Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha.

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CERTIFICATE-I

This is to certify that the thesis entitled**"EVALUATION AND SELECTION OF SPRAY CHRYSANTHEMUM (*Chrysanthemum morifolium* Ramat) GENOTYPES SUITABLE FOR COMMERCIAL CULTIVATION UNDER COASTAL PLAIN ZONE OF ODISHA."**submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)**to the Orissa University of Agriculture and Technology is a faithful record of *bonafide* and original research work carried out by **TAKHELLAMBAM HENNY CHANU**under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by her from various sources during the course of investigation has been duly acknowledged.

CHAIRMAN
ADVISORY COMMITTEE

CERTIFICATE-II

This is to certify that the thesis entitