CHARACTERIZATION OF CHRYSANTHEMUM GERMPLASM

BY

MD. HASINUR RAHMAN

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Approved by:

Dr. Kabita Anzu-Man-Ara
Senior Scientific Officer
Floriculture Division
HRC, BARI, Gazipur
Supervisor

Prof. Md. Ruhul Amin
Dept. of Horticulture and Postharvest Technology
SAU, Dhaka.
Co- supervisor

Prof. A.K.M. Mahatabuddin
Chairman
Examination Committee

উদ্যানতত্ত্ব গবেষণা কেন্দ্র
Horticulture Research Centre
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701, Bangladesh

Fax : 880-2-9261495
Tel. 9252529
E.mail: director_hrc@yahoo.com
directorhrc@gmail.com

CERTIFICATE

This is to certify that the thesis entitled, "**Characterization of Chrysanthemum Germplasm**" submitted to the Department of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **Md. Hasinur Rahman, Registration No. 03-01089** under my supervision and my guidance. No part of the thesis has been submitted for any other degree in any institutes.

I further certify that any help or sources of information, received during the course of this investigation have been duly acknowledged.

Dated: December 2008
Dhaka, Bangladesh

Dr. Kabita Anzu-Man-Ara
Senior Scientific Officer
Floriculture Division
HRC, BARI, Gazipur
Supervisor


DEDICATED
TO MY
BELOVED PARENTS

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ABSTRACT

The experiment was carried out at the Landscape, Ornamental and Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh during July 2007 to June 2008. Twenty seven germplasm of chrysanthemum were evaluated and characterized in respect of yield and yield contributing characters to select promising line(s). The results indicated the existence of wide variability among the germplasm on their physio-morphological characters along with yield and yield attributes. The genetic parameters, correlation and path coefficient analysis revealed that stalk length, flower number, flower size, sucker number and vase life were the most important traits to be selected for the development of chrysanthemum. Based on these selection criteria, the germplasm CM-004, CM-015, CM-022, CM-023, CM-024 and CM-025 were identified as good germplasm for cut flower and CM-009, CM-012, CM-018, CM-019 and CM-021 for pot culture. The effect of different potting media like soil, cocodust and rice husk was used singly and in combination on morphological and floral characteristics of chrysanthemum. The highest number of flowers (40), the longest stalk (13.3 cm) and maximum durability of flowering (40 days) was produced by coco dust medium. There were six pinching like without pinching, once 40 days, once 50 days, once 60 days, twice 40 and 50 days and thrice 40, 50 and 60 days. Maximum number of leaves (235), branches (12) and flowers (45) were produced by pinching thrice in chrysanthemum. Foliar application of 150 ppm GA_3 was the best for obtaining maximum number of cut blooms (40) with longer stalk (15 cm) as well as big flower size (7.3 cm).

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The Author

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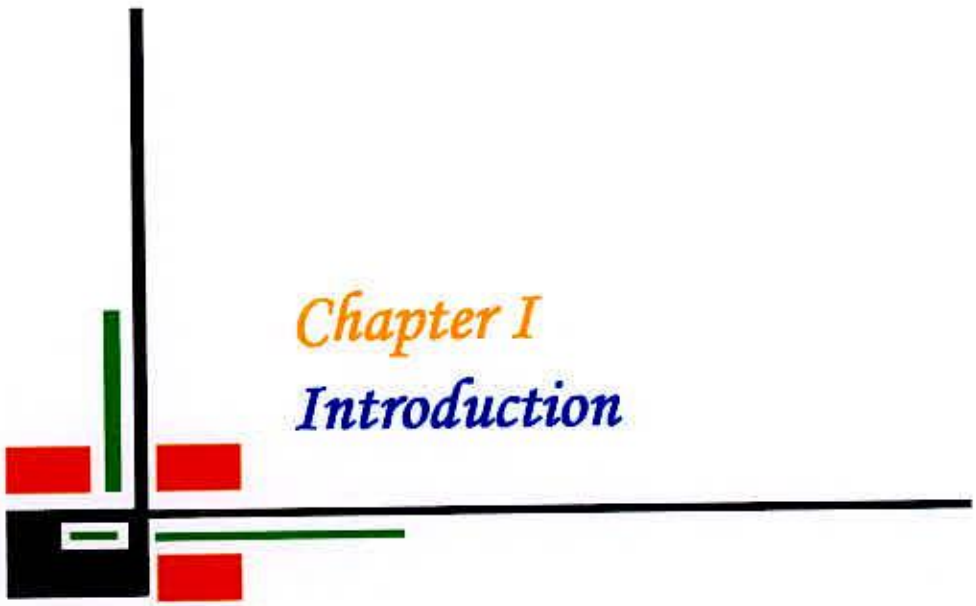
LIST OF ABBREVIATIONS

ABBREVIATION	EXPANTION
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
CCC	Cycocel
CRD	Completely Randomized Design
DMRT	Duncan's Multiple Range Test
et al	And others (at elli)
e.g.	For Example
etc.	*Et cetera*=and others
g	Gram
GA_3	Gibbrellic Acid
GCV	Genotypic Coefficient of Variation
HRC	Horticulture Research Centre
i.e.	*id est*= in other words
LSD	Least Significant Difference
MH	Maleic Hydrazide
mg	Milli gram
mm	Millimeter
MP	Muriate of Potash
^{o}C	Degree Celsius
PCV	Phenotypic Coefficient of Variation
P^{H}	Hydrogen ion concentration
ppm	Parts Per Million
RCBD	Randomized Complete Block Design
RH	Relative Humidity
SAU	Sher-e-Bangla Agriculture University
Kg/ha	Kilogram Per Hectare
TSP	Triple SuperPhosphate



Chapter I
Introduction

CHAPTER I
INTRODUCTION

Chrysanthemum (Chrysos, golden; anthos, flower) is a popular flower crop of commercial importance. It belongs to the family Compositae and has been commonly grown in gardens for more than 2500 years (Singh, 1995). It has no rival as a cutflower for versatile beauty and even economy and they often remains in good condition for two to three weeks depend on cultivars (Tewari and Shankar, 1994).

The wide variation exhibited by the large number of cultivars in respect of growth habit, size, colour and shape of blooms make them suitable for every purpose conceivable of a flower. The erect and tall growing cultivars are suitable for background planting in borders or for use as cutflowers. The cultivars with the dwarf and compact growing habit, on the other hand, are suitable for front row plantation or pot culture. The decorative and fluffy bloomed cultivars are ideal for garland making and hair decoration. The extra large- bloomed cultivars are prized for their exhibition value. Cut blooms are also used in cemeteries in Japan (Matsuo, 1990). Different morphotypes are also grown in Bangladesh. Most of them are flowered in winter season. Genetic variation for flower yield and its component character were not properly assessed in the past. Dadlani (2003) reported that some high yielding exotic varieties were introduced in this country during early seventies. Some of them have become well adapted to our agro climates. In recent years, demand of them as pot plant for house decoration and for use in an amenity horticulture has also steadily increased.

Though it is an important commercial flower crop but limited attempt had been made for its genetic improvement (Negi *et al.*, 1994). An understanding of the nature and magnitude of variability among the genetic stocks is the prime importance to the breeder. A good knowledge of genetic wealth might help in identifying desirable genotype for commercial cultivation. The Floriculture Division of HRC, BARI, Gazipur, has a collection of 25 genotypes of Chrysanthemum with wide variabilities both in respect of plant and floral characteristics. Expression of different plant characters are controlled by genetic and environmental factors. It is often difficult to know the proportion factors of heritable and environmental variation. The progress of breeding conditioned by magnitude, nature and

interaction of genotypic and environmental variations in the plant characters. So, the study of genetic parameters is necessary for breeding programme. This will provide valuable information on mode of inheritance of different characters that would be useful in selecting plants with desirable characters to develop new varieties or promising genotypes.

For commercial cultivation, quality flower production is important in Chrysanthemum (Kher, 1988). A prerequisite of good quality cut flowers is that a large number of flowers should be borne on long stems with healthy and pest and disease free foliage. Good quality flower production depends upon various factors such as genotype, environment, spacing, disbudding, pinching, substrate, use of growth regulator etc. (Jayathi and Gowda, 1988; Dutt *et. al.*, 2002; Moond and Rakesh, 2006). However, there was no information available on the effect of pinching, substrates and use of growth regulator on quality flower production of Chrysanthemum in Bangladesh. So, it is necessary to find optimum substrate, use of growth regulator and pinching time for better growth and yield.

Demand of flowers of Chrysanthemum has been increasing recently both in local and international markets. At present, some NGOs like BRAC and PROSHIKA, private Companies, Dipta Orchids Ltd, Wonderland Toys Ltd., Micro Orchid Ltd., Omni Pvt. Ltd. and some reputed nurseries such as Krishibid Orchid and Cactus Nursery, Krishibid Upakaran Nursery, Sabuj Nursery, Kingshook Nursery etc. have started commercial production of Chrysanthemum. They need superior genotypes to get quality cut flowers for competition in local and world markets. So, there is an urgent need of research for selection of superior germplasm(s) of Chrysanthemum and their quality flower production. Therefore, the study on "Characterization of Chrysanthemum germplasm" was undertaken with the objectives as below:

i) To study the physio-morphological characters of Chrysanthemum germplasm,
ii) To identify superior Chrysanthemum germplasm(s) under Bangladesh condition for commercial production and
iii) To produce quality flower of Chrysanthemum through use of growth regulator, pinching and potting media.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Among the flowering annuals, Chrysanthemum is one of the most commonly cultivated both for cut flowers as well as loose flowers (Dhua, 1999). A few number of research works have been done all over the world by different workers on characterization, genetic variability, correlation studies, effect of growth regulators , pinching and substrates on quality flower production of chrysanthemum but information is meager under climatic conditions of Bangladesh. Therefore, information available in the literature pertaining to those aspects of chrysanthemum and other flowering crops have been reviewed briefly and presented below:

Variability

The extent of existing genetic variability of genotype of a crop plant is an index of its genetic dynamism (Luthra *et al.*2006). Plant breeding revolves around selection, which can be effectively practiced only in presence of variability of desired traits. Hence the success of breeding depends entirely upon the variability.

Singh and Mandhar (2004) observed appreciable variability for plant height, stalk length, flower number, flower colour, flower diameter, floret number, and shelf life in gerbera.

According to Bose *et al.* (2003), a high value of genotypic and phenotypic coefficient of variation was observed in gerbera for early flowering, flower number, flower diameter and vase life of stalk.

Evaluation of 25 china aster germplasm were done by Chadha in 1986 at the Indian Institute of Horticultural Research, Bangalore. He observed 'AST-1'and 'AST-2' were found to be promising. In F_1 generation, heterotic effects were observed for earliness in flowering, stalk length, number of flowers per plant and size of flowers. 'AST-1' performed better than local varieties with regard to stalk length, colour, size shape and number of flowers.

Khan *et. al.*, (2003) observed highly significant variation among the entries of chrysanthemum in respect of plant height, number of flowers per plant, yield of flowers per plant, diameter of

flower, stalk length and vase life of flowers. Yield per plant of different chrysanthemum genotypes was found highly correlated with number of flowers per plant.

Misra and Mohanty (2003) assessed the magnitude of genetic divergence among eighten dahlia genotypes at regional plant genetic resource centre at Bhubaneswar, India in order to identify suitable types for commercial use directly and/or through hybridization late flowering genotypes Croydon Monarch Red, Thelma Davidson, Kenya White, Kenya Gerua and Kenya Bicolour with less number of large sized flowers and short ornamental crop duration in one hand and early flowering were identified.

Several dwarf and compact-growing varieties like 'Arun singar' 'Sharad singar', 'Hemant singar' and 'Suhag singar' chrysanthemum were evolved by Kher (1997) at the NBRI, Lucknow, which naturally posses the desired characters rendering other methods of growth regulation unnecessary.

Misra *et al.*, (1999) carried out an experiment to observe performance of some chrysanthemum (*Chrysanthemum* spp.) cultivars under the agro-climatic condition of North Bihar, India. Eleven cultivars of chrysanthemum were evaluated for growth and flowering parameters during 1996-97. Cultivars 'Puja', 'Syamal', 'Kundan', and 'Jayanti' were promising under North Bihar conditions.

An appreciable range of variability was noticed for the various character of hippeastrum studied (Tejaswini *et al.*, 1994). The phenotypic coefficient of variability observed for number of flowers per spike, spike length and vase life indicates the possibility of developing varieties containing long spike with more flowers as well as longevity of individual floret.

In a study with chrysanthemum at NBRI, Lucknow, dwarf cultivars were used by Cockshull (1976) for enterior decoration as such or can also be transplanted in flower vases in a group of 3 or 4 to make artistic arrangements like cut-flower arrangement, or in flat trays to make attractive landscapes in conjunction with other items such as mini-huts, streams, ponds and hillocks.

Training chrysanthemum plants in different attractive styles in an art in which the Japanese growers have attained perfection. Recently, at the NBRI, Lucknow, a few other highly attractive

styles like cascade, sen-rin sukuri, hanging baskets and various deviations of miniculture have been successfully tried and popularized (Chadha, 1997).

Studies conducted by Prakash *et al.*, (1994), at Punjab Agricultural University through selection of suitable cultivars belonging to the thermozero group extending the photoperiod by artificial lighting of the stack plants, production of cut blooms could be extended up to April to June. They again reported that 'Jwala' and 'Jyoti' variety of chrysanthemum were suitable for summer.

Twelve genotypes of chrysanthemum were evaluated. Tewari and Shankar (1994) found that plant height, flower size, plant spread, flower number, shelf life and sucker number had positive direct effects on flower yield.

Studies were conducted in eleven varieties of African Marigold in India. Janakiram and Rao (1994) carried out to assess the variability and nature of relationships prevailing amongst yield and related components. Highly significant varietal differences and a wide range of phenotypic variability of all the characters were found.

Twelve new varieties of chrysanthemum developed in India were evaluated along with three local varieties by Negi *et al.* (1994). In the yellow-coloured flower group, Basanti was the highest flower yielder and would be good for loose-flower purposes. The variety Indira was suitable as a cut flower as well as loose flower. Among the red/pink coloured flower group, the variety Red-Gold gave the highest flower yield, followed by 11HR-Sel.5. Both would be good as loose flower as well as cutflowers. In the white-coloured flower group, 11HR-Sel.6. gave the highest flower yield and good as a loose flower.

Various quantitative traits of China aster were estimated by Raghava and Negi in 1994 at Indian Institute of Horticultural Research, Bangalore. Variation due to additive effects was found controlling the traits flower size and ray florets per flower head. These two characters can be improved in the desired direction through selection. Other traits like plant height, main branches per plant, lateral branches per plant, plant spread, days to flower, flowers per plant, stalk length, flower weight, flowering duration and vase life showed preponderance of dominance components over the additive components in their expression.

Germplasm of chrysanthemum was screened at 11HR, Karnataka for growth and flower characteristics. Chadha and Choudhury (1997) reported that 'Red Gold' and 'Indira' variety of chrysanthemum gave higher income than a commercial variety 'local yellow' in farmer's field.

In a varietal trial of chrysanthemum at the NBRI, Lucknow with ten cultivars 'Apsara', 'Birbal Sahni', 'Jayanthi' and 'Kundan' have been recognized by Sane (1997) as much superior to existing ones for cut flower owing to their attractive blooms borne on erect stems and long-lasting quality.

Twenty six germplasm accession of chrysanthemum were evaluated by Hemalata *et al.* (1992) for yield and yield components to study the extent of variation in different quantitative traits. Highest phenotypic and genotypic coefficients of variation were recorded for flower yield followed by flower number, sucker number, vase life, plant height and flower size. Qualitative traits also showed wide variability among the genotypes.

Heritability and genetic advance

Heritability is the degree to which variability of quantitative characters is transmitted from parent to the offspring. So the estimation of heritability is of great interest to the breeders primarily as a measure of the value of selection for particular characters in various types of progenies and as an index of transmissibility. A quantitative character having high heritability is transmitted from parent to offspring conveniently. In broad sense, heritability is the ratio of genetic variance to the total variance expressed in percent. In narrow sense, it is only a portion of genetic variance, which is due to additivity of genes.

Mahanta *et al.*, (1998) studied on variability in gerbera (*Gerbera jamesonii*). Ten cultivars of gerbera were evaluated for 14 characters in trials conducted at Assam Agricultural University. For all these characters, data are tabulated on range, mean, genotypic and phenotypic coefficient of variability, heritability and genetic advance. Plant height, vase life, flower size exhibited greater genetic variability and high heritability coupled with high genetic advance.

Productivity is mainly determined by the additive effect of genes. High heritability for flower diameter and number of ray florets and relatively low for disc diameter and stalk length in chrysanthemum was studied by Bose *et al.* (2003).

Janakiram and Rao (1994) carried out an experiment to assess nature of relationships prevailing amongst yield and related components in eleven varieties of African marigold in India. Characters such as days to flower, plant height, flower weight and number of flowers per plant of exhibited a high value of heritability.

Thirty- eight genotypes were evaluated by Rao and Negi (1994). Studies on variability, heritability and genetic advance were conducted on 12 biometric characters in China aster. Highly significant differences were observed among the genotypes. Heritability in the broad sense was medium to high and genetic advance as percentage of mean was high for flower weight, number of ray florets per head and number of laterals shoot per plant. Thus, selection based on these traits would be very effective for further improvement of China aster.

Shanmugam *et al.* (1972) reported maximum heritability estimates for the characters for flowering days, plant height, flower diameter, stalk length and flower number in chrysanthemum.

A study was undertaken by Aswath and Parthasarathy in 1993 to estimate the heritability, the degree to which important traits are related and also to define correlation among parameters using frequencies significant correlations in china aster. The estimates of heritability and co-heretability indicated that all the characters showed high heritability as well as co-heritability suggesting the use of these characters for selection in china aster. Certain characters like plant spread with stalk length showed medium to low heritability.

Misra (1999) studied genetic parameters in chrysanthemum. Stalk length, flower number and sucker number had high broad sense heritability, high genetic advance indicating the success of direct selection.

Singh and Dadlani (1988) reported that the estimated heritability values in gladiolus were 19% for plant height, 20% for flower diameter and nearly 46% for spike length.

In a study with Gladiolus, Sharma and Sharma (1984) found that the estimate of variances for the characters spike length, rachis length and vase life was significant.

Raghava *et al.* (1992) reported that heritability in the broad sense was medium to high and genetic advance as percentage of mean was high for stalk length, flower number and sucker number per plant in chrysanthemum.

Negi *et al.* (1981) observed very high heritability (84.45) and medium genetic advance as percent of mean (42.30) for flower number but flower diameter showed medium heritability (60.39 and 36.91) and low genetic advances as percent of mean (20 .65 and 25.30) in gladiolus. Cormel diameter showed medium heritability (53.93) and genetic advance as percent of mean (44.45).

