3.9	39	81.9	9.09	45.3	7
159	48.2	20	113	1.61	5738.62	27.3	20.5	23	28.4	6.5	3.5	3	42	52	62	28	6.1	61	140.3	15.58	18.4	8
160	52.1	21	115	1.58	5224.5	25.3	24.7	20	25	6	3	3	39	49	60	32	5.3	53	106	11.77	35.4	7
161	45.9	12	118	1.42	4558.2	20.6	19.5	15	18.5	5.7	2.5	3.2	49	59	69	30	4.9	49	73.5	8.16	27.3	6
162	53.4	18	120	1.52	5358.5	25.3	22.8	21	22	6.1	2.1	4	42	52	62	29	3.98	39.8	83.58	9.28	38.2	7
163	49.3	21	136	1.62	6150.5	23.7	23.2	25	23	6.8	2.5	4.3	39	49	52	22	5.8	58	145	16.11	35.4	6
164	45.2	20	123	1.58	5885.8	21.8	21.8	23	18.5	5.7	1.7	4	40	50	61	28	6.2	62	142.6	15.84	18.5	8
165	39.6	12	112	1.39	3950.65	19.2	19.8	13	20.8	4.8	2.8	2	46	57	75	32	4.1	41	53.3	5.92	20.8	7
166	48.2	15	121	1.48	4865.65	20.1	22.8	17	17.2	4.8	2.15	2.65	48	53	73	29	6.2	62	105.4	11.71	49.3	7
167	45.8	17	116	1.42	4528.82	19.8	20.5	19	18.5	5.1	2.1	3	51	59	80	30	5.22	52.2	99.18	11.01	14.35	8
168	50.2	22	118	1.5	5055.52	22.1	23.8	25	20.5	5.3	1.8	3.5	46	57	77	30	5.9	59	147.5	16.38	23.8	7
169	48.9	15	115	1.42	4862.51	19.8	19.7	18	19.5	5	2.2	2.8	40	48	68	27	6.1	61	109.8	12.19	64.3	6
170	52.6	23	122	1.56	5625.25	22.7	22.6	30	22.6	5.8	2.9	2.9	39	53	65	30	5.28	52.8	158.4	17.59	22.9	7
171	38.2	13	120	1.5	3852.52	18.6	19.5	15	20.8	4.9	2.51	2.39	40	52	62	28	5.12	51.2	76.8	8.53	44.39	9
172	52.8	21	125	1.4	5565.81	20.5	25.2	28	23.2	5.8	2.1	3.7	39	49	60	30	4.5	45	126	13.99	10.2	8
173	43.5	15	113	1.4	4320.5	19.5	19.8	18	22.8	5.1	2.7	2.4	48	57	67	30	4.7	47	84.6	9.39	21.9	10