According to Katiyar *et al.* (1974) heritability value alone provides the indication of the amount of genetic progress that would result from selecting the best individual. They mentioned that heritability along with genetic advance would be more useful in predicting yield under phenotype selection than heritability estimation alone. Genetic advance measures the differences between the mean genotypic values of the few selected line and mean genotypic values of the original population, upon which expected genetic gain resulting from selection of superior individuals can be drawn by experimenter.

The extent of genetic variability, heritability and genetic advance as percent of mean in respect of ten quantitative characters in twenty germplasm of chrysanthemum was studied by Behera *et al.* (1992). There was high phenotypic (46.01%) and genotypic coefficient of variation (45.98%) for number of flowers followed by number of suckers/plant and flower weight and vase life indicating the extent of variability based on these characters. High heritability and genetic advance as percent of mean was observed for number of flowers/plant and flower weight which ranged from 13.20 to 58.76 and 1.46 to 5.83 g respectively, showing high heritability (99.90%) coupled with high genetic advance as percent of mean.

Correlations

Yield, the ultimate goal for a plant breeder, is the outcome of the interaction of a number of factors inherent both in the plants and in the environment in which the plant grow. Yield is a complex character, which is not only controlled by genetically but also influenced by its component characters.

Anuradha and Gowda (2000) studied the association of cut flower yield with growth and floral characters in gerbera. In studies on 25 gerbera genotypes at Bangalore, cut flower yield exhibited

a high level of positive and significant correlation with number of leaves per plant, weight of ray florets and days taken to flower opening.
Negi *et al.* (1994) found that plant height, flower size, plant spread, flower number showed highly significant correlation coefficients with flower yield in chrysanthemum.

Association analysis of chrysanthemum by Kher (1997) indicated number of flower and flower size had significant positive correlation with flower yield.

Shanmugam *et al.* (1972) carried out an experiment on interrelationship between yield and certain growth and floral attributes of two chrysanthemum varieties in India. They noted that association between flower size and flower yield per plant was positive and significant whereas flower size had negative and significant correlation with flowers per plant. They stated that number of flowers per plant was positively correlated with flower yield per plant.

A correlation coefficient at genotypic and phenotypic levels among the seven traits studied by Bhattacharjee and Wahi (1982) in dahlia showed that genotypic correlations were on the higher side. Path analysis of 39 genotypes indicated that flower diameter, plant height, longevity of flowers and number of branches were important component character for the number of flowers per plant.

Correlation was studied by Raghava *et al.* (1992) in seventeen genetically diverse stocks of small flowered chrysanthemum at Indian Institute of Horticultural Research, Bangalore. Flowers per plant and flower yield per plant were recorded to have high genotypic coefficients of variation as compared to other characters studied. These two characters had high heritability and genetic advance (per cent of mean) together. Flower yield per plant showed positive and significant association with plant height, days to flower, flower size and flowers per plant.

Correlation response was studied by Arora and Khanna (1986) on 28 gladiolus genotypes and positive significant correlation were found for plant height and spike length at both genotypic and phenotypic levels.

A positive correlation was found between bigger trans floret diameters in large flowers with vase life in chrysanthemum (Ragahava, *et al.* 1992) whereas length of stalk and number of flowers had failed to show any correlation with vase life.

A study by Misra (1999) of the various yield- contributing characters in chrysanthemum revealed that all the genotypic correlation coefficients were higher than the phenotypic. The floret diameter was highly significant and positively correlated with floret length, stalk length and plant height.

Bose *et al.* (2003) carried out correlation study of 22 chrysanthemum genotypes and reported that flower number and flower size was significantly associated with yield.

A study was conducted with 20 chrysanthemum varieties to study the association among 10 characters by Parthasarathy and Shah in 1984. They reported that plant height along with flower and sucker characters such as flower number, weight of flower, weight of flower stalk, stalk length, vase life and sucker number per plant could serve as selection indices in chrysanthemum improvement programme.

Misra *et al.* (1992) studied variability and coefficient of correlations of nine characters like plant height, flower weight, number of flowers per plant, days to first flower and diameter of first flower. They reported that number of flowers per plant showed positively significant correlation with plant spread, whereas days to flower had negative correlation with plant spread. Selections of varieties like 'Golden Glory' and 'Annapurra' would be of importance in the improvement of dahlia as they had showed maximum excellent performance for some of the desired characters like plant spread, number of flowers per plant and number of shoots per plant as these are of primary importance in dahlia crop.

A trial was carried out by Misra *et al.* (1990) dahlia varieties under late planted condition in calcareous soil of plains at Samastipur, India. It was inferred that varieties differ greatly in respect of growth, flowering and flower yield.

Path analysis

Path analysis helps to find out the direct and indirect causes of association. Path coefficient analysis is a standardized partial regression coefficient analysis and as such measures the direct influence of one variable upon other and allows the partitioning of correlation coefficient onto direct and indirect effects of component characters. So it is used to analyze the real contribution of individual complex character in yield.

Path analysis revealed that number of leaves per plant had the greatest positive direct effect on flower yield in chrysanthemum (Bose *et al.*,2003).

Machin and Scopes (1978) studied the association of cut flower yield with growth and floral characters in chrysanthemum. In studies on 25 chrysanthemum genotypes at Bangalore, cut flower yield exhibited a high level of positive and significant correlation with number of leaves per plant, weight of ray florets and days taken to flower opening. Path analysis revealed that number of leaves per plant had the greatest positive direct effect on flower yield.

The path analysis in gerbera revealed that leaf area, girth of stalk and days to flower bud opening had high direct effects (Mahanta *et al.*, 1998). The significant positive correlation of leaf area with flower number/clump could thus be attributed to the high positive direct effect of the characters.

Anuradha and Gowda (1994) analyzed data on yield per plant of 24 gladiolus genotypes and indicated that number of flowers had the largest direct position contribution to yield, followed by rachis length.

Data on yield contributing characters from 23 gladiolus genotypes were analyzed by Neil and Raghava (1994). They observed that maximum direct effect towards yield through rachis length followed by plant height and flower number.

Teijaswini *et al.* (1994) reported that the phenotypic coefficient of variation in spike length of tuberose was observed comparatively low (23.25%) while the range for this character indicated possibility for improvement. By utilizing the character of more spikes per bulb the cut-flower yield could be increased in the varieties of tuberose to be developed

Path analysis of flower yield and its component revealed that days to flower and flowers per plant had direct effect on flower yield per plant in chrysanthemum. Days to flower also influenced flower yield indirectly through flowers per plant. Plant height and flower size exerted indirect effect on flower yield through the number of flowers per plant and plant height, respectively. They suggested that flower number, the main component of flower yield, would be given maximum emphasis in selection programme (Bose *et al.* 2003).

Kher (1988) studied path coefficient analyses of 6 characters in chrysanthemum and reported that plant height, stalk length, shelf life, sucker number and flower number had positive directed effects on flower yield.

Lai *et al.* (1984) reported that highest direct positive effects on flower yield through number of flowers per plant (0.48) followed by rachis length (0.19). The results indicated that number of flowers and rachis length as selection criteria for improving gladiolus flower yield.

Media

Acati and Devecchi (1994) observed no significant differences in plant growth or flowering when peat amended with 50% sewage sludge and peat + pumice with 50% sewage sludge, indicating a commercial possibility for reducing the quantity of peat required for pot carnation culture and consequently lowering the production costs.

The effect of substrate on the quality of flowers was dependent on the nutrient solution used. Dittrich (1980) carried out trials with low moor peat, FYM and pine tree bark, in various proportions, to make 7 substrate mixtures with a depth of 10 or 20 cm. Several mixtures gave good growth and high yields.

Volf *et al.* (1985) observed that carnation flower yield in winter was slightly higher in the bark-peat mixture but total yield was 85% higher in soil with cocodust.

Incorporating cocodust and soil (1:1) showed better results with chrysanthemum seedlings as they were heavier and produced more leaves (Anderson, 1990).

Quality cut flowers of chrysanthemum were obtained from a glasshouse and in cocodust medium (Acock and Pachepsky, 1996). Cermeno (1989) also found that cocodust with peat was suitable for growing chrysanthemums.

Raju *et al.* (1997) hardened the *in vitro* rooted *Dendrodium* plantlets using coir dust, perlite and vermicompost in the ratio of 1:1:1 (v/v) under mist conditions and successfully established in the Orchidarium.

A study on the effect of media on orchid plantlets were assessed by Ara (2005). The cocodust medium gave good results for plantlet establishment.

Kaptan (1985) found alluvial soil, peat manure, sand and cocodust in the ratio of 2:1:1:1 as the best growing medium for greenhouse cut flower production in carnation.

Rao (1985) reported that terrestrial orchids like *Spathoglottis, Paphiopedilum, Phaius* and *Calanthe* had grown well in 20-25 cm pots with 1: 1: 1 mixture of cocodust, FYM and soil.
The production of more flowers as well as long stalk length of chrysanthemum were observed in soil with cocodust medium (Longton, 1984).

Among various treatments, cocopeat + soilrite, soilrite + compost and cocopeat + compost showed overall improved growth and quality flower production in chrysanthemum (Dutta *et al.* 2002.)

Starck *et al.* (1991) found plants grown in peat + cocodust mixtures had longer stems and bigger flowers than those grown in peat or sawdust alone in carnation.

Kaplan (1999) reported that carnation plants grown in spil with cocodust @ 1:1, gave the best cutflower yield.

Commercially desirable chrysanthemum plants with the highest number of flower buds were produced in a 1:1 mixture of soil and cocodust (Dallon, 1988).

Bose *et al.* (2003) observed that best plant growth and flowering of chrysanthemum plantlet was obtained in a 100% cocodust medium.

Barman *et al.* (2006) reported that maximum flower yield of *in vitro* grown rose in respect of number of flowers/m^2 per year and per month were recorded when grown in the media combined with 1 soil: 1 comdust.

The well-rooted gerbera plants were transferred from the jars and transplanted singly into polythene bags containing soil and coco dust (1:1). The *in vitro* raised plants showed a high degree of uniformity in growth, number of petals and in size; and the colour of the flowers were found similar as in *in vivo* plants (Aswath *et al.*, 1995).

Dutt *et al.* (2002) reported that among various treatments, coco peat + soil rite, soil rite + compost and coco dust + compost showed overall improved growth and flowering performance with more numbers of leaves/plant, earliest flowering and improved quality aspects like flower diameter, stalk length and girth and numbers of flowers/plant in chrysanthemum.

Pivot (1985) conducted the use of different growing media in greenhouse chrysanthemum cut flower production. Perlite, peat, pumice and cocodust were used either alone or in combination for cut blooms of chrysanthemum. The effects of these growing media on flower yield and quality were investigated. After 15 months, the highest total flower yield (70.31 flowers/plant) was obtained from the plants grown in peat + cocodust (1:1, v/v), followed by plants grown in peat (67.71 flowers/plant).

The effect of cocodust perlite, coal cinder or a 1:1 mixture of rice chaff and perlite on seedling survival and root growth were investigated for chrysanthemum growing in tissue culture. Cocodust was the best medium for plant survival (93.8% survival); coal cinder was the worst medium. Better root growth was also observed in the cocodust treatment (Li *et al.* 1998).

Acclimatized gerbera plants were transferred to polythene bag containing equal amount of soil : sand : farmyard manure, where better establishment with 95-100% survivality was observed (Parthasarathy and Nagaraju, 1995).

Chrysanthemum plantlets was cultivated on three substrates (Zeolite, perlite and cocodust) and yield and quality of flowers was recorded during one year growing cycle. Significant differences

in yield, flower quality and photosynthetic rate was noticeable in plant grown in the mixture 1:1 perlite to cocodust medium (Pierik *et al.* 1982).

Pinching

The flower quality was improved by pinching in chrysanthemum. Zuker *et al.* (2001) studied the effect of pinching on the growth, productivity and quality of carnation flowers cv. Nora. They observed that pinching twice 40 and 60 days after planting increased flower production as well as improved vase life.

Investigations carried out in different parts of India have clearly indicated that in both African and French marigold , flower production was markedly improved by application of N, P, K, @ 80, 40, 80 kg/ha and pinching twice (Bose *et al.* 1999).

Datta and Gupta (1983) reported that chrysanthemum was pinched at least twice to induce more branching, more production of leaves and flower.

Son and Byoun (1995) reported that pinching twice or thrice play important roles in keeping quality cut flowers as well as production of more number of branches and flowers in carnation.

Flower and seed production of marigold was significantly increased with P application with thrice pinching (Anuradha *et al.* 1990). Moustafa and Morgan (1983) also reported pinching was effective in quality flower production of chrysanthemum.
In order to promote branching and number of flower, pinching was done by Bose *et al.* (2003) after two or three pairs of new leaves appear in dahlia.

Swami (1985) reported that pinched dahlia plants produced more flowers, flowered later, had smaller flowers and were taller than non- pinched controls. On an individual plant basis, pinching at node 4 generally gave the best result while pinching at node 2 resulted in the maximum delay and lowest number of flowers.

Patel and Arora (1988) reported that pinched carnation plants with single strong shoot, at node 3 or 4 resulted in the best compromise between increased flower production and delayed flowering and increased plant height.

Experiment on pinching of marigold revealed that removal of shoot apices 40 days and 50 days after transplanting enhanced the flower yield, late planting at 60 days proved less effective in this respect (Singh and Sen, 2000).

In tall cultivars of marigold, pinching was done at 40 to 50 days after planting to produce short plants, quality blooms and more number of flower production (Arora and Khanna, 1986).

The application of pinching significantly influenced the number of flowers and sucker production in chrysanthemum (Ravindran *et al.*, 1986).

The effect of interaction between spacing and pinching in marigold were found highly significant (*Ravin dran et al.*, 1986). The highest number of flower yield and seed yield in marigold was recorded under 30cm×30cm spacing with twice pinching.

Pinching is an important cultural management practice for obtaining good quality bloom of chrysanthemum (Jayanthi and Gowda, 1988). Among the different treatment combinations of pinching used on chrysanthemum, thrice pinching showed the best effect with regard to flower production, vase life and flower quality.

Growth Regulators

Panwar *et al.* (2006) studied the effect of gibberellic acid sprays on growth, flowering, quality and yield of bulbs in tuberose. Among all the treatments, application of GA_3 @ 100 ppm was found best resulting in more number of leaves/plant and early initiation of spike and that too in more number/hill. Length and weight of spike and number of flowers per spike were found maximum in this treatment. Yield of bulbs per plant was also maximum in this treatment.

A field experiment was carried out by Moond and Rakesh (2006) on chrysanthemum to study growth and flowering response of GA_3 (50, 100, 150, 200 and 250 ppm), CCC (2000, 4000, 6000, 8000 and 10,000 ppm) and MH (250, 500, 750, 1000 and 1250 ppm). Minimum plant height was recorded with MH at 1250 ppm, while the shortest internode and maximum number of internodes were produced with 10,000 ppm CCC. GA_3 treated plants showed significant increase in plant spread. Growth regulators GA_3 had positive impact on the production of

number of leaves, number of sucker and flowers, whereas CCC produced less. GA_3 also caused faster initiation of flowering and CCC and MH delayed it. Length of flower stalk significantly increased with GA_3. Use of GA_3 also showed an increasing vase life of flowers. In this study, they reported that foliar application of 150 ppm GA_3 was the best for obtaining better growth of plants, maximum number of cut blooms with longer stalk as well as bigger flower size.

Talukdar and Paswan (1988) studied the effect of growth regulators on the flowering of chrysanthemum. The number of flower/plant, flower size and vase life increased with increasing concentration of GA_3 @150 ppm.

A study was conducted by Verma *et al.* (1995) on chrysanthemum at different concentrations of GA_3, CCC and MH. They reported that 150 ppm GA_3 produced the significantly highest number of flower, leaf spread, sucker number as well as prolonged vase life in chrysanthemum.

Khan and Tewari (2003) studied the effect of growth regulators on growth and flowering of dahlia. Two growth regulators, viz. gibberellic acid (30, 60 and 90 ppm) and chlormequat (2000, 4000 and 6000 ppm) when tried with dahlia revealed that 90 ppm gibberellic increased plant height and leaf area maximally, while 6000ppm chlormequat resulted in maximum reduction.Flower diameter, shelf life and number of flowers were observed maximum with 4000 ppm chlormequat.

Sen and Maharana (1972) reported that growth, development and flowering of chrysanthemum were significantly increased under GA_3 @100-150 ppm, whereas increase in concentration of gibberellic acid @ 250 ppm increased plant height and leaf area.

Matukin and Makisimova (1960) studied the effect of GA_3 on growth and development of chrysanthemum. The results indicated that maximum flowering, number of branches, number of 'A' grade quality flower were recorded in 150 ppm GA_3 followed by 100 ppm GA_3.
Growth regulators have been found to influence the growth and flowering of Gerbera. In gerbera, treatment with low concentration of GA_3 (50 ppm) resulted in early flowering whereas CCC at 500 ppm promoted flowering in both the season while at 750 ppm fewer number of heavy flowers were produced (Bose *et al.* 2003).

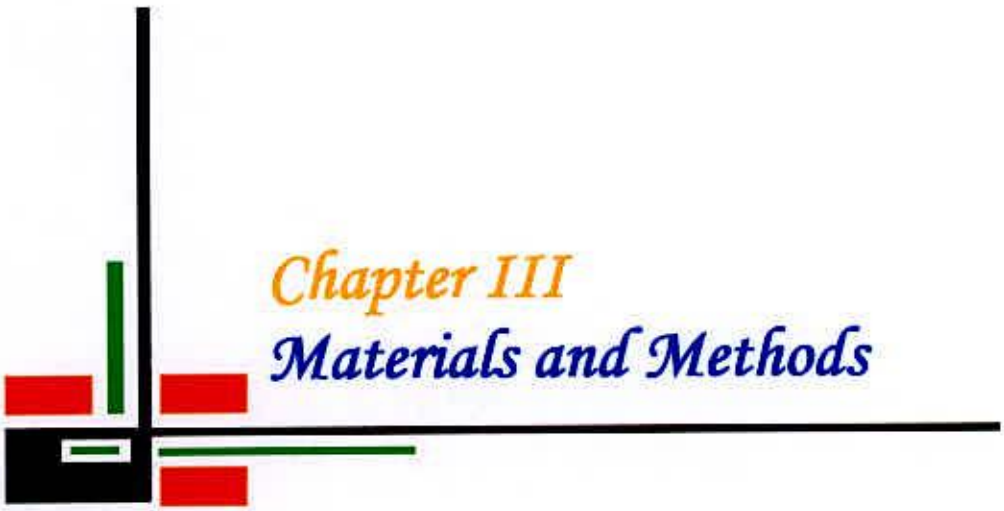
A study was undertaken by Khan and Tewari (2003) to note the effect of growth regulator on growth and flowering of dahlia. Two growth regulators, viz. gibbrellic acid (30, 60 and 90 ppm) and chlormequat (2000, 4000 and 6000 ppm) when sprayed on dahlia revealed that 90 ppm gibbrellic acid increased plant height and leaf area maximally whereas flower diameter, shelf life and number of flowers were observed maximum with 4000 ppm chlormequat.

Foliar application of 100 ppm GA_3 at monthly intervals from January to May was the best treatment for obtaining best growth of plants, maximum number of cut blooms with stalk length as well as flower size in gerbera meeting the global standards cut flower trade (Sujatha *et al* 2002).

In an experiment on carnation, Verma *et al.* (2000) found improved flower quality and better sucker multiplication when the plants were sprayed thrice with 100 ppm of GA_3.

In a field trial in Kanpur, Prakash and Jha (1998) observed that GA_3 treatment at 150 ppm improved all the floral traits (time of flowering, inflorecence length, spike length, floret length and number of florets/spike) in gladiolus, cv. 'Friendship'. The longest inflorescence and spikes with the highest number of florets/spike was produced with 150 ppm GA_3. In another experiment, 20 ppm GA_3 gave the greatest spike length while 40 ppm GA_3 produced spikes having the longest (16.2 days) life in the field (Pal and Chowdhury, 1998).

A single foliar spray of GA_3 (100 and 200 ppm) in chrysanthemum enhanced vegetative growth and flowering (Verma *et al.* 1995).



Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

Details of experimental materials and methods followed during the time of the present investigation are described in this chapter.

Experiment 1. Physio-morphological characteristics and yield–potentials of chrysanthemum germplasm

Experimental Site

An experiment was conducted to find out morphological variabilities and yield –potentialities of 27 chrysanthemum germplasm. The Research work was carried out at the Experimental Farm of Landscape, Ornamental and Floriculture Division, HRC, BARI, Gazipur during the period from July 2007 to June 2008.

Climate

The experimental area was under subtropical climate characterized by heavy rainfall during the month from April to September and scanty for the rest period of the year. Detailing of weather data during the growth period has been presented in Appendix I.

Experimental treatments

It was a single factor experiment included with twenty seven germplasm of chrysanthemum which were as follows: CM-001, CM-002, CM-003, CM-004, CM-005, CM-006, CM-007, CM-008, CM-009, CM-010, CM-011, CM-012, CM-013, CM-014, CM-015, CM-016, CM-017, CM-018, CM-019, CM-020, CM-021, CM-022, CM-023, CM-024, CM-025, CM-026 and CM-027.

Pot preparation

The experiment was conducted in earthen pots of 12 cm size. The pots were washed and cleaned thoroughly before filling up of potting media.

Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. One plant was planted in a pot, containing the potting media treatments and five plants were constituted the unit of treatment.

Seedling raising, transplanting and fertilization

Primarily cuttings were prepared for planting in the sand in mid August, 2008. Immediately after rooting, the mini plantlets were transferred to pot containing media that consists of one part coarse sand, one part garden soil, one part cocodust, one part cowdung, a quarter part of wood ashes and two table spoonfuls of bone meal in mid September, 2008. Subsequently 10 g TSP and 3 g MP per pot were applied. Urea @ 2, 3 and 3 g per pot was applied at 20, 30 and 40 days after transplanting respectively.

Irrigation and weeding

Weeding and mulching were done in the pots whenever it was necessary to keep the pots free from weeds. Chrysanthemum plants need frequent irrigation. The pots were watered at every alternate day to keep the media moistened.

Staking of plant

Each plant was supported by 40 cm long bamboo stick to facilitate the branches of the plant to keep erect. The plant in each pot was fastened loosely with the bamboo stick by jute string to prevent the plant from lodging.

Pest and disease control

Ridomil 2g /L and Malathion 2ml/L of water was sprayed once fortnight to the plants as protective measures against diseases and insect attack.

Harvesting of flowers:

The spikes were harvested when the flower attained commercial stage (Flower open before shedding of pollens from the outer row of the disc florets).

Collection of data

Data were collected on the following parameters for interpretation of the result of the experiment:

Plant height

Plant height refers to the length of the plant from ground level to tip of erect leaf. Height of 5 plants was measured and the mean was calculated. It was measured in cm.

Number of leaves plant^{-1}

Number of leaves per plant was recorded by counting all the leaves from 5 plants and the mean was calculated.

Plant spread

The plant spread was measured in cross way (North-South and East-West) by measuring scale. The average of the two measurements was done and expressed in cm.

Number of suckers plant^{-1}

Number of suckers plant^{-1} was recorded by counting suckers from 5 individual plant and then mean was calculated.

Leaf size

The length and breadth of leaf was measured by a measuring scale and the average of the two measurements was done and expressed in cm for a single leaf. Later on, the mean of individual leaf size from 5 selected plants was calculated.

Days required to first flowering

It was recorded by counting the days from planting to first visibility of flower bud in the plant from each pot.

Days required to 80% flowering

It was recorded by counting the days from planting to 80% visibility of flower bud in the plant from each pot.

Days required to complete flowering

It was recorded by counting the days from planting to full visibility of flower in the plant from each pot.

Stalk length

Length of stalk was measured from base to the tip of the spike.

Number of flowers plant^{-1}

Number of flowers produced per plant was counted and recorded.

Flower size

Flower size was measured in cross way following North-South and East-West position by a measuring scale and the average of the two measurements was done and expressed in cm for a single flower. Later on, the mean of individual flower size from 5 selected plants was calculated.

Vase life of chrysanthemum

For good vase life, cut flowers should be placed in fresh water immediately after harvest. The flower spikes were harvested at late afternoon with sharp sterile knife when flower open before shedding of pollens from the outer row of the disc florets. The flower spikes were then carried out to the Horticulture Research Centre Laboratory, BARI, Joydebpur, Gazipur and placed in the glass bottles partially filled with 100 ml fresh water to study the vase life of chrysanthemum.

Flower yield

Weight of flowers were measured in grams from selected plants of each genotype and multiplied with total number of flower obtained from plants of each genotype and averaged.

Leaf colour

Colour of leaves was noted by visual observation.

Flower colour

Colour of flower was noted by visual observation.

Flowering period

Flowering period of all the germplasm was recorded.

Utility

The utility of all germplasm was recorded .by panel team.

Statistical analysis

The collected data for various traits were statistically analyzed using MSTAT-C computer package programme.

i. Analysis of variance

The mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between treatment means were separated by Least Significant Difference Test according to Steel and Torrie (1960) for the interpretation of the results.

ii. Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to formula given by Johnson *et al.* (1955).

$$\text{Genotypic variance } (\acute{o}^2 g) = \frac{MS_v - MS_e}{r}$$

Where,

MS_V = Mean sum of squares for genotypes

MS_e = Mean sum of squares for error

r = Number of replications

Phenotypic variance $(\acute{o}^2_p) = \acute{o}^2_g + \acute{o}^2_e$

Where,

$\acute{o}^2_g$ = Genotypic variance

$\acute{o}^2_e$ = Mean square for error

Estimation of genotypic and phenotypic coefficients of variation

Genotypic and phenotypic coefficients of variation were calculated according to the following formula given by Burton (1952):

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{\sigma_g^2}}{\overline{X}} \times 100$$

Where,

$ó^2_g$ = Genotypic variance

$\overline{X}$ = population mean

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

Where,

$ó^2 p$ = Phenotypic variance

$\overline{X}$ = Population mean

Estimation of heritability

Heritability in broad sense (h^2_b) was estimated by the formula as suggested by Johnson *et al.* (1955).

$$h^2_b (\%) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

$ó^2_g$ = Genotypic variance

$ó^2_p$ = Phenotypic variance

Estimation of genetic advance

The expected genetic advance (GA) = h^2_b k. $ó_p$

Where,

h^2_b = Heritability in broad sense

k = Selection intensity which is equal to 2. 06 at 5%

$ó_p$ = Phenotypic standard deviation

Genetic advance in percentage of mean was calculated by the formula given by Comstock and Robinson (1952) as follows:

$$GA (\%) = \frac{GA}{\overline{X}} \times 100$$

Where,

GA = Genetic advance

$\overline{X}$ = Population mean

Estimation of genotypic and phenotypic covariance

Genotypic and phenotypic covariance were calculated using the following formula (Singh and Chaudhary, 1985):

$$\text{Genotypic covariance } Cov_g(xy) = \frac{MSP_v - MSP_e}{r}$$

Where,

MSP_v = Mean sum of products of characters x and y

MSP_e = Mean sum of products due to error of characters x and y

r = Number of replication

$$\text{Phenotypic covariance } Cov_p(xy) = Cov_g(xy) + MSP_e$$

Where,

Cov_v = Genotypic covariance

MSP_e = Mean sum of products due to error of characters x and y

Estimation of genotypic and phenotypic correlation coefficients

Genotypic and phenotypic correlation coefficients for different characters in all possible combination were calculated with formula given by Miller *et al.* (1958).

$$\text{Genotypic correlation coefficient } (r_g) = \frac{Cov_g(xy)}{\sqrt{\sigma^2_{(g)x}} \times \sqrt{\sigma^2_{(g)y}}}$$

Where,

$Cov_g(xy)$ = Genotypic covariance between the characters x and y

$\sigma^2_{(g)x}$ = Genotypic variance of the character x

$\sigma^2_{(g)y}$ = Genotypic variance of the character y

$$\text{Phenotypic correlation coefficient } (r_p) = \frac{Cov_p(xy)}{\sqrt{\sigma^2_{(p)x}} \times \sqrt{\sigma^2_{(p)y}}}$$

Where,

$Cov_p(xy)$ = Phenotypic covariance between the characters x and y

$\sigma^2_{(P)x}$ = Phenotypic variance of the character x

$\sigma^2_{(p)y}$ = Phenotypic variance of the character y

Estimation of path coefficients

The components of correlation coefficients of different yield attributes with spike length per plant were partitioned into components of direct and indirect effects by path coefficient analysis. Path coefficient analysis was done according to the procedure stated by Singh and Choudhary (1985) and which was originally suggested by Dewy and Lu (1959).

In the present study, spike length was considered as resultant characters and the nine yield attributes were considered as the causal factor. The following sets of simultaneous equation were obtained depending upon the cause and effect relationship.

$r_{1y} = P_{1y} + r_{12}P_{2y} + r_{13}P_{3y} + r_{14}P_{4y} + r_{15}P_{5y} + r_{16}P_{6y} + r_{17}P_{7y} + r_{18}P_{8y} + r_{19}P_{9y}$

$r_{2y} = r_{23}P_{1y} + P_{2y} + r_{24}P_{3y} + r_{25}P_{4y} + r_{26}P_{5y} + r_{27}P_{6y} + r_{28}P_{7y} + r_{29}P_{8y} + r_{30}P_{9y}$

$r_{3y} = r_{34}P_{1y} + r_{35}P_{2y} + P_{3y} + r_{36}P_{4y} + r_{37}P_{5y} + r_{38}P_{6y} + r_{39}P_{7y} + r_{40}P_{8y} + r_{41}P_{9y}$

$r_{4y} = r_{45}P_{1y} + r_{46}P_{2y} + r_{47}P_{3y} + P_{4y} + r_{48}P_{5y} + r_{49}P_{6y} + r_{50}P_{7y} + r_{51}P_{8y} + r_{52}P_{9y}$

$r_{5y} = r_{56}P_{1y} + r_{57}P_{2y} + r_{58}P_{3y} + r_{59}P_{4y} + P_{5y} + r_{60}P_{6y} + r_{61}P_{7y} + r_{62}P_{8y} + r_{63}P_{9y}$

$r_{6y} = r_{67}P_{1y} + r_{68}P_{2y} + r_{69}P_{3y} + r_{70}P_{4y} + r_{71}P_{5y} + P_{6y} + r_{72}P_{7y} + r_{72}P_{8y} + r_{73}P_{9y}$

$r_{7y} = r_{77}P_{1y} + r_{78}P_{2y} + r_{79}P_{3y} + r_{80}P_{4y} + r_{81}P_{5y} + r_{82}P_{6y} + P_{7y} + r_{83}P_{8y} + r_{84}P_{9y}$

$r_{8y} = r_{88}P_{1y} + r_{89}P_{2y} + r_{90}P_{3y} + r_{91}P_{4y} + r_{92}P_{5y} + r_{93}P_{6y} + r_{94}P_{7y} + P_{8y} + r_{95}P_{9y}$

$r_{9y} = r_{99}P_{1y} + r_{100}P_{2y} + r_{101}P_{3y} + r_{102}P_{4y} + r_{103}P_{5y} + r_{104}P_{6y} + r_{105}P_{7y} + P_{9y} + r_{106}P_{9y}$

Where,

r_{iy}= Genotypic correlation coefficient between y and i^{th} character (i= 1, 2, 3.....9)

y = Spike length

P_{iy} = Path coefficient due to i^{th} character (i = 1, 2, 3 .....9)

1 = Plant height

2 = Number of leaves $plant^{-1}$

3= Plant spread

4 = Number of side shoot $hill^{-1}$

5 = Number of flower $plant^{-1}$

6 =Flower size

7 = Stalk diameter

8 = Vase life

9 = Days to flower

Total genotypic correlation say, between 1 and y, i. e. r_{1y} was thus partitioned as follows:

P_{1y} = The direct effect of 1 on y

$r_{12}\ P_{2y}$ = The indirect effect of 1 via 2 on y

$r_{13}\ P_{3y}$ = The indirect effect of 1 via 3 on y

$r_{14}\ P_{4y}$ = The indirect effect of 1 via 4 on y

$r_{15}\ P_{5y}$ = The indirect effect of 1 via 5 on y

$r_{16}\ P_{6y}$ = The indirect effect of 1 via 6 on y

$r_{17}\ P_{7y}$ = The indirect effect of 1 via 7 on y

$r_{18}P_{8y}$ = The indirect effect of 1 via 8 on y

$r_{19}P_{9y}$ = The indirect effect of 1 via 9 on y

After calculating the direct and indirect effects of the characters, residual effect (R) was calculated by using the following formula (Singh and Choudhary, 1985):

$P2Ry = 1 - \Sigma P_{iy}\, r_{iy}$

Where, $P^2_{Ry} = R^2$

P_{iy} = Direct effect of the characters on yield

R_{iy} = Correlation coefficient of the characters with yield

Therefore,

Residual effect = $\sqrt{P^2Ry}$

Experiment 2. Effect of potting media on growth and yield of chrysanthemum

Experimental Site

The present investigation was carried out at the experimental farm of Landscape, Ornamental and Floriculture Division, HRC, BARI, Gazipur during the period from July 2007 to June 2008.

Treatments

There were seven treatments in the experiment, comprising varying proportion of different potting media. The treatment combinations used in the experiment were:

T_1 = 100% soil,

T_2 = 50% soil + 25% cowdung + 25% cocodust,

T_3 = 100% cocodust,

T_4 = 50% soil + 25% cowdung + 25% rice husk,

T_5 = 50% cocodust + 25% cowdung + 25% soil,

T_6 = 50% cocodust +25% rice husk + 25% cowdung and

T_7 = 100% rice husk

Pot preparation

The experiment was conducted in earthen pots of 12 cm size. The pots were washed and cleaned thoroughly before filling up of potting media.

Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. One plant was planted in a pot, containing the potting media according to the treatments and five plants were constituted the unit of treatment.

Seedling raising, transplanting and fertilization

Primarily cuttings of CM-022 were prepared for planting in the sand in mid August, 2007. Immediately after rooting, the mini plantlets were transferred to pot. The basic substrates were rice husk, cocodust and soil which were used singly and in combinations. All the mixtures were made on a v/v basis. The potting media were made available two months before transplanting of Cuttings and kept in shady place covering with polyethylene paper. Watering was done to decompose media twice in a week for two months. Before 30 days of transplanting each pot was supplied with well rotten oil cake @ 150 g/pot. The oil cake was well mixed into the surface soil of the pots with the help of khurpi. Urea @ 5 and 7 g per pot was applied at 25 and 35 days after transplanting. P_2O_5 and K_{20} @ 5 g per pot were applied for getting best growth and flowering of plants according to Bose *et al.* (2003).

Irrigation and weeding

Weeding and mulching were done in the pots whenever it was necessary to keep the pots free from weeds. Chrysanthemum plants need frequent irrigation. The pots were irrigated at every alternate day to keep the media moistened.

Staking of plant

Each plant was supported by 40 cm long bamboo stick to facilitate the branches of the plant to keep erect. The plant in each pot was fastened loosely with the bamboo stick by jute string to prevent the plant from lodging.

Pest and disease control

Ridomil 2g /L and Malathion 2ml/L of water was sprayed once fortnight to the plants as protective measures against diseases and insect attack.

Harvesting of flowers

The spikes were harvested when the flower attained commercial stage (Flower open before shedding of pollens from the outer row of the disc florets).

Collection of data

Data were collected on the following parameters for interpretation of the result of the experiment:

Plant height

Plant height refers to the length of the plant from ground level to tip of erect leaf. Height of 5 plants was measured and the mean was calculated. It was expressed in cm.

Number of leaves plant^{-1}

Number of leaves per plant was recorded by counting all the leaves from 5 plants and the mean was calculated.

Plant spread

The plant spread was measured in cross way (North-South and East-West) by measuring scale. The average of the two measurements was done and expressed in cm.

Number of suckers plant^{-1}

Number of suckers plant^{-1} was recorded by counting suckers from 5 individual plant and then mean was calculated.

Leaf size

The length and breadth of leaf was measured by a measuring scale and the average of the two measurements was done and expressed in cm for a single leaf. Later on, the mean of individual leaf size from 5 selected plants was calculated.

Number of branches plant^{-1}

Number of branches per plant was recorded by counting all the main branches from 5 plants and the mean was calculated.

Days to flowering

It was recorded by counting the days from planting to first visibility of flower bud in the plant from each pot.

Stalk length

Length of stalk was measured from base to the tip of the spike and was expressed in cm.

Number of flowers plant^{-1}

Number of flowers produced per plant was counted and recorded.

Flower size

Flower size was measured in cross way following North-South and East-West position by a measuring scale and the average of the two measurements was done and expressed in cm for a single flower. Later on, the mean of individual flower size from 5 selected plants was calculated.

Weight of flower stalk

Weight of flower stalk were measured in grams from randomely 5 selected plants of each treatment and averaged.

Flowering duration

Flowering period was recorded from the time of first flower opening to full bloom of last flower bud.

Statistical analysis

The data recorded on different plant and floral parameters were statistically analyzed through analysis of variance with the help of 'MSTAT' software. The difference between treatment means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1960).