Plant no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
174	50.5	19	119	1.38	5215.15	23.5	28.6	22	21.2	6	2.3	3.7	38	48	58	25	5.1	51	112.2	12.46	19.8	6
175	53.2	22	135	1.82	6820.2	20.6	26.8	25	23.6	6.7	2.7	4	40	50	61	27	3.9	39	97.5	10.83	54.3	8
176	45.2	20	125	1.7	6150.2	17.8	21.8	23	22.5	6	1.9	4.1	40	51	62	28	4.8	48	110.4	12.26	24.3	7
177	47.5	19	118	1.6	5570.7	19.5	23.6	18	21.8	5.9	1.6	4.3	39	49	60	26	5.1	51	91.8	10.19	19.8	7
178	51.2	18	128	1.52	5825.8	25.3	23.6	20	20.2	5.8	1.7	4.1	39	48	59	27	4.133	41.33	82.66	9.18	35.2	8
179	43	12	135	1.42	4320	20.8	18.5	15	22.5	5	2.5	2.5	48	57	68	25	5.2	52	78	8.66	19.5	9
180	57.2	18	132	1.71	6150.2	22.8	25.1	25	25.7	6.5	2.4	4.1	45	53	65	31	4.1	41	102.5	11.38	20.8	6
181	55.1	21	118	1.51	5572.5	24.5	23.8	22	24.9	6.2	2.2	4	48	53	63	29	3.8	38	83.6	9.28	11.8	7
182	52.3	20	128	1.62	6120.52	26.3	22.53	26	25	6.8	2.9	3.9	51	58	68	27	4.2	42	109.2	12.13	24.9	9
183	53.5	18	118	1.75	5320.52	24.5	25.2	21	22.5	5.89	2	3.89	48	53	63	30	5.2	52	109.2	12.13	53.29	7
184	51.8	15	113	1.8	5120.52	23.8	22.8	20	21.3	5.7	2.5	3.2	46	57	67	29	4.1	41	82	9.11	19.8	9
185	39.5	12	120	1.32	3952.58	19.8	17.9	17	17.5	5.01	2.3	2.71	46	56	66	25	3.9	39	66.3	7.36	20.7	7
186	44.8	16	115	1.25	4482.85	20.5	19.5	20	18.3	5.1	3.1	2	40	50	64	28	5.51	55.1	110.2	12.24	21.2	8
187	52.1	17	123	1.32	5235.75	25.3	23.6	22	20.5	6.3	3.1	3.2	39	47	57	31	4.2	42	92.4	10.26	17.5	7
188	48.2	20	135	1.35	5845.85	22.5	21.9	25	22.5	6.9	2.9	4	38	47	68	29	5.8	58	145	16.11	33.2	6
189	39.8	12	118	1.4	3845.45	20	24.9	17	20.8	5.8	2.1	3.7	49	57	77	26	6.2	62	105.4	11.71	24.8	7
190	48.1	15	112	1.22	4875.45	22.5	24	14	30.8	6	3	3	38	48	62	25	6.1	61	85.4	9.48	18.6	9
191	39.9	13	115	1.5	3950.8	28.4	19.5	20	28.2	6	2.1	3.9	48	58	68	28	5.8	58	116	12.88	54.2	10
192	48.9	16	110	1.62	4982.85	22.8	26.8	27	29.2	6.5	2.5	4	40	50	61	26	5.52	55.2	149.04	16.55	62.3	8
193	45.3	13	116	1.7	4752.82	27.2	22.8	25	18.5	6.3	2.8	3.5	42	52	52	29	6.2	62	155	17.22	21.6	6
194	47.7	16	112	1.53	5132.83	25.8	20.7	22	21.8	5.9	2.6	3.3	43	53	64	25	7.1	71	156.2	17.35	23.9	7
195	50.1	20	122	1.62	5850.5	23.5	22.5	30	23.5	6.9	2.55	4.35	39	49	62	26	4.8	48	144	15.99	22.5	5
196	38.3	12	110	1.32	3920.8	26.5	25.1	15	19.2	5.1	1.7	3.4	42	60	72	29	3.6	36	54	5.99	24.8	6
197	52.1	18	135	1.5	5240.12	29.5	29.8	32	25	6.85	2.5	4.35	47	52	75	30	5.1	51	163.2	18.13	19.2	8
198	46.8	17	115	1.42	4652.52	25.8	30.5	20	20.1	6.1	2.6	3.5	46	55	76	28	4.92	49.2	98.4	10.93	45.34	7
199	42.35	13	121	1.02	4023.53	26	20.2	17	19.8	5.01	2.3	2.71	35	48	62	30	5.5	55	93.5	10.38	18.5	7
200	45.2	20	118	1.6	5570.7	28.2	32.6	18	19	5.9	1.6	4.3	40	52	78	32	4.5	45	81	8.99	20.56	8

1) Plant height 2) No. of branches 3) No. of leaves 4) Stem girth 5.) Leaf area 6) Plant spread (N-S) 7) Plant spred (E-W) 8) No. of flowers 9) Stalk length 10) Flower diameter 11) .Disc diameter 12) Ray florets length 13) Days for first bud initiation 14) Days for first flowering 15) Days for 50 per cent flowering 16.) Duration of flowering 17) Individual flower weight 18) Ten flower weight 19) Yield per plant 20) Yield per hectare 21) Percent disease intensity 22) Vase life

SCREENING OF GENOTYPES AND F_2 SEGREGATING POPULATION OF CHINA ASTER (*Callistephus Chinensis* [L.] NEES.) FOR ALTERNARIA LEAF SPOT

NISHCHITHA N. **2016** **Dr. MUKUND SHIRAGUR**
MAJOR ADVISOR

ABSTRACT

An investigation was carried out on "Screening of genotypes and F_2 segregating population of China aster (*Callistephus chinensis* [L.] Nees.) for alternaria leaf spot." during 2015-2016 at Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi.

Sixteen genotypes were used in this experiment. Each genotype replicated three times. Among sixteen genotypes screened, cv. AAC-1 recorded resistant disease reaction under the both natural disease pressure and artificial inoculated conditions (12.53% and 14.23%). Two genotypes PG Pink (20.87% and 23.73%) and AAC-5 (23.41% and 24.60%) recorded moderately resistant reaction in both conditions. However, cv. Arka Poornima shown high susceptible reaction with the highest PDI (76.60% and 80.40%), AAC-1 can be used as a resistance source. Study on growth and flower yield of China aster genotypes revealed that the cv. PG White (71.37 cm) recorded the highest plant height. The genotype Arka Archana recorded highest numbers of branches (28.83) and flowers per plant. However the maximum flower yield (21.99 t / ha) was recorded by the cv. PG Pink.

Screening of F_2 population under natural disease pressure conditions revealed that both the crosses (AAC-1 x Arka Kamini and PG Purple x AAC-1) fit reasonably well to segregation ratio of 3 resistant : 1 susceptible. Estimates of high heritability with high genetic advance as per cent of mean (GAM) were observed for plant height, number of leaves, number of branches per plant, number of flowers per plant and flower yield per hectare in the both the crosses indicating the possible role of additive gene action. In general for all the characters studied in the two F_2 population *viz.,* AAC-1 x Arka Kamini and PG Purple x AAC-1 emerged as potential population for improving productivity and disease resistance in China aster. Among the genotypes studied, PG Pink and AAC-1 have emerged as promising genotypes.