Experiment 3. Effect of pinching on growth and quality flower production of chrysanthemum

Experimental Site

The present investigation was carried out at the experimental farm of Landscape, Ornamental and Floriculture Division, HRC, BARI, Gazipur during the period from July 2007 to June 2008.

Treatments

There were six treatments in the experiment, comprising different pinching. The treatment combinations used in the experiment were:

T_0- No pinching,

T_1- Once 40 days,

T_2- Once 50 days,

T_3- Once 60 days,

T_4- Twice 40 and 50 days and

T_5- Thrice 40, 50 and 60 days

Pot preparation

The experiment was conducted in earthen pots of 12 cm size. The pots were washed and cleaned thoroughly before filling up of potting media.

Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. One plant was planted in a pot, containing the potting media according to the treatments and five plants were constituted the unit of treatment.

Seedling raising, transplanting and fertilization

Primarily cuttings of CM-022 were prepared for planting in the sand in mid August, 2007. Immediately after rooting, the mini plantlets were transferred to pot containing media that consists of one part coarse sand, one part garden soil, one part cocodust, one part cowdung, a quarter part of wood ashes and two table spoonfuls of bone meal in mid September, 2007. Subsequently 10 g TSP and 3 g MP per pot were applied. Urea @ 2, 3 and 3 g per pot was applied at 20, 30 and 40 days after transplanting respectively for getting best growth and flowering of plants according to Bose *et al.* (2003).

Irrigation and weeding

Weeding and mulching were done in the pots whenever it was necessary to keep the pots free from weeds. Chrysanthemum plants need frequent irrigation. The pots were irrigated every alternate day to keep the media moistened.

Staking of plant

Each plant was supported by 40 cm long bamboo stick to facilitate the branches of the plant to keep erect. The plant in each pot was fastened loosely with the bamboo stick by jute string to prevent the plant from lodging.

Pest and disease control

Ridomil 2g /L and Malathion 2ml/L of water was sprayed once fortnight to the plants as protective measures against diseases and insect attack.

Harvesting of flowers

The spikes were harvested when the flower attained commercial stage (Flower open before shedding of pollens from the outer row of the disc florets).

Collection of data

Data were collected on the following parameters for interpretation of the result of the experiment:

Plant height (cm)

Plant height refers to the length of the plant from ground level to tip of erect leaf. Height of 5 plants was measured and the mean was calculated. It was measured in cm.

Number of leaves plant^{-1}

Number of leaves per plant was recorded by counting all the leaves from 5 plants and the mean was calculated.

Plant spread (cm)

The plant spread was measured in cross way (North-South and East-West) by measuring scale. The average of the two measurements was done and expressed in cm.

Leaf size

The length and breadth of leaf was measured by a measuring scale and the average of the two measurements was done and expressed in cm for a single leaf. Later on, the mean of individual leaf size from 5 selected plants was calculated.

Number of branches plant^{-1}

Number of branches per plant was recorded by counting all the main branches from 5 plants and the mean was calculated.

Days to flowering

It was recorded by counting the days from planting to first visibility of flower bud in the plant from each pot.

Number of flowers plant^{-1}

Number of flowers produced per plant was counted and recorded.

Flower size

Flower size was measured in cross way following North-South and East-West position by a measuring scale and the average of the two measurements was done and expressed in cm for a single flower. Later on, the mean of individual flower size from 5 selected plants was calculated.

Statistical analysis

The data recorded on different plant and floral parameters were statistically analyzed through analysis of variance with the help of 'MSTAT' software. The difference between treatment means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1960).

Experiment 4. Effect of plant growth regulators on growth and quality flower production of chrysanthemum

Experimental Site

The present investigation was carried out at the experimental farm of Landscape, Ornamental and Floriculture Division, HRC, BARI, Gazipur during the period from July2007 to June 2008.

Climate

The experimental area was under subtropical climate characterized by heavy rainfall during the month from April to September and scanty for the rest period of the year. Details of weather data during the growth period has been presented in Appendix I.

Treatments

There were ten treatments in this experiment:

T_1-50ppm GA_3,

T_2-100ppm GA_3,

T_3-150ppm GA_3,

T_4-400ppm CCC,

T_5-600ppm CCC,

T_6-800ppm CCC,

T_7-250ppm MH,

T_8-500ppm MH,

T_9-750ppm MH and

T_{10}-Control

Pot preparation

The experiment was conducted in earthen pots of 12 cm size. The pots were washed and cleaned thoroughly before filling up of potting media.

Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. One plant was planted in a pot, containing the potting media according to the treatments and five plants were constituted the unit of treatment.

Seedling raising, transplanting and fertilization

Primarily cuttings of CM-022 were prepared for planting in the sand in mid August, 2007. Immediately after rooting, the mini plantlets were transferred to pot containing media that consists of one part coarse sand, one part garden soil, one part cocodust, one part cowdung, a quarter part of wood ashes and two table spoonfuls of bone meal in mid September, 2007. Subsequently 10 g TSP and 3 g MP per pot were applied. Urea @ 2, 3 and 3 g per pot was applied at 20, 30 and 40 days after transplanting respectively for getting best growth and flowering of plants according to Bose *et al.* (2003).

Irrigation and weeding

Weeding and mulching were done in the pots whenever it was necessary to keep the pots free from weeds. Chrysanthemum plants need frequent irrigation. The pots were irrigated every alternate day to keep the media moistened.

Staking of plant

Each plant was supported by 40 cm long bamboo stick to facilitate the branches of the plant to keep erect. The plant in each pot was fastened loosely with the bamboo stick by jute string to prevent the plant from lodging.

Pest and disease control

Ridomil 2g /L and Malathion 2ml/L of water was sprayed once fortnight to the plants as protective measures against diseases and insect attack.

Harvesting of flowers:

The spikes were harvested when the flower attained commercial stage (Flower open before shedding of pollens from the outer row of the disc florets).

Collection of data

Data were collected on the following parameters for interpretation of the result of the experiment:

Number of leaves plant^{-1}

Number of leaves per plant was recorded by counting all the leaves from 5 plants and the mean was calculated.

Plant spread

The plant spread was measured in cross way (North-South and East-West) by measuring scale. The average of the two measurements was done and expressed in cm.

Number of suckers plant^{-1}

Number of suckers plant^{-1} was recorded by counting suckers from 5 individual plant and then mean was calculated.

Leaf length

The length of leaf was measured by a measuring scale from leaf base to the tip and was expressed in cm.

Number of branches plant^{-1}

Number of branches per plant was recorded by counting all the main branches from 5 plants and the mean was calculated.

Days to flowering

It was recorded by counting the days from planting to first visibility of flower bud in the plant from each pot.

Stalk length

Length of stalk was measured from base to the tip of the spike and was expressed in cm.

Number of flowers plant^{-1}

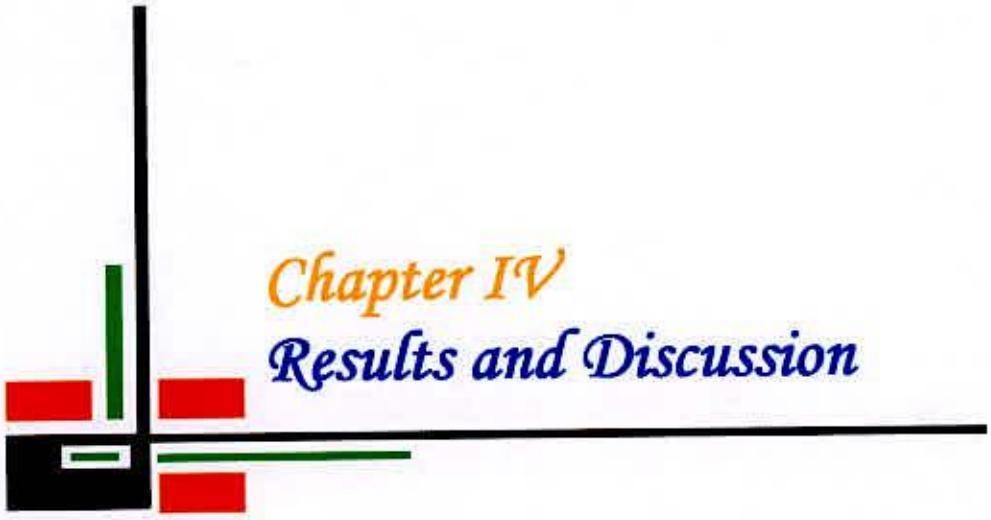
Number of flowers produced per plant was counted and recorded.

Flower size

Flower size was measured in cross way following North-South and East-West position by a measuring scale and the average of the two measurements was done and expressed in cm for a single flower. Later on, the mean of individual flower size from 5 selected plants was calculated.

Statistical analysis

The data recorded on different plant and floral parameters were statistically analyzed through analysis of variance with the help of 'MSTAT' software. The difference between treatment means were compared by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1960).



Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Experiment 1. Physio-morphological characteristics and yield –potentials of chrysanthemum germplasm

The present study was conducted during the period from July 2007 to June 2008 to investigate the physio-morphological and yield potentialities of chrysanthemum germplasm. The characteristics studied included plants, leaves and flowers. The variabilities among the germplasm, correlation coefficient among different important flower producing traits and direct and indirect effect of flower producing traits were estimated. The results of present study have been presented and discussed in this chapter under the following headings:

Colour of leaf

As regards to the colour of leaf, the observed germplasms showed remarkable variation such as green, light green and deep green. The variability on colour of leaf in chrysanthemum is shown in Table1.

Colour of flower

Wide range of variations was observed in respect of colour. The different germplasms showed attractive colour of flowers (Table1). The colour of flower in chrysanthemum were categorized into white, yellow, red, orange, pink and intermediate colours (Fig. 1)

Flowering period

Flowering periods of different germplasms were recorded and presented in Table 1. The different germplasms gave flowering with varying times in a year. However, the maximum period of flowering was observed in germplasms CM-009 (Late Dec- Late April).

Table 1. Characteristics of chrysanthemum germplasm in respect of leaf colour, flower colour and flowering period

Germplasm	Leaf colour	Colour of flowers	Flowering period
CM -001	Green	Light pink	Mid December-Mid January
CM -002	Light green	Yellow	Early December-Early February
CM -003	Green	Light pink	Mid December-Late January
CM -004	Deep green	Red	Early December-Late January
CM -005	Green	Bronzy yellow	Early December-Late January
BARI Chry-1	Light green	Yellow	Early December-Late January
CM -007	Green	Light pink	Mid December-Mid January
CM -008	Green	Purple red	Mid December-Mid January
CM -009	Light green	Yellowish bronze	Late December-Late April
CM -010	Green	Orange yellow	Mid December-Early February
CM -011	Light green	Red	Mid December-Early February
CM -012	Green	Reddish yellow	Early December-Early February
CM -013	Light green	Orange	Mid December-Late January
BARI Chry-2	Light green	White	Early December-Early February
CM -015	Green	Majenta	Early December-Early February
CM -016	Green	Pinkish white	Mid December-Mid January
CM -017	Light green	Whitish yellow	Mid December-Late January
CM -018	Green	Deep pink	Mid December-Early February
CM -019	Deep green	Blackish red & pink	Early December-Early February
CM -020	Green	Light pink	Early December-Late January
CM -021	Light green	Light pink	Early December-Late January
CM -022	Deep green	Deep pink	Early December-Early February
CM -023	Deep green	Blackish red	Early December-Early February
CM -024	Green	Deep yellow	Early December-Early February
CM -025	Green	Red	Early December-Early February
CM -026	Light green	Light pink	Early December-Early February
CM -027	Light green	White	Early December-Early February

Fig. 1. Flower variability in chrysanthemum germplasm

Bud initiation to bud burst

Significant variations were observed among the germplasms on different flowering behaviour (Table 2). The germplasm CM-009 took the maximum duration (59 days) for bud initiation to bud burst while the minimum (38 days) days were required by BARI Chrysanthemum-2 closely followed by CM-004 (39 days).

Table 2. Flowering behaviour of chrysanthemum germplasm

Germplasm	Time taken (days)		
	Bud initiation to bud burst	80% flowering	Complete flowering
CM-001	45	60	69
CM-002	51	65	73
CM-003	45	58	67
CM-004	39	53	65
CM-005	51	65	74
BARI Chry-1	47	62	71
CM-007	54	68	77
CM-008	49	65	75
CM-009	59	75	84
CM-010	48	62	71
CM-011	46	60	69
CM-012	53	67	76
CM-013	49	63	72
BARI Chry-2	38	65	65
CM-015	44	57	66
CM-016	53	55	72
CM-017	54	68	73
CM-018	46	60	69
CM-019	41	55	66
CM-020	43	57	68
CM-021	44	58	67
CM-022	45	65	73
CM-023	46	65	74
CM-024	51	67	75
CM-025	46	60	69
CM-026	55	70	79
CM-027	48	59	70
CV (%)	**9.2**	**7.8**	**10.1**

Days to 80% flowering

The data presented in Table 2. revealed the highly significant difference among the germplasm for days required to 80% flowering. The germplasm CM-004 took the minimum days (53 days) to 80% flowering while the maximum days (75 days) were required for CM-009.

Days to complete flowering

The maximum number of days (84 days) for completion of flowering from bud initiation was recorded in germplasm CM-009 while CM-004 and BARI Chrysanthemum-2 required the lowest number of days (65 days). Similar observation was also reported by Negi *et al.* (1994) while working with 12 different genotypes of chrysanthemum.

Inflorescence type

The different germplasms showed a wide variation in type of inflorescence (Fig. 2). The type of inflorescence was graded into anemone, pompon, single, incurved, spider, spoon, reflexed and intermediate. Among the germplasms, 25.94% anemone, 3.70% pompon, 3.70% single, 22.22% incurved, 3.70% spider, 18.52% reflexed, 3.70% spoon and 18.52% intermediate type of inflorescence.

Plant height

Analysis of variances revealed marked differences among the genotypes in respect of plant height (Appendix II). It varied from 35 to 75 cm where the tallest plant was produced by the germplasm CM-026, while the shortest plant was recorded in germplasm CM-05 (Table 3). The co-efficient of variation (CV) was moderately high (20.87) for this trait indicating the presence of variability among the genotypes. Tewari and Shankar (1994) conducted a performance trial of chrysanthemum cultivars and reported that plant height ranged from 38 -77 cm which was not at par with the present investigation. The variation observed here might be due to difference in genetic constituents among the germplasm along with environmental effects.

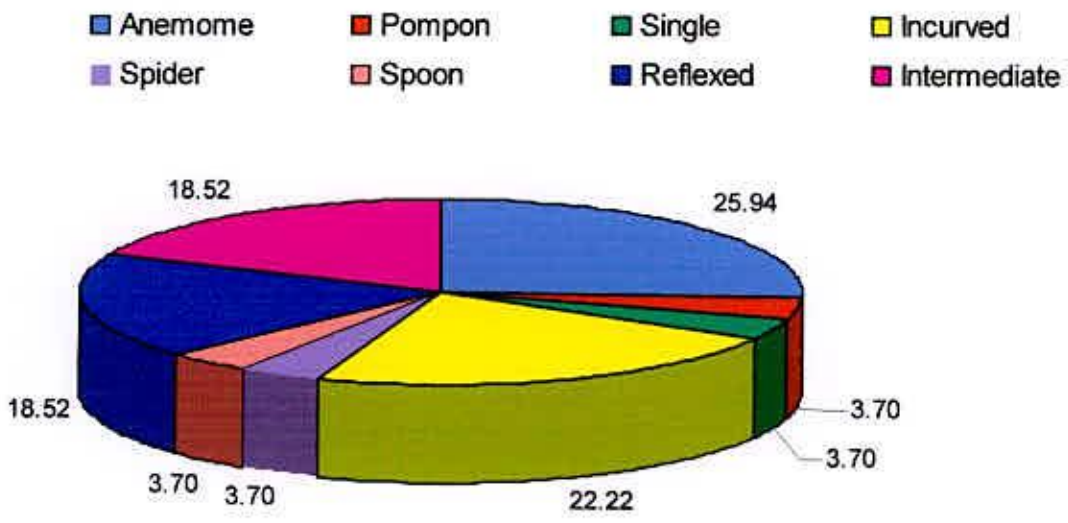


Fig. 2. Variability in Inflorescence type

Number of leaves

Significant variation was observed as to the number of leaves among the germplasms. The maximum number of leaves (210) was obtained from the germplasm CM-002 closely followed by germplasm CM-024 (205), CM-012(200), CM-022(200) and CM-025 (200) whereas germplasm CM-017 attained minimum number of leaves (95). This variation might be due to genotypic variation as well as environmental effects. Plants produce food materials through the process of photosynthesis. With the increasing number of leaves, photosynthesis will generally increase, thus plant can produce more plant food that influences the growth and development of the plant. So, genotypes that can produces more leaves have more plant growth leading to higher yield.

Number of branches

Variation regarding number of branch per plant among the germplasm was observed and varied from 5 to 8 (Table 3). The highest number of branch per plant was produced by CM-018 (8). The germplasm CM-003 and CM-017 produced the lowest number of branch per plant (4). The number of branch per plant varied from 4-10 as reported by Parthasarathy and Shah (1984) from their experiment on chrysanthemum evaluation in India.

Plant spread

The character plant spread ranged from 13.00-21.00 cm (Fig. 3). The maximum plant spread of 21.00 cm was observed in CM-002 which was nearer to the values 20.00 cm; and 19.00 cm produced by the germplasm CM-009 and CM-015 respectively. The germplasm CM-003 had minimum plant spread of 13.00 cm.

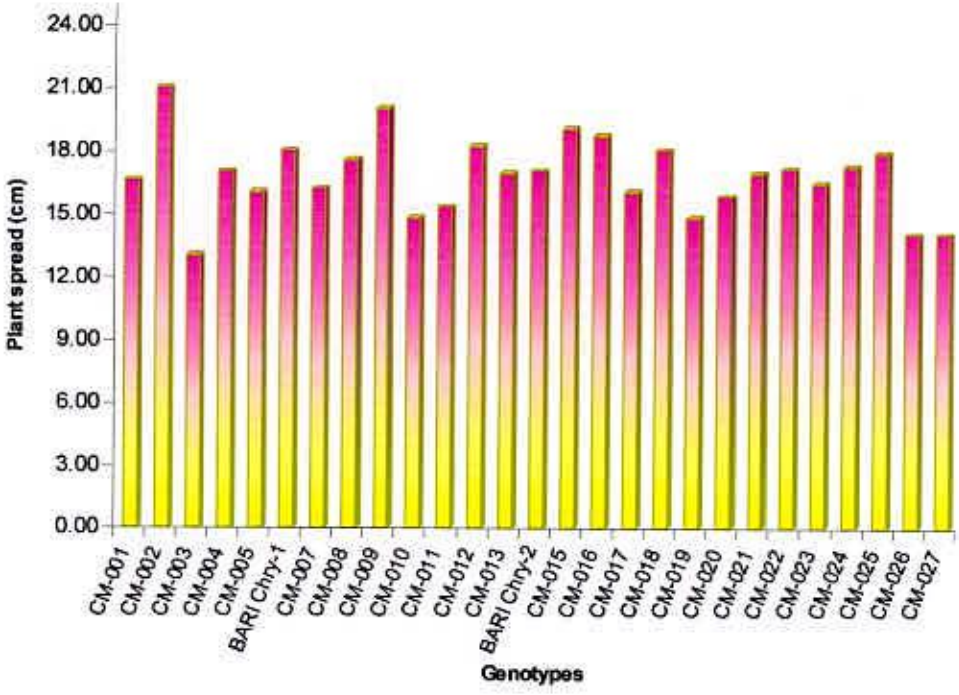


Fig 3. Plant spread of chrysanthemum germplasm

Length of flower stalk

Significant variation in respect of stalk length was observed among the germplasm (Fig. 4). The longest spike (12.00 cm) was produced by germplasm CM-022 followed by CM-004, CM-024, CM-025 (11.00 cm) while the shortest spike of 5.40 cm was produced by CM-021. Bose *et al.* (2003) recorded stalk length ranged from 7 to 15 cm in varietal evaluation of chrysanthemum showed more or less similarity with the present investigation.

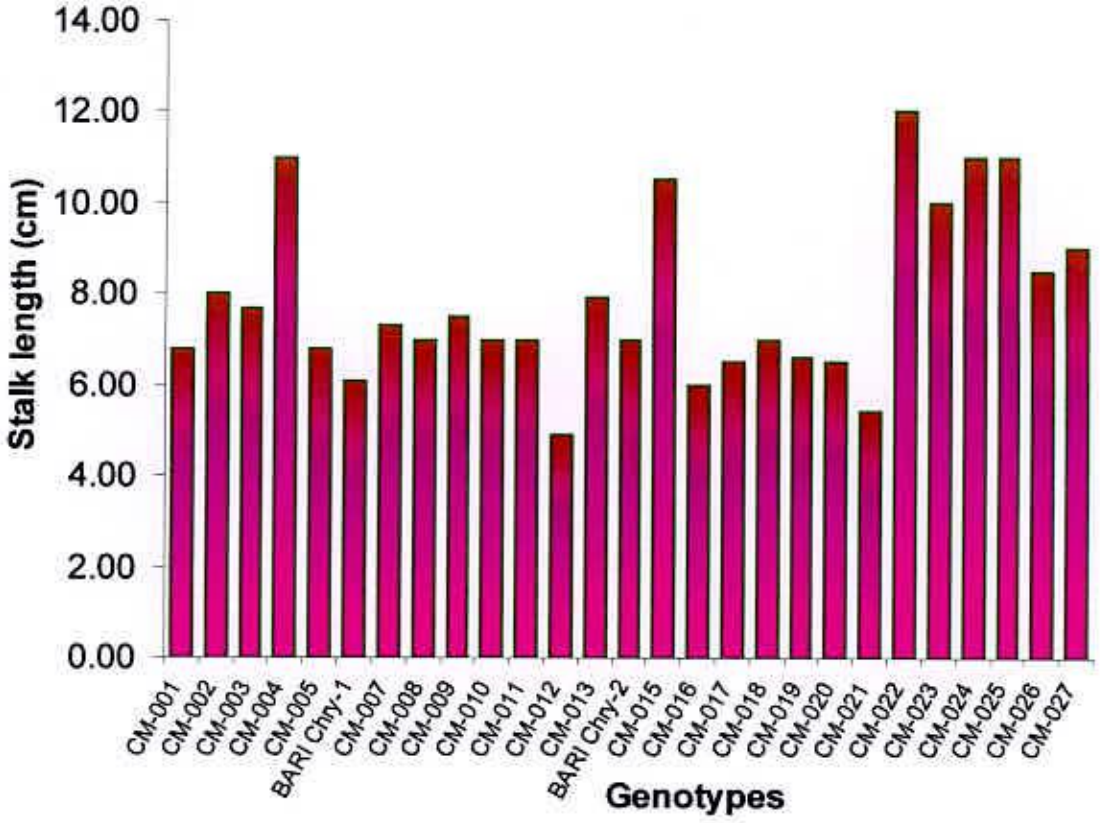


Fig 4. Stalk length of chrysanthemum germplasm

Flower size

It was revealed that flower size varied significantly and ranged from 2.5 cm to 9.0 cm. The germplasm CM-023 showed the highest flower size (9.00 cm) followed by germplasm CM-017(7.80 cm), CM-022(7.50 cm) and CM-023 (7.30 cm). The lowest flower size (2.50 cm) was observed in germplasm CM-002 and CM-021 (Table 3). Misra (1999) found flower diameter varied from 2.30 – 10.00 cm which was at par with the present investigation and also mentioned this difference due to inherent genetic factors.

Table 3. Plant and flower characteristics of chrysanthemum germplasm

Germplasm	Plant height	Branch number	Leaf number	Leaf size	Flower size	Flower yield/plant
CM -001	46.00	5	145	8.0	4.5	57.6
CM -002	48.00	6	210	5.9	2.5	65.0
CM -003	45.00	4	130	5.5	4.2	28.0
CM -004	42.00	6	180	9.0	7.0	108.0
CM -005	35.00	6	137	6.5	4.5	72.2
BARI Chry-1	40.00	7	165	6.5	4.0	44.0
CM -007	55.00	5	150	8.5	6.8	93.6
CM -008	45.00	5	110	6.5	5.7	71.5
CM -009	58.00	6	170	8.0	5.0	133.5
CM -010	50.00	5	140	7.4	4.8	33.8
CM -011	49.00	5	157	7.3	4.4	40.0
CM -012	39.00	6	200	5.8	2.6	68.6
CM -013	61.00	5	135	7.0	7.8	110.0
BARI Chry-2	40.00	6	175	7.5	7.0	270.0
CM -015	45.00	7	195	7.3	7.0	270.0
CM -016	50.00	5	110	7.0	5.1	40.0
CM -017	56.00	4	95	12.0	7.2	100.0
CM -018	51.66	8	195	6.8	4.5	104.0
CM -019	40.00	7	120	6.0	2.8	70.4
CM -020	50.00	6	130	6.9	4.2	57.0
CM -021	40.00	5	150	6.4	2.5	78.4
CM -022	60.00	6	200	7.4	7.5	121.0
CM -023	58.00	7	190	7.6	9.0	125.0
CM -024	48.00	7	205	7.3	6.5	120.0
CM -025	64.00	7	200	7.5	7.3	126.0
CM -026	75.00	5	120	10.8	7.4	90.0
CM -027	55.00	5	125	10.5	5.0	86.7
LSD (0.05)	**6.35**	**3.23**	**5.60**	**4.11**	**6.62**	**5.69**
CV%	**20.87**	**20.50**	**21.71**	**22.14**	**20.44**	**24.18**

Leaf size

As regards leaf size ranged from 5.5 to 12.0 cm with the mean value of 8.75 among the observed germplasm, the largest size of leaf per plant was obtained from germplasm CM-017 (12.0 cm) while the smallest leaf (5.5) were recorded from the germplasm CM-002 (Table 3).

Number of flowers per plant

Distinct variation was observed in respect of number of flowers within the germplasm (Fig 4). The maximum number of flowers per plant was produced by CM-002 (100) closely followed by CM-012 (98) and CM-009 (89). The germplasm CM-027 produced the lowest number of flowers (17) per plant which was followed by CM-026 (18). The number of flowers per plant varied from 15.00 - 130.00 as reported by Kher (1988) in chrysanthemum.

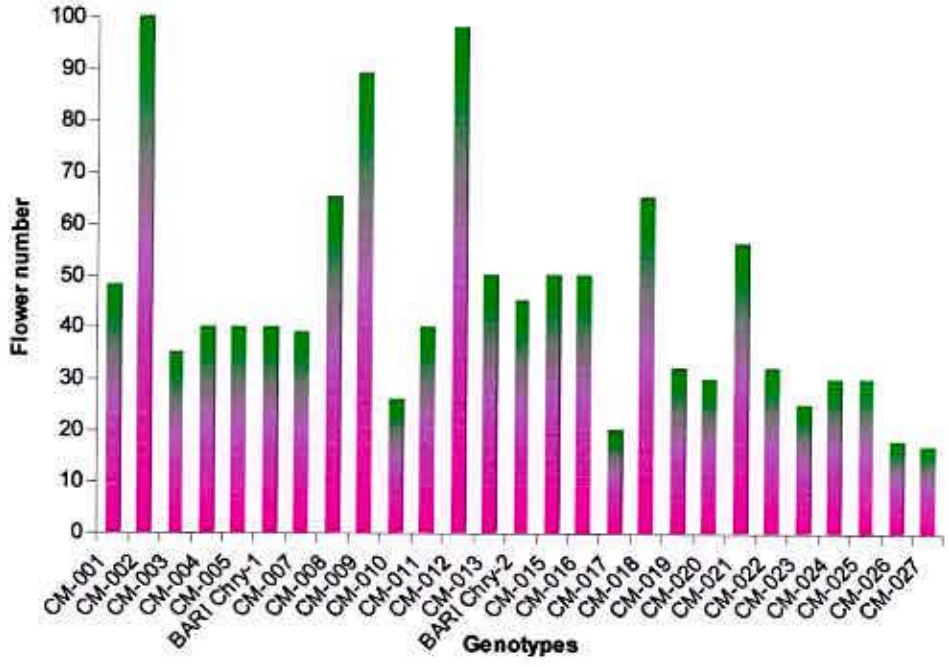


Fig 5. Flower number of chrysanthemum germplasm

Vase life

A great deal of genotypic variation was observed in case of vase life (Fig 6). Among the, germplasm, CM-009 and BARI chrysanthemum-2 exhibited the longest vase life of 14 days closely followed by CM-015, CM-022, CM-023, CM-024, and CM-025 with 12 days of duration. The shortest vase life duration (5 days) was exhibited by germplasm CM-008.

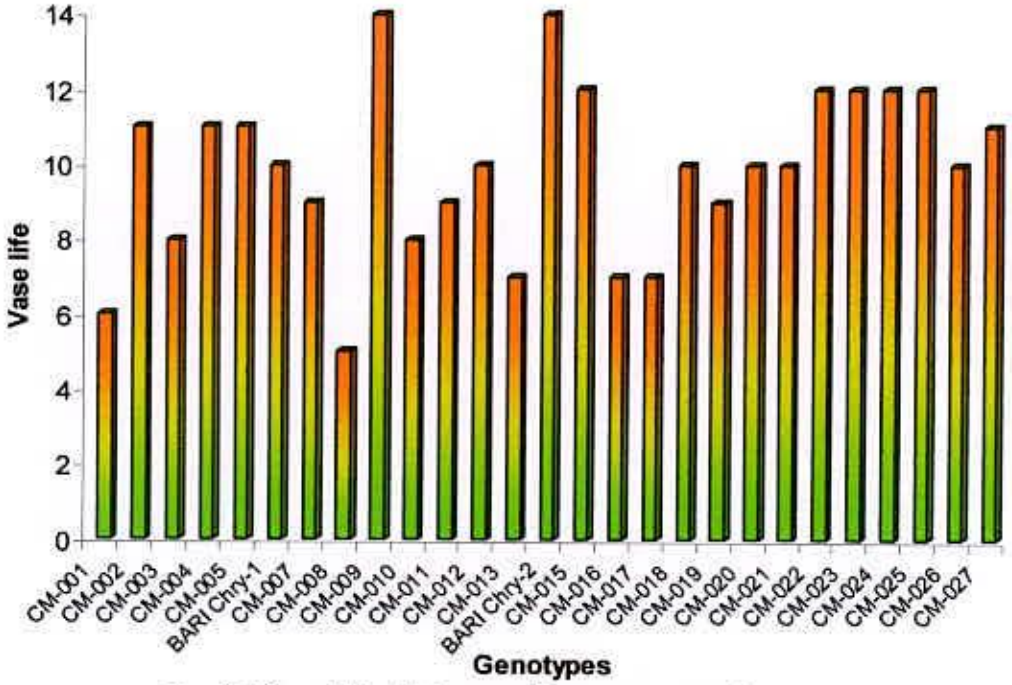


Fig. 6. Vase life of chrysanthemum germplasm

Number of sucker

Variation regarding number of sucker per plant among the germplasm was observed and varied from 17 to 35. The highest number of 35 suckers per plant was produced by CM-015 where the germplasm CM-017 produced the lowest number of suckers (17) per plant (Fig 7). The number of sucker per chrysanthemum plant varied from 15.00-40.00 as reported by Ragava *et al.* (1992) which seems more or less similarity with the present finding.

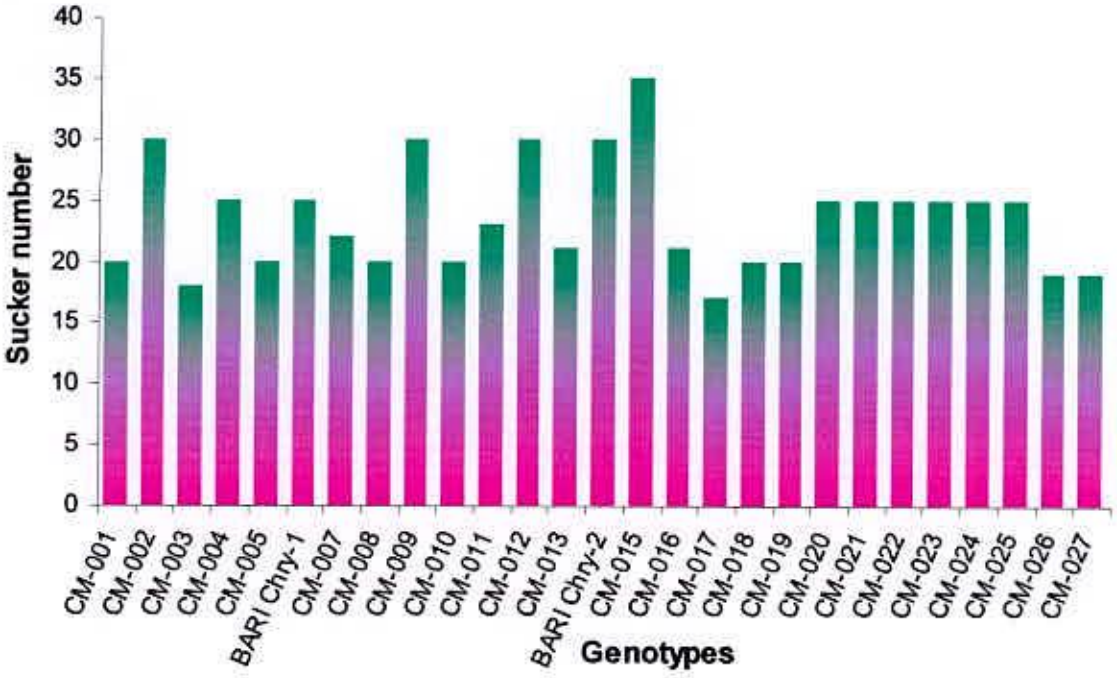


Fig 7. Sucker number of chrysanthemum germplasm

Flower yield

Data recorded in respect of flower yield in twenty seven germplasm of chrysanthemum are presented in Table 3. The variety BARI chrysanthemum-2 and CM-015 produced the maximum flower yield per plant (270 g). The minimum flower yield per plant (28g) was recorded in CM-003. The same result was also observed by Tewari and Shankar (1994).

Utility of germplasm

Utility of different germplasms were graded as pot, cutflower and both pot and cutflower. Among the germplasms, 7 were suitable for pot, 15 for cutflower and 5 for both pot and cutflower. The variablity on flower utility is shown in Fig 8.

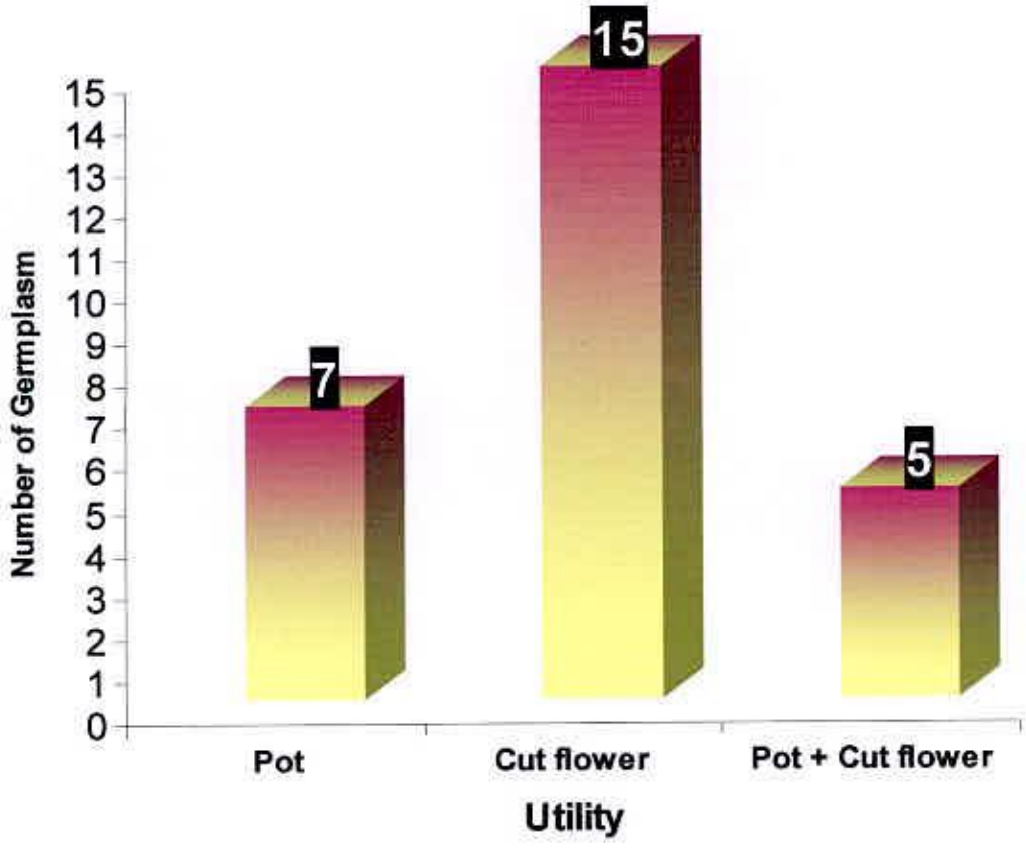


Fig 8. Variability in utility of germplasm

Insect and disease reaction

Chrysanthemum is susceptible to several insect and disease which adversely affect the quality and quantity of the crop. The crop was mostly infested by aphid, thrips and caterpillars, the three major insects. Two major diseases like powdery mildew and wilting occurred in chrysanthemum. Generally, it may be said that very few disease and pests used to occur during winter (Kher, 1988). There had only aphids' infestation and no disease infection which is furnished in Table 4.