C®£ÃðjAiÀ J¯ÉèÃ¥ÉgÉÃUÀ¼À ¤gÉÃzÀåÆÃV ZÀ¼ÉÄ D¸gï v¼ÀUÀ¼À ªÀÄvÀÄ J¥ïs-2 ¸ÀAÄÆ ºÀÄÄ¥À j²Ã®£É

¤²vÀJ£ï **2016** **qÁ. ªÀÄPÀÄ zÀ²gÀÀÄgÀ ¥ÀÄ£À ªÀÄUÀzÀÀÄPÀgÀ**

¸ÁgÁA±À

2015-16 £Ã ¸Á°£° QvÆgÄ gÁt Z£ªiÁ vÆÃlUÁjPÁ ªÄºÁ«zÁ®AiÄz ¥Äµ PÈ¶ ªÄvÄ GzÁ£«£Á¸ ±Á¸ «¨ÁUz° C®£ÃðjAiÄ J¯ZÄP gÆÃUz ¤gÆÃzPvUÁV ZÈ£Á D¸gï v½U¼Ä ªÄvÄ J¥ï-2 ¸ªÄÆºU¼ ¥j²Ã®£AiÄ ªÄÃ¯ CzAiÄ£ PÈUÆ¼¯ÁVvÄ.

ZÈ£Á D¸gï£ º¢£ÁgÄ v½U¼£Ä £È¸VðP gÆÃUz Mvq ªÄvÄ PÈvPªÁV C®£ÃðjAiÄ ²°ÃAzæ©ÃdPU¼£Ä ¹A¥r¹z JgqÄ ¹wU¼®Æ ¥j²Ã°¸¯Á¬Ävä. JgqÆ ¥j¹wU¼®Æ gÆÃU ¤gÆÃzPvAiÄÄ J J ¹-1 JA§ v½AiÄ° zÁR¯ÁVz (12.53% ªÄvÄ 14.23% C£ÄPæªÁV). ¦ f ¦APï (20.87% ªÄvÄ 23.72%) ªÄvÄ J J ¹-5 (23.41% ªÄvÄ 24.60% C£ÄPæªÁV) JA§ v½U¼° ªÄzªÄ gÆÃU ¤gÆÃzP ¥æÀAiÄÄ JgqÄ ¥j¹wU¼®Æ ªPªÁVz. CPÁð ¥Ætðª (76.60% ªÄvÄ 80.50% C£ÄPæªÁV) JA§ v½AiÄ° CwÃ ºZÄ gÆÃUz wÃªæAiÄÄ F ªÄÃ°£ JgqÄ ¹wU¼° PAqÄ§A¢z. DzjAz J J ¹-1 v½AiÄ£Ä gÆÃU ¤gÆÃzPvAiÄ ªÄÆ® v½AiiÁV §¼¸§ºÄzÄ. ««z v½U¼ ¨¼ªtU ªÄvÄ E¼Äªj AiÄ ªÄÃ¯ Cz¬Ä¹zÁU ¦ f ªmï JA§ v½AiÄ° Ujµ Jvgª£Ä (71.37 ¸A. «ÄÃ.) UªÄ¤¸¯ÁVz. CPÁð CZð£ v¼AiÄ° Ujµ ¸ASAiÄ gA¨U¼Ä (28.83) ªÄvÄ Ujµ ¸gÁ¸j ºÆU¼ ¸AS (41.37) zÁR¯ÁVz. ¦ f ¦APï v½AiÄ° Cv¢P E¼Äªj (21.99 l£ï) ¥æºPjU zÁR¯ÁVz.

£È¸VðP gÆÃUz Mvq ¥j¹wAiÄ° JgqÄ J¥ï-2 ¸ªÄÆºU¼£Ä (J J ¹-1 x CPÁð PÁ«Ä¤ ªÄvÄ ¦ f ¥¥ð¯ï x J J ¹-1) ¥j²Ã°¹zÁU 3:1 (¤gÆÃzP:¤gÆÃzPª®z) g C£Ä¥Ávz° ¸ªÄAd¸ªÁV ¨Ã¥ðnª. Cz¬Ä¹z JgqÆ ¸ªÄÆºU¼° ºZÄ C£ÄªA²ÃAiÄv ªÄvÄ f. J. Jªiï ª£Ä Vqz Jvg, J¯U¼ ¸AS, gA¨U¼ ¸AS, ºÆU¼ ¸AS ªÄvÄ ¥æ ºPÃjU ºÆ«£ E¼Äªj AiÄ° PAqÄ§A¢z.F J¯Á UÄt ®PtU¼° ¸AAiÆÃd¤ÃAiÄ fÃ£ï ¥æÀAiÄ ¥ÁvæPAqÄ§A¢gÄvz.

¸ÁªiÁ£ªÁV Cz¬Ä¹z J¯Á UÄt ®PtU¼ ¥æÀég ¦ f ¦APï ªÄvÄ J J ¹-1 v½U¼Ä C¢P E¼Äªj ºÁUÆ gÆÃU ¤gÆÃzPvAiÄ£Ä ºÆA¢ª JAzÄ PAqÄ§A¢z.