Table 4. Insect and Disease infestation of chrysanthemum germplasm

Germplasm	Insect infestation			Disease infestation	
	Aphid	Thrips	Caterpillar	Powdery mildew	Wilting
CM-001	4	Nill	Nill	Nill	Nill
CM-002	0	Nill	Nill	Nill	Nill
CM-003	3	Nill	Nill	Nill	Nill
CM-004	0	Nill	Nill	Nill	Nill
CM-005	4	Nill	Nill	Nill	Nill
BARI Chry-1	0	Nill	Nill	Nill	Nill
CM-007	2	Nill	Nill	Nill	Nill
CM-008	3	Nill	Nill	Nill	Nill
CM-009	0	Nill	Nill	Nill	Nill
CM-010	3	Nill	Nill	Nill	Nill
CM-011	3	Nill	Nill	Nill	Nill
CM-012	0	Nill	Nill	Nill	Nill
CM-013	2	Nill	Nill	Nill	Nill
BARI Chry-2	0	Nill	Nill	Nill	Nill
CM-015	0	Nill	Nill	Nill	Nill
CM-016	3	Nill	Nill	Nill	Nill
CM-017	3	Nill	Nill	Nill	Nill
CM-018	0	Nill	Nill	Nill	Nill
CM-019	0	Nill	Nill	Nill	Nill
CM-020	2	Nill	Nill	Nill	Nill
CM-021	0	Nill	Nill	Nill	Nill
CM-022	0	Nill	Nill	Nill	Nill
CM-023	0	Nill	Nill	Nill	Nill
CM-024	0	Nill	Nill	Nill	Nill
CM-025	0	Nill	Nill	Nill	Nill
CM-026	1	Nill	Nill	Nill	Nill
CM-0027	1	Nill	Nill	Nill	Nill

0 = no population; 1= a small colony of 10-20 aphid/plant; 2 = a colony with > 20 aphid/plant; 3=> one colony; 4 = severe infestation of maximum plants

Estimation of genetic parameters in chrysanthemumgenotypes

The analysis of variance (Appendix II) indicated the existence of significant variability for all the characters studied. The coefficient of phenotypic and genotype variations, heritability estimates and expected genetic advance in percent of mean (1%) are shown in Table 5.

Estimates of genetic parameters for each character are important for getting idea about their mode of inheritance. Such idea usually helps toward efficient selection. In the present study, a narrow difference between phenotypic and genotype coefficients of variation was noticed for flower number, stalk length, flower size, sucker number and vase life, indicating less environmental interference on the expression of these characters. Similar observations were made by Nanjan (1994) in gerbera.

A character can be improved only if it is highly heritable. The magnitude of h^2 indicates the effectiveness with which the selection of genotypes can be made based on phenotypic performance (Johnson *et al.* 1995). Out of 10 quantitative characters studied, stalk length, flower number, vase life, stalk length, flower size and plant height exhibited high heritability. The results were in consonance with the findings of Sujatha (2002) in gerbera.

Even though the h^2 values give indication of effectiveness of selection based on the phenotypic performance, it does not necessarily mean a high genetic advance for a particular character. Heritability along with estimates of expected genetic advance should be considered while making selection. In crop improvement only the genetic component of variation is important since only this component of h^2 serve as a useful guide to the breeder.

Table 5. Phenotypic and genotypic co-efficients of variation, heritability, genetic advance for different characters in chrysanthemum germplasm

Characters	Genotypic co-efficients of variation	Phenotypic co-efficient of variation	Heritability	Genetic advance (1% of mean)
Plant height (cm)	26.52	27.69	80.37	35.10
No. of leaves	19.77	26.03	53.48	29.78
Plant spread (cm)	15.67	21.63	57.99	44.65
No. of sucker plant^{-1}	29.93	30.63	64.58	63.21
No. of flower plant^{-1}	29.01	30.77	90.71	84.43
Flower size (cm)	19.87	20.38	98.73	90.29
Stalk length (cm)	46.29	47.86	93.94	92.61
Vase life (days)	25.01	26.20	83.66	86.50
Days to flowering	4.85	9.45	62.96	59.74
Flower yield (gm)	13.81	14.99	82.56	81.69

If the h^2 of a character is high (0.8 or more), selection of that character is very effective. This is because there would be close correspondence between genotype and phenotypic variances due to relatively smaller contribution of environment to phenotype. But for character with low h^2 (less than 0.4), selection may be ineffective or virtually impractical due to masking effect of environment on genotypic effects. The characters exhibiting high h^2 with high genetic advance (Table 5) in this study were flower yield (82.56 and 81.69%), number of flower/plant (90.71 and 84.43%), flower size (98.73 and 90.29%), stalk length (93.94 and 92.61%) and vase life of flower (83.66 and 86.50%). This indicated additive gene action, suggesting the possibility of improvement of these traits through selection.. Similar observations were reported by Bhattacharjee (1981) in gerbera. The characters exhibited moderate heritability along with moderate genetic advance were observed in number of sucker (64.58 and 63.21%) and days to flowering (62.96 and 59.74%) thus indicated moderate scope for improvement by selection for those character. The moderate heritability with the lowest genetic advance was observed in number of leaves (53.48 and 29.78%) thus indicated less scope for improvement by selection for this character. The high heritability along with the lowest estimates of genetic advance was found in plant height (80.37 and 35.10%) which might be due to non-additive gene effects for the particular character and would offer less scope for selection; because that was under the influence of environment.

Correlation Coefficient

Yield is a complex product being influenced by several interdependable quantitative characters. Thus selection for yield may not be effective unless the other yield components influence it directly or indirectly are taken into consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated characters. Hence, knowledge regarding association of character with yield and among themselves provides guideline for making improvement through selection vis-a-vis provides a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors (Dewey and Lu, 1959).

The genotypic and phenotypic correlation coefficients between different pairs of characters in chrysanthemum are presented in Table 6. Character association analysis among flower and flower producing traits revealed that all the genotypic correlation co-efficients were higher than

the corresponding phenotypic correlation coefficients. This indicates that suppressing effect of the environment, which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Accordingly, Negi *et al.*, (1994) reported that the genotypic correlations were greater than the phenotypic values in chrysanthemum.

It appeared from the results that, flower yield was positively correlated with number of leaves plant^{-1}, plant spread, number of sucker plant^{-1}, number of flower plant^{-1}, stalk length and vase life both at genotypic and phenotypic levels. Among them, plant spread, stalk length and vase life were correlated positively and significantly with flower yield. Bose *et al.* (2003) reported flower yield was significantly and positively associated with plant spread, vase life and flower number in China aster which is agreeable with the present investigation results.
The genotypic correlations for days to flower with flower yield were negative but its corresponding phenotypic correlations were positive. So, it was indicated that this was due to the influence of environmental correlations among these traits for getting positive phenotypic correlations.

It was observed that plant spread had the highest positive significant effect with flower yield both in genotypic and phenotypic level. Number of flower plant^{-1} was positively and significantly associated with flower size. Plant spread had significant positive correlations with number of sucker plant^{-1} and number of flowers plant^{-1} with flower size. So, plant spread would increase by the increasing number of suckers plant^{-1}.

Therefore, the correlations study among different characters suggested that number of flower plant^{-1}, stalk length, vase life, number of sucker plant^{-1} and flower size were the most important traits, which possessed significant positive association with flower yield. Therefore, selection for chrysanthemum genotypes having long stalk length, vase life, number of suckers plant $^{-1}$, number of flowers plant^{-1} and flower size will provide crop improvement towards in positive direction.

Table 6. Genotypic (g) and phenotypic (p) correlations among ten characters in 27 chrysanthemum germplasm

Traits	Corre. coeffi-cient	No. of leaves /plant	Plant spread	No. of sucker / plant	No. of flower/ plant	Flower size	Stalk length	Vase life	Days to flower	Stalk length
Plant	r_g	-0.372	0.014	-0.120	-0.220	-0.196	-0.425*	-0.45*	0.742**	-0.244
height	r_p	-0.291	-0.015	-0.072	-0.052	-0.175	-0.409*	-0.389*	0.637	-0.231
No. of	r_g		0.174	0.484**	0.409*	0.623**	0.335	0.504**	-0.304	0.271
leaves	r_p		0.113	0.350	0.072	0.988**	0.198	0.074	-0.225	0.235
Plant	r_g			0.830**	0.674**	0.725**	0.596**	0.877**	-0.740**	0.764**
spread	r_p			0.578**	0.408 *	0.465*	0.464*	0.574**	-0.366	0.598**
No. of	r_g				0.652**	0.566**	0.540**	0.625**	-0.469**	0.514**
sucker/ plant	r_p				0.441*	0.385*	0.498**	0.487**	-0.284	0.436*
No. of	r_g					0.856**	0.540**	0.540**	-0.756**	0.494**
flower/ plant	r_p					0.655**	0.350	0.481*	-0.190**	0.325
Flower	r_g						0.435*	0.656**	-0.838**	0.495**
size	r_p						0.375*	0.525**	-0.460**	0.389*
Stalk	r_g							0.269**	-0.918*	0.663**
length	r_p							0.254**	-0.534*	0.591**
Vase	r_g								-0.941**	0.746**
life	r_p								0.438	0.540**
Days to	r_g									-0.987**
flower	r_p									0.525**

* and ** Significant at 5% and 1% levels respectively; r_g and r_p indicate genotypic and phenotypic correlation respectively

Path coefficient

In the present investigation flower yield is considered as a resultant variable and plant height, number of leaves, plant spread, number of sucker, number of flower, flower yield, flower size, days to flower and vase life were causal (independent) variables. The cause and effect of relationship between stalk length and yield related characters have been presented in Table 7. Residual effects of other independent variables, which have influence to yield to a small extent, have been denoted as 'R'.

Association of characters determined by correlation coefficients may not provide an exact picture of the relative importance of direct and indirect influence of each of the yield components on yield. As a matter of fact, in order to find out a clear picture of the

interrelationship between flower yield and other yield attributes, direct and indirect effects were worked out using path analysis at genotypic level which also measured the relative importance of each component.

Estimates of direct and indirect effect of nine yield contributing characters are shown in Table 7. From this analysis, it was observed that plant spread had maximum direct positive effect on flower yield. The genotypic correlation of plant spread with flower yield was also high. Such high correlation with flower yield was mainly due to the high positive direct effect of plant spread and considerable positive indirect effects via number of leaves plant^{-1}, flower size, number of stalk length and days to flower. The other traits like flower number, number of sucker plant^{-1} and vase life had also high positive direct effects on flower yield. These direct effects were the principal components of their relationships with flower yield. Anuradha and Gowda (2000) studied on gerbera where the greatest positive direct effect was leaves plant^{-1} on flower yield. So, the results of present study disagree with their finding. Mahanta *et al.* (1998) reported that plant spread, flower size, flower number, stalk length and days to flower initiation had high direct effects. So, these findings partially support the present results.

Plant height had positive direct effect but its correlation with flower yield was negative. Such negative correlations might be due to the negative indirect effects of plant height via number of leaves plant^{-1}, number of sucker plant^{-1} possessed high positive direct effect on flower yield. The genotypic correlation between number of sucker plant^{-1} and flower yield was also high.

Such high correlation with flower yield was mainly due to the high positive direct effect on number of sucker plant^{-1}. Similarly, vase life had also positive direct effect on flower yield. The positive correlation between numbers of sucker plant^{-1}and stalk length was mainly such positive direct effect. Days to flower had negligible negative direct effect on flower yield. It also expressed negative genotypic correlation with flower yield which was mainly through the negative direct effect as well as negative indirect effects via leaves plant^{-1}, number of sucker plant^{-1} and flower size.

Table 7. Path co-efficients of different yield contributing characters on flower yield of chrysanthemum germplasm

Characters	Plant height (cm)	No. of leaves plant^{-1}	Plant spread (cm)	No. of sucker plant^{-1}	No. of flower plant^{-1}	Flower size (cm)	Stalk length (cm)	Vase life (days)	Days to flower	Total correlation on flower yield
Plant height (cm)	**0.06**	-0.02	-0.008	-0.15	0.04	0.07	0.4	0.004	0.001	-0.244
No. of leaves plant^{-1}	0.02	**0.08**	0.38	0.12	0.74	0.11	0.26	0.006	-0.008	0.271
Plant spread (cm)	-.006	0.30	**0.84**	-0.33	-0.36	0.08	0.25	-0.003	0.0010	0.764
No. of sucker plant^{-1}	0.014	-0.01	0.40	**0.74**	-0.36	0.09	0.37	0.006	0.007	0.514
No. of flower plant^{-1}	-0.003	0.08	0.44	-0.35	**0.70**	-0.08	0.24	-0.002	-0.003	0.494
Flower size (cm)	0.02	0.04	0.32	-0.29	0.26	**0.50**	-0.35	0.004	-0.004	0.495
Stalk length(cm)	0.04	0.03	0.32	-0.39	-0.26	-0.12	**0.69**	0.005	0.008	0.663
Vase life (day)	-0.002	0.05	-0.34	-0.55	0.16	0.09	0.41	**0.801**	0.75	0.746
Days to flower	0.005	-0.03	0.07	-0.26	0.13	-.05	0.3	0.34	**-0.070**	0.987

Bold figures indicate direct effect

Residual effect ⊗ = 0.35

Flower size had moderate direct effect with flower yield. The positive correlation with flower yield was mainly due to positive direct effect accompanied by positive indirect effects via plant height, number of leaves plant^{-1}, plant spread, number of flower plant^{-1} and vase life. The residual effect of the present study was 0.35 indicating that 65 percent of the variability in flower yield was contributed by the ten characters studied in the path analysis. This residual effect towards yield in the present study might be due to other characters which were not studied, environmental factors and sampling errors (Sharifuzzaman, 1998). Therefore, path analysis revealed that plant spread, number of sucker plant^{-1}, number of flower plant^{-1}, flower size and stalk length were related to flower yield of chrysanthemum germplasm mainly through

their direct effects. So, selection criteria including these characters will give better response to the improvement of yield status of chrysanthemum germplasm.

Selection of Superior Germplasm

Chrysanthemum germplasms showed variation for all quantitative and qualitative characters. However, coefficient of variation (CV) of the flower yield, number of flowers, flower size, stalk length, sucker number and vase life was higher (cv > 20%) than other characters and thus considered as higher variability in respect of those characters.

- The number of flower per plant as well as stalk length, flower size, sucker number and vase life of flower were reported to be desired selection criteria for increasing flower yield by Behera *et al.* (1992) and Parthasarathy and Shah (1984) in chrysanthemum. The genetic parameters, correlation and path coefficient analysis of the present study revealed that stalk length, sucker number, flower size, flower number and vase life of flower were the most important yield contributing traits in gerbera. Plant selection based on those traits will be most effective in existing collection for its improvement.

- The germplasm CM-004, CM-015, CM-022, CM-023, CM-024 and CM-025 were identified as good germplasm for cut flower (Fig. 9) and CM-009. CM-012, CM-018, CM-019 and CM-021 were identified as good germplasm for pot flower (Fig 10).

Fig. 9. Selected chrysanthemum germplasm for cutflower

CM-009

CM-012

CM-018

CM-019

CM-021

Fig. 10. Selected chrysanthemum germplasm for pot

Experiment 2. Effect of potting media on the growth and yield of chrysanthemum

Results and Discussion

The effect of different potting media on morphological and floral characteristics of chrysanthimum was investigated in this study. The findings of the present study presented in Table (8 & 9) and Figure (10, 11 and 12) have been discussed in following heading.

Plant height

Significant variation was observed among the treatments for plant height (Table8). It varied from 54.0 to 66.0 cm. The treatment T_3 had the tallest plant (66.0 cm) followed by T_4 (63.0 cm), T_2 (62.8 cm) and T_5 (61.7 cm). The height of plant was found to be minimum in T_7 (54.0 cm). The results are in more or less close conformity with findings of Bose *et al.* (2003) who recorded the highest plant height of chrysanthemum of 65.0 cm.

Number of leaves

The number of leaves produced in different treatments varied significantly. The number of leaves per plant ranged from 208-240. The treatment T_3 was the superior and produced the highest number of leaves per plant (240) followed by T_5 (233) and T_2 (231). Adequate numbers of leaves are essential for normal growth and production. An increase in number of leaves causes the accumulation of greater photosynthates leading to better growth parameters. The treatment T_7 produced the lowest number of leaves (208).

Leaf size

The difference in leaf size among the treatments was observed to be statistically significant. The highest leaf size (8.5) was recorded in treatment T_3 while the shortest was in T_7 (4.3). The shortest leaf size producing treatment was statistically identical with those of treatment T_1 (4.5 cm). The leaf size of chrysanthemum produced by the 'Toms' variety was reported to be 9 cm in cocopeat substrate (Dutta *et al.*, 2002) which is similar as has been found in the genotype CM-018 in treatment T_3.

Table 8. Effect of potting media on some morphological characteristics of chrysanthemum at different growth stages

Potting media	Plant height	No. of leaves	Leaf size	Plant spread
T_1	57.0 cd	225 bc	4.5 c	23 c
T_2	62.8 ab	231 b	6.0 b	25 bc
T_3	66.0 a	240 a	8.5 a	32a
T_4	63.0ab	220 c	5.2 bc	22 cd
T_5	61.7 b	233 ab	7.8 ab	28 b
T_6	58.0 c	220 c	5.0 bc	26 bc
T_7	54.0 d	208 d	4.3 c	19 d
CV (%)	**14.5**	**16.0**	**5.4**	**11.7**

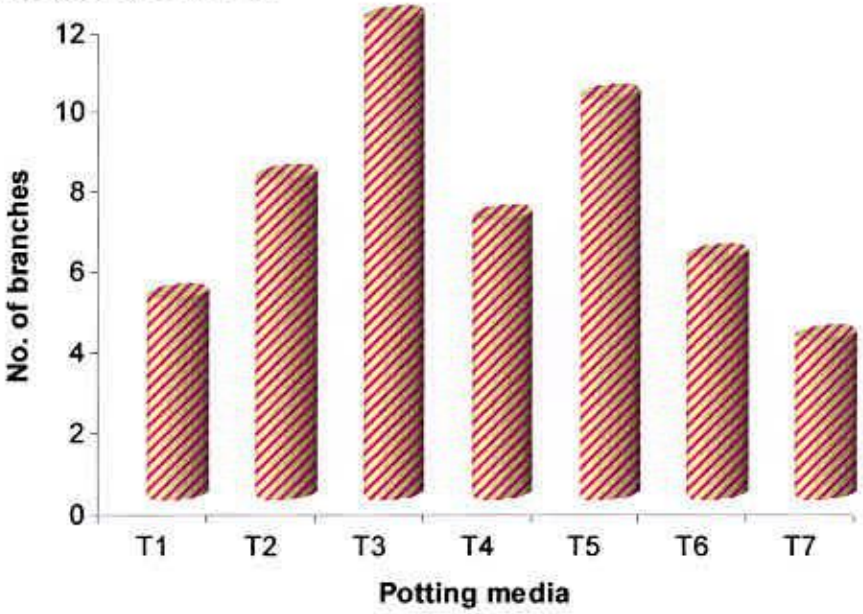
Means in a column having common letter (s) are not significantly different from each other at 5% level of significance by DMRT
T_1 = 100% soil, T_2 = 50% soil + 25% cowdung + 25% cocodust, T_3 = 100% cocodust, T_4 = 50% soil + 25% cowdung + 25% rice husk, T_5 = 50% cocodust + 25% cowdung + 25% soil, T_6 = 50% cocodust +25% rice husk + 25% cowdung, T_7 = 100% rice husk

Plant spread

There was wide variation among the treatments for plant spread. It varied from 19.0 cm to 32.0 cm. The highest plant spread was obtained from the treatment T_3 (32.0 cm) followed by treatment T_5 (28.0 cm). Treatments T_2 and T_6 produced in the range of 25.0 cm - 26.0 cm and they were statistically identical to each other. The lowest was in T_7 (19.0 cm).

Number of branches

The number of branch was quite variable in different treatments (Fig. 11). The highest number of branch (12) was observed in T_3 treatment followed by T_5 treatment (10). The lowest number of branch was recorded in T_7 treatment (04). The above findings are in agreement with that of Aswath *et al.* (1995) in gerbera.



T_1 = 100% soil, T_2 = 50% soil + 25% cowdung + 25% cocodust, T_3 = 100% cocodust, T_4 = 50% soil + 25% cowdung + 25% rice husk, T_5 = 50% cocodust + 25% cowdung + 25% soil, T_6 = 50% cocodust +25% rice husk + 25% cowdung, T_7 = 100% rice husk

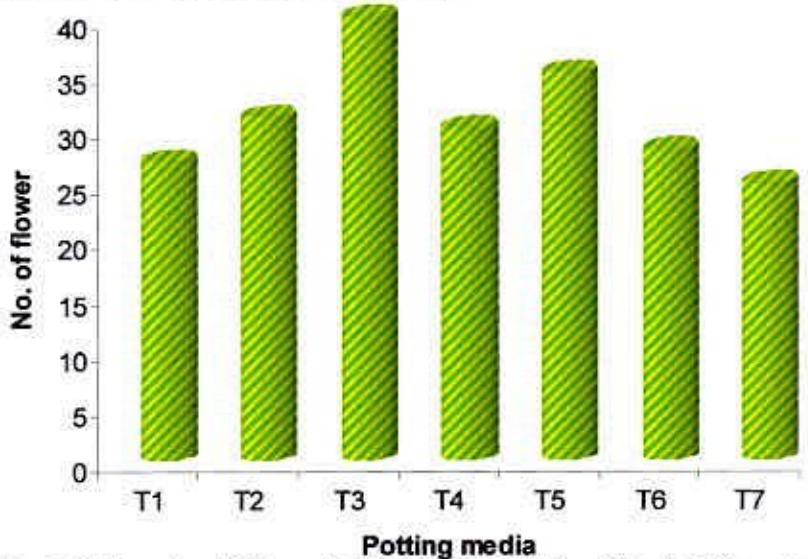
Fig 11. Number of chrysanthemum branches as influenced by different potting media

Days to flower

Statistical difference regarding days to flowering were observed among the various treatments (Table 2). It varied from 55 to 70 days. The maximum days in T_7 (70 days) followed by T_6 (65 days) whereas the minimum by T_3 (55 days) closely followed by T_5 (58 days). Tomati *et al.* (1993) reported that 'Dora' variety of chrysanthemum was found to take 50 days for 1st flowering in perlite medium.

Number of flowers/plant

Significant variation was observed regarding number of flowers produced per plant. It varied from 25-40 (Fig. 12). The highest number of flowers per plant was produced by T_3 (40) followed by T_5 (35). Plants of the treatments T_1 and T_7 produced the lowest member of flowers (25 and 27). Maximum number of flowers was also obtained in cocodust and cocodust with compost in gerbera reported by Tomati *et al.* (1993).



T_1 = 100% soil, T_2 = 50% soil + 25% cowdung + 25% cocodust, T_3 = 100% cocodust, T_4 = 50% soil + 25% cowdung + 25% rice husk, T_5 = 50% cocodust + 25% cowdung + 25% soil, T_6 = 50% cocodust +25% rice husk + 25% cowdung, T_7 = 100% rice husk

Fig.12. Number of chrysanthemum flower as influenced by different potting media

Stalk length

The difference in stalk length among the treatments was statistically significant (Table 9). The longest stalk was in treatment T_3 (13.3 cm) followed by T_5 (12.1 cm) while the shortest in T_7 (8.8 cm) which differed significantly from all other treatments. The results are in partial agreement with Pivot (1985) who reported that the length of flower stalk in chrysanthemum ranged from 12.0 cm to 20.0 cm depending on various substrates used in 'Glory' variety of chrysanthemum.

Average weight of flower stalk

Potting media under study had shown their differential responses with regard to average weight of flower stalk per plant (Table 9). The treatment T_3 produced the highest weight of flower stalk per plant (5.5 g) closely followed by T_5 (5.4 g). Contrasting to this, T_7 yielded the lowest

(3.0 g) weight of flower stalk per plant. Similar results were reported by Dutta *et al.* (2002) in chrysanthemum.

Table 9. Effect of different potting media on flower characteristics of chrysanthemum

Potting media	Days to Flower	Stalk length (cm)	Flower size (cm)	Av. wt. of flower stalk (g)
T_1	65 b	10.0 bc	7.0	3.5 bc
T_2	64 b	11.0 b	7.3	4.3 ab
T_3	55 d	13.3 a	7.5	5.5 a
T_4	60 c	10.4 bc	7.3	4.0 b
T_5	58 cd	12.1 ab	7.4	5.4 a
T_6	67 ab	11.0 b	7.2	4.2 ab
T_7	70 a	8.8 c	6.9	3.0 c
CV (%)	**11.5**	**10.2**	**12.4**	**9.7**

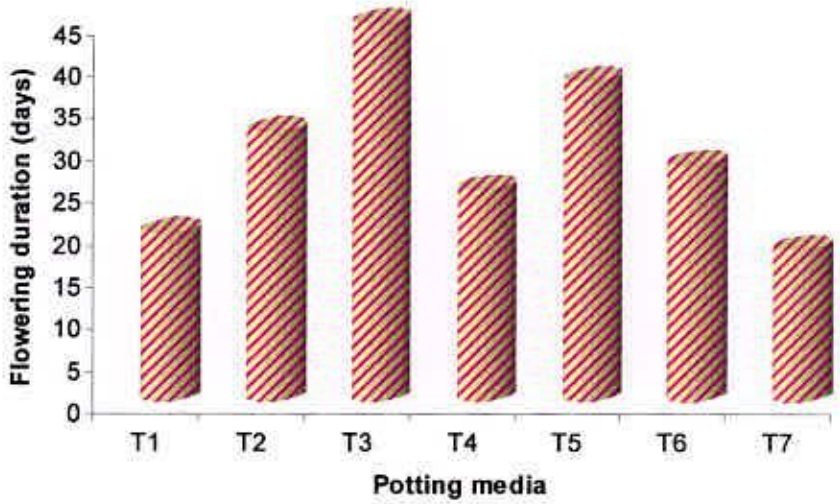
Means in a column having common letter (s) are not significantly different from each other at 5% level of significance by DMRT

Flower size

The flower size of flowers was not significantly improved by various treatment of potting. The results are in agreed with Wilson (1983) in chrysanthemum.

Flowering Duration

Maximum duration of flowering was observed in cocodust (T_3) (45 days) followed by cocodust with soil and cowdung (T_5) (38 days) showed in Figure 13. Tomati *et al.* (1993) obtained similar results in chrysanthemum, where higher duration from full bloom to flower deterioration was observed in plants grown in cocodust substrate. The increased flowering duration could be attributed to conducive conditions in the media and higher nutrient uptake and utilization in plants grown in T_3 and T_5 media. The minimum flowering duration was in T_7 and T_1 (18 and 20 days).



T_1 = 100% soil, T_2 = 50% soil + 25% cowdung + 25% cocodust, T_3 = 100% cocodust, T_4 = 50% soil + 25% cowdung + 25% rice husk, T_5 = 50% cocodust + 25% cowdung + 25% soil, T_6 = 50% cocodust +25% rice husk + 25% cowdung, T_7 = 100% rice husk

Fig. 13. Flowering duration of chrysanthemum as influenced by different potting media

Experiment 3. Effect of pinching on growth and quality flower production of chrysanthemum

Results and discussion

The effect of different pinching on morphological and floral characteristics of chrysanthemum was investigated in this study. The findings of the present study have been discussed and presented in Table 10 and Figure 13.

Plants height (cm)

Height of Chrysanthemum plant (CM-022) was significantly influenced by pinching. Thus the highest plant height (60 cm) was observed under no pinching and lowest (45 cm) was recorded by pinching the plants thrice (T_5). This was due to repetitive removal of apical portion of main branch; axillary buds become free from correlative inhibition of apical dominance and started growing. This resulted into more branching and spread of plants. Thus height was reduced in pinched plants.

Table 10. Plant and floral character of chrysanthemum as influenced by pinching

Treatment	Plant height (cm)	Days to flowering	Branch number	Leaf number	Plant spread (cm)	Flower size (cm)
T_0	60a	57d	05c	200d	17.0d	6.9
T_1	57ab	62c	07bc	214cd	19.0cd	6.9
T_2	55b	63c	07bc	218c	21.0c	7.0
T_3	52bc	63c	09b	224bc	23.0bc	7.1
T_4	49c	68ab	10ab	228b	25.0b	7.2
T_5	45d	70a	12a	235a	30.0a	7.3
CV (%)	**12.40**	**10.80**	**16.30**	**13.00**	**11.72**	**8.14**

T_0- No pinching, T_1- Once 40 days, T_2- Once 50 days, T_3- Once 60 days, T_4- Twice 40 and 50 days, T_5- Thrice 40, 50 and 60 days

Days required for flowering

It is evident from the Table 10 that the increased number of pinching resulted into significant delay in the flowering of Chrysanthemum. Thus the earliest flowering (57 days) was observed where no pinching was followed. There was no significant difference between pinching once (T_1, T_2 and T_3) which took 62, 63 and 63 days respectively, but further significant delay in flowering (68 days) was recorded by pinching the plants twice followed by pinching the plants thrice (70 days). The delay in flowering by pinching was due to removal of physiological mature portion and the new shoots which emerged out from the pinched plants took more time to become physiological inductive to produce flowers than non-pinched plants. Similar results have been observed by Jayanthi and Gowda (1988) in Chrysanthemum.

Number of branches

The number of branch was quite variable in different treatments (Table 10). The highest number of branch (12) was observed in T_5 treatment followed by T_4 treatment (10). The lowest number of branch was recorded in T_0 treatment (05). This was due to repetitive removal of apical bud which leads to enhanced branch number observed in T_5 treatment. The above findings are in agreement with that of Arora and Khanna (1986) in marigold.

Number of leaves

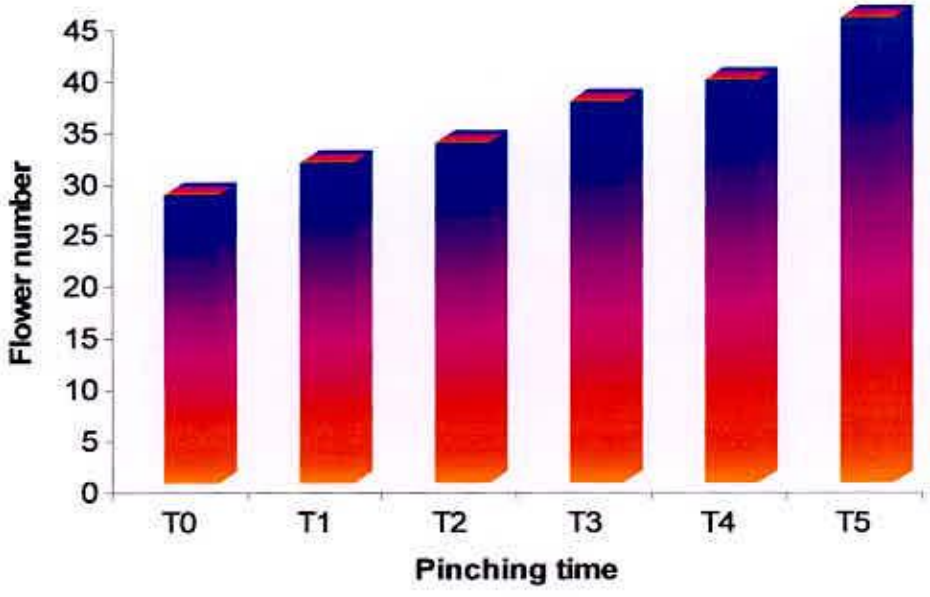
Maximum number of leaves (235) was recorded in T_5 treatment (pinching thrice) followed by T_4 treatment (228). Patel and Arora (1988) also observed increased leaf number in carnation plants while pinched thrice. Adequate numbers of leaves are essential for normal growth and production. An increase in number of leaves causes the accumulation of greater photosynthesis leading to better growth parameters.

Plant spread

It has been observed that plant spreads were significantly affected by the different treatments (Table 10). The treatment T_5 attained maximum plant spread (30 cm). This was due to higher the branch number with high leave content under pinched thrice ultimately increased plant spread. Jayanthi and Gowda (1988) also observed increased plant spread while pinched twice or thrice in Chrysanthemum.

Number of flowers

Perusal of Fig. 14 show that by increasing the number of pinchings, there was an increase in the number (45) of flower per plant .Lowest number of flowers (28) was recorded under no pinching. Number of flowers was affected by pinching was due to increased number of branches.



T_0- No pinching, T_1- Once 40 days, T_2- Once 50 days, T_3- Once 60 days, T_4- Twice 40 and 50 days, T_5- Thrice 40, 50 and 60 days

Fig. 14. Flower number of chrysanthemum

Flower size (cm)

The flower size of flowers was not significantly improved by various treatment of pinching. The result are in agreed with Khanna *et al.*, (1986) in carnation.

Experiment 4: Effect of plant growth regulators on yield and quality of chrysanthemum

Results and Discussion

The Table 11 showed that the different plant characteristics exhibited differences among the ten treatments under study. In general, GA_3 treated plants showed significant improvement in plant spread compared to other treatment variables (Table 11). The maximum spreading of plant (27.0 cm) was observed when plants were treated with GA_3 @ 150 ppm which was closely followed by the application of GA_3 @ 100 ppm. The minimum plant spread (16.8 cm) was recorded in plants treated with CCC @ 800 ppm. Foliar application of GA_3 might have influence on cell division and cell elongation that resulting in enhanced vegetative growth of plants. In contrast, CCC may act as growth retardants and thereby inhibited biochemical processes resulting in less spreading of plants. The findings are in agreement with those of Mittal (1967) in dahlia, Sen and Maharana (1972) and Verma *et al.* (1995) in Chrysanthemum and Verma *et al.* (2000) in carnation. The variation in number of leaf production was pronounced by the application of different growth regulators. However, the highest number of leaves (140) was produced by the application of GA_3 @ 150 ppm as foliar spray (Table 1). This was closely followed by the other concentrations of GA_3 @ 100 ppm. The effects of the GA_3 treatments were observed at par but significantly superior to the rest of the treatments. All the concentrations of CCC were at par recording minimum number of leaves. This is similar with the findings of Talukdar and Paswan (1988), who observed more number of leaves by the application of GA_3 and less number of leaves by foliar application of CCC. The leaf length was also significantly increased with the application of GA_3 at different concentrations, of which GA_3 @ 150 gave the longest leaf length (13.35 cm). Leaf length highly reduced even in respect of control with the use of CCC growth regulators irrespective of concentrations. These findings confirmed that GA_3 acted as growth promoter and that of CCC as growth retardants on different plant characters of chrysanthemum.

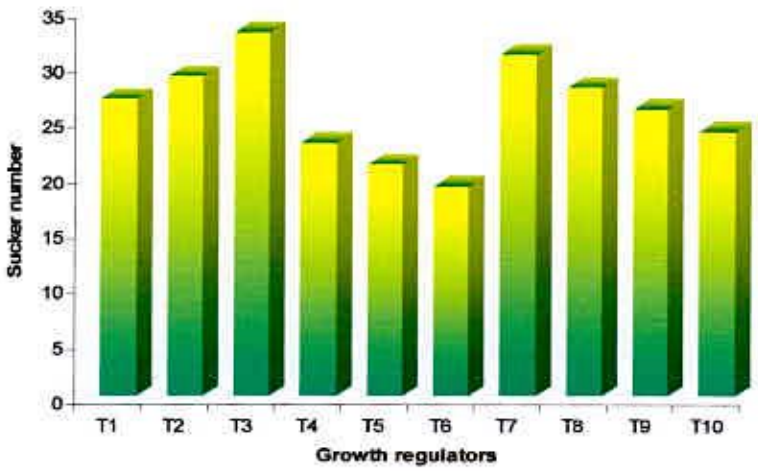
Table 11. Effect of plant growth regulators on plant characteristics in chrysanthemum

Growth regulators (ppm)	Plant spread (cm)	Number of leaves	Leaf length (cm)
GA_3-50	22.9b	125b	11.00b
GA_3-100	25.0ab	135ab	12.00ab
GA_3-150	27.0a	140a	13.35a
CCC-400	22.5b	117bc	9.90cd
CCC-600	18.5c	95d	8.63d
CCC-800	16.8cd	94d	8.47d
MH-250	19.0c	96d	10.89bc
MH-500	20.8bc	118bc	10.74bc
MH-750	21.0bc	119bc	10.80bc
Control	17.0cd	108c	9.20c
CV (%)	**15.25**	**16.00**	**14.92**

T_1-50ppm GA_3, T_2-100ppm GA_3, T_3-150ppm GA_3, T_4-400ppm CCC, T_5-600ppm CCC, T_6- 800ppm CCC, T_7-250ppm MH, T_8-500ppm MH, T_9-750ppm MH, T_{10}-Control

The higher number of suckers (33) per pot was produced when pots were treated with GA_3 @ 150ppm followed by GA_3 @ 100ppm (29), whereas, application of CCC at three different concentrations produced lower number of suckers (Fig. 15). Use of CCC @ 600 and 800ppm produced the lowest number of suckers, which was much less than control treatment. This is in agreement with the findings of Verma *et al.* (2000). The higher number of sucker production by using GA_3 might be due to increase the number and size of leaves as a results of higher translocation of the photosynthates and eventually that would have been used for the production of propagules (suckers).

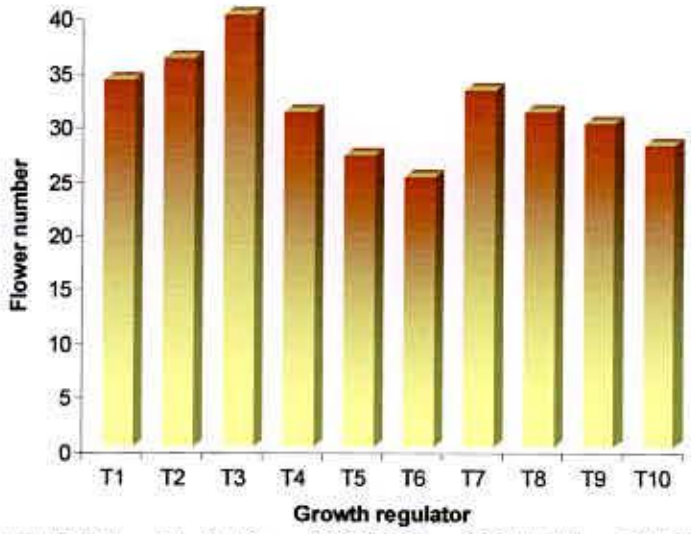
In general, GA_3 at different concentrations produced the higher number of flowers (Fig.16). The highest number of flower (40) was recorded with 150 ppm GA_3, which was significantly superior to those observed by spraying 100 ppm GA_3 and 50 ppm GA_3.



T_1-50ppm GA_3, T_2-100ppm GA_3, T_3-150ppm GA_3, T_4-400ppm CCC, T_5-600ppm CCC, T_6-800ppm CCC, T_7-250ppm MH, T_8-500ppm MH, T_9-750ppm MH, T_{10}-Control

Fig 15. Effect of growth regulators on the production of sukers in Chrysanthemum

Application of 800 ppm CCC produced minimum number of flowers (25) per pot, which was at par with 600 ppm CCC (27) and 400 ppm CCC (31). This was in line with the findings of El-Shafie and Hassan (1978) and Verma *et al.* (1995). The increase in number of flowers for GA_3 treated plants might be due to increase in number of leaves and leaf area compared to control and other treatments. This might have resulted in the production and accumulation of more photosynthates that were diverted to the sink (flower) and give increased number of flowers



T_1-50ppm GA_3, T_2-100ppm GA_3,T_3-150ppm GA_3, T_4-400ppm CCC, T_5-600ppm CCC, T_6- 800ppm CCC, T_7-250ppm MH, T_8-500ppm MH, T_9-750ppm MH, T_{10}-Control

Fig 16. Effect of growth regulators on the production of flower in Chrysanthemum

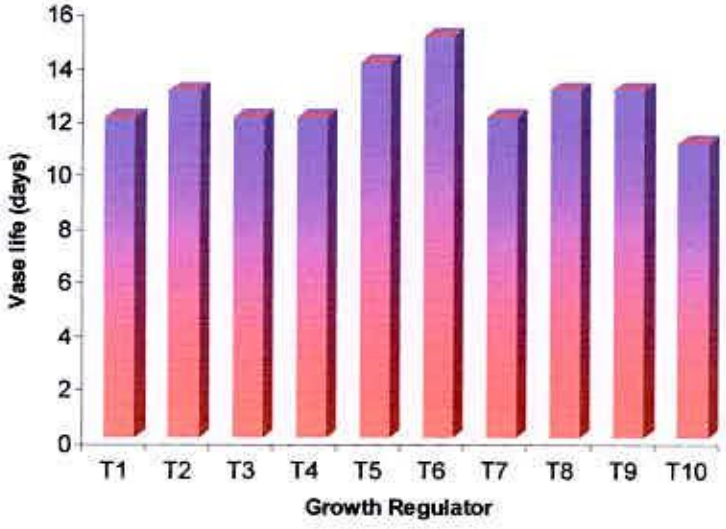
Irrespective of concentrations, GA_3 significantly reduced the number of days to initiation of flowering (Table 12). The plants sprayed with 50 ppm GA_3 took 48 days to flower initiation, where as, it took 70 days with 750 ppm MH. Among the growth regulators GA_3 caused faster initiation of flowering and ACC and MH delayed it in respect of control. Flower size was not significantly affected by the application of growth regulators at different concentrations (Table 2). However, it was recorded highest (7.40 cm) when plants were sprayed with 800 ppm CCC, whereas, lowest size (6.50 cm) was obtained with the application of 500 ppm MH. This was closely followed that obtained by the use of 750 ppm MH. This was in line with the findings of El-Shafie and Hassan (1978) in gerbera and Shanmugam and Muthuswamy (1974) and Talukdar and Paswan (1988) in chrysanthemum. Here, food reserves may have been diverted to only a fewer sinks that enhanced to produce bigger flowers. Length of flower stalk significantly increased when plant was treated with GA_3 regardless of different concentrations (Table 12). The application of 150 ppm GA_3 produced maximum length of flower stalk (15.0 cm), which was identical with those produced by 100 and 50 ppm GA_3. This was in line with the findings of Sachs (1968) and El-Shafie and Hassan (1978). This might be due to the fact that giberellic acid promotes cell division and cell elongation resulting in longer stalks. The growth regulators CCC and MH at different concentrations gave the shorter stalk compared to control

Table 12. Effect of plant growth regulators on floral characteristics in chrysanthemum

Treatment (ppm)	Days to flowering	Flower size (cm)	Stalk length (cm)
GA_3-50	48e	7.10	14.40a
GA_3-100	53d	7.20	14.70a
GA_3-150	55cd	7.30	15.00a
CCC-400	58c	7.10	7.00d
CCC-600	60bc	7.20	8.00cd
CCC-800	62b	7.40	8.00cd
MH-250	65ab	6.80	9.00bcd
MH-500	68a	6.50	8.00cd
MH-750	70a	6.60	10.00bc
Control	57c	6.90	12.00b
CV (%)	**13.64**	**17.50**	**12.41**

T_1-50ppm GA_3, T_2-100ppm GA_3,T_3-150ppm GA_3, T_4-400ppm CCC, T_5-600ppm CCC, T_6-800ppm CCC, T_7-250ppm MH, T_8-500ppm MH, T_9-750ppm MH, T_{10}-Control

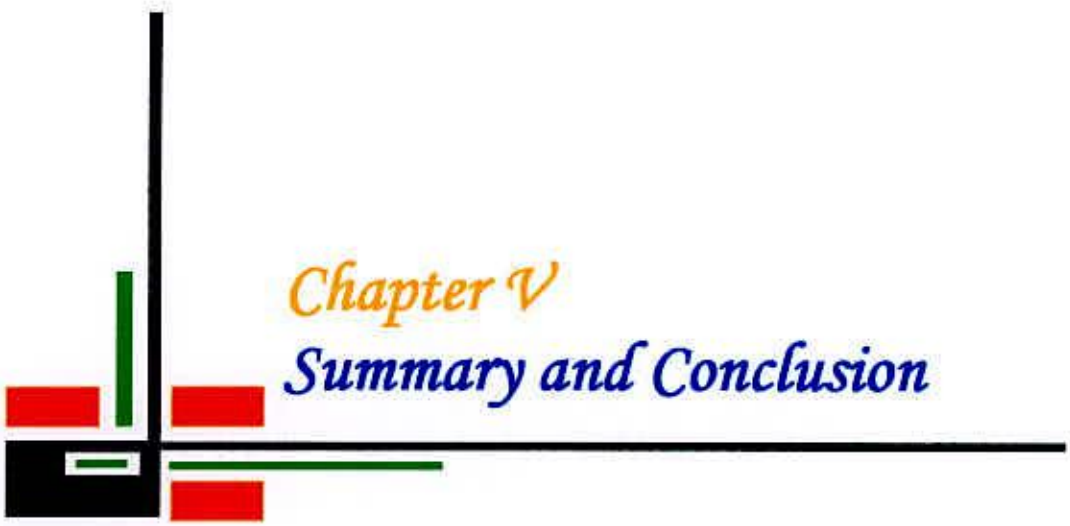
Use of growth regulators showed an increasing vase life of flowers in respect of control (Fig.17). The maximum vase life of flowers was recorded for the treatment 800 ppm CCC (15 days), which was at par with 13 days vase life obtained by spraying 600 ppm CCC. This is in line with the findings of Talukdar and Paswan (1988) in chrysanthemum. This might be due to the fact that CCC acted as growth retardants that may reduce the cell size and stomatal opening and thereby reduce the area for transpiration for which it maintained better water balance.



T_1-50ppm GA_3, T_2-100ppm GA_3,T_3-150ppm GA_3, T_4-400ppm CCC, T_5-600ppm CCC, T_6-800ppm CCC, T_7-250ppm MH, T_8-500ppm MH, T_9-750ppm MH, T_{10}-Control

Fig 17. Effect of growth regulators on the vase life of Chrysanthemum

The study revealed that growth regulators had significant impact on the plant characters, quality and vase life of flower. The performance of the chrysanthemum also depended on the concentration of the growth regulators. The GA_3 @ 150 ppm performed better than other concentrations, where as, CCC at all concentrations had some adverse effect on the plant performance. Therefore, it is concluded that GA_3 acted as growth promoter and that of CCC as growth retardants on yield and quality of chrysanthemum.



Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Summary

An investigation was carried out at Floriculture Experimental Farm of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during July 2007 to June 2008 to study the variability, estimate genetic parameters and the nature of relationship between flower yield and yield contributing characters with 27 genotypes in chrysanthemum and to produce quality flower through pinching and using of growth regulators and potting media. The salient findings of the present study had been summarized below.

All the germplasm varied significantly with each other for all the characters studied. The germplasm CM-026 (75 cm) and CM-005 (35 cm) exhibited maximum and minimum plant height, respectively. The highest leaf number was obtained by CM-002 (200) and lowest in CM-017 (95). Number of branches ranged from 5 to 8 cm.The maximum number of flower was found in CM-002 (200) and the minimum in CM-027(17), the CM-004 took minimum days (53) to 80% spike initiation. The maximum day was required for the germplasm CM-009 (75 days). The highest spike length (12 cm) was found in CM-022 and the lowest in CM-021 (5.4 cm). Regarding plant spread, the germplasm CM-002 produced the maximum plant spread (21 cm). The minimum plant spread (13 cm) was observed in CM-003. Considering flower size, the germplasm CM -023 (9.0 cm) was found the best. The variety BARI chrysanthemum-2 and CM-015 produced the maximum flower yield per plant (270 g). The minimum flower yield per plant (28 g) was recorded in CM-003. A great deal of genotypic variation was observed in case of vase life. Among the germplasm, CM-009 and BARI chrysanthemum-2 exhibited the longest vase life of 14 days closely followed by CM-015, CM-022, CM-023, CM-024, and CM-025 with 12 days of duration. The shortest vase life duration (5 days) were exhibited by germplasm CM-008.

A large variation in qualitative traits of chrysanthemum germplasm were recorded. As regards to colour of flower, the observed germplasm showed remarkable variation such as white, yellow, orange, red, pink and intermediate colours. As regarding to the colour of leaf, the observed germplasms also showed remarkable variation such as green, light green and deep green. The different germplasms showed a wide variation in type of inflorescence. The type of inflorescence

was graded into anemone, pompon, single, incurved, spider, spoon, reflexed and intermediate. Among the germplasm, 25.94% anemone, 3.70% pompon, 3.70% single, 22.22% incurved, 3.70% spider, 18.52% reflexed, 3.70% spoon and 18.52% intermediate type of inflorescence. Utility of different germplasms were graded as pot, cutflower and both pot and cutflower. Among the germplasms, 26% were suitable for pot, 56% for cutflower and 18% for both pot and cutflower.

Chrysanthemum being a cross pollinated crop has much variation and therefore estimates of genetic parameters for each character are important for getting idea about their mode of inheritance. In the present study, a narrow difference between phenotypic and genotype coefficients of variation was noticed for flower number, flower yield, flower size, stalk length and vase life, indicating less environmental interference on the expression of these characters.

In crop improvement only the genetic component of variation is important since this component of h^2 serve as a useful guide to the breeder. The characters exhibiting high h^2 with high genetic advance in this study were flower yield (82.56 and 81.69%), number of flower (90.71 and 84.43%, flower size (98.73 and 90.29%), stalk length (93.94 and 92.61%) and vase life of flower (83.66 and 86.50%). This indicated additive gene action, suggesting the possibility of improvement of these traits through selection. Other characters exhibited moderate heritability with low genetic advance.

The correlation study among different characters suggested that number of flowers plant^{-1}, stalk length, vase life and flower size were the most important traits, which possessed significant positive association with flower yield. However, the correlation study revealed that selection of parents should be done based on those characters for a useful breeding programme .

Path analysis revealed that plant spread, number of sucker plant^{-1}, flower size and stalk length had the highest positive direct effect on flower yield followed by vase life and number of flowers^{-1} might be due to highly significant positive correlation of flower yield with the corresponding characters.

The germplasm CM-004, CM-015, CM-022, CM-023, CM-024 and CM-025 were identified as good germplasm for cut flower and CM-009. CM-012, CM-018, CM-019 and CM-021 were identified as good germplasm for pot flower.

Cocodust (T_3) singly performed best in respect of growth and floral characteristics of chrysanthemum. Pinching the chrysanthemum plants thrice recorded the lowest plant height, whereas highest was observed under control. An increase in number of leaves, shoot and flower production was recorded under thrice and twice pinching respectively.It was observed that foliar application of 150 ppm GA_3 was the best treatment for obtaining best growth of plants, maximum number of cut blooms with more stalk length as well as big sized flower.

Conclusion

The following conclusions are drawn from the results of the study:

- Evaluation of morphological characters indicated wide variation exists among the chrysanthemum germplasm in respect of both qualitative and quantitative characters.
- The germplasm CM-004, CM-015, CM-022, CM-023, CM-024 and CM-025 were identified as good germplasm for cut flower and CM-009. CM-012, CM-018, CM-019 and CM-021 were identified for pot.
- The cocodust was the best substrate for growth and flowering of chrysanthemum.
- Pinching thrice followed by pinching twice performed best in respect of growth and floral character of Chrysanthemum.
- Foliar application of 150 ppm GA_3 was the best treatment for obtaining best growth of plants, maximum number of cut blooms with stalk length as well as flower size in chrysanthemum.

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Appendices

Appendix I. Weather data during the period of experimental site (July 2007 to June 2008)

Year	Month	** Air temperature (°C)		*Humidity (%)	* Rainfall (mm)
		Max.	Min.		
2007	July	28.8	27.1	89.4	073.9
2007	August	31.2	27.7	88.6	082.3
2007	September	31.3	28.2	88.0	101.3
2007	October	30.5	28.1	86.9	118.0
2007	November	26.2	23.7	87.7	035.8
2007	December	22.0	19.4	84.2	000.0
2008	January	19.9	17.6	84.0	029.6
2008	February	20.5	17.8	85.0	064.3
2008	March	26.2	23.5	83.6	015.0
2008	April	30.0	28.6	76.2	010.4
2008	May	31.3	28.3	79.2	226.2
2008	June	30.6	27.9	83.1	321.8
2008	July	30.2	27.5	84.0	246.1

Appendix : II. Analysis of variance of the data on different characters of 27 Chrysanthemum germplasm

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm)	Leaf number	Leaf length	Branch number	Sucker number
Replication	2	18.79	96.20	14.10	20.51	33.12
Chrysanthemum germplasm	27	50.48*	57.05*	25.23*	17.48*	15.97*
Error	54	16.60	6.14	5.10	4.66	5.40

* = Significant at 5% level of probability

Appendix II. Contd.

Source of variation	Degrees of freedom	Mean square				
		Days to 50% flower	Flower number	Flower size	Stalk length	Vase life
Replication	2	1.18	68.20	70.12	0.96	7.15
Chrysanthemum germplasm	27	16.09*	47.05*	57.05*	3.37*	6.34*
Error	54	3.01	7.19	6.14	1.12	1.05

* = Significant at 5% level of probability

Appendix III. Analysis of variance of the data of potting media on growth characteristics of chrysanthemum

Source of variation	Degrees of freedom	Mean square				
		No. of leaves	Leaf size	Plant spread	Plant height	Number of branches
Replication	2	15.60	16.40	13.20*	21.40*	15.52^{NS}
Treatment	6	92.1 0 *	27.60 *	28.60*	35.00*	28.00^{NS}
Error	12	8.85	3.65	4.605	5.90	4.60

* = Significant at 5% level of probability
NS= Non significant

Appendix III. Contd.

Source of variation	Degrees of freedom	Mean square					
		Days to flowering	No. of flowers/ plant	Stalk length	Flower size	Av. Wt of flower stalk	Flowering duration
Replication	2	16.20*	17.00*	23.55*	40.70*	4.14^{NS}	15.60^{NS}
Treatment	6	80.11*	25.99*	42.00*	54.77*	16.06^{NS}	10.85^{NS}
Error	12	11.00	2.64	3.98	5.94	3.01	5.94

* = Significant at 5% level of probability
NS= Non significant

Appendix IV. Analysis of variance of the data of pinching on morphological and floral characters of chrysanthemum

Source of variation	Degrees of freedom	Mean square						
		No. of leaves	Days to flower	Plant height	Plant spread	Branch number	Flower size	No. of flower/plant
Replication	2	16.69	19.40	44.20	17.75	15.15	15.00	23.70
Treatment	5	20.33*	31.62*	56.98*	33.00*	28.00*	27.48^{NS}	19.75*
Error	10	4.00	3.49	4.28	4.30	3.70	2.73	4.55

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data of plant growth regulators on morphological and floral characters of chrysanthemum

Source of variation	Degrees of freedom	Mean square				
		No. of leaves	Plant spread	Leaf length	Sucker number	Days to flower
Replication	2	18.34	20.52	18.08	13.75	25.59
Treatment	9	118.10*	103.00*	52.50*	148.10*	60.42*
Error	18	12.0	8.34	3.99	11.0	5.90

* = Significant at 5% level of probability

Appendix V. Contd.

Source of variation	Degrees of freedom	Mean square			
		Flower size	Stalk length	Flower number	Vase life
Replication	2	32.15	48.99	29.94	28.78
Treatment	9	85.00^{NS}	89.25*	115.00*	62.70*
Error	18	5.98	6.30	6.05	4.10

- = Significant at 5% level of probability
- NS= Non significant

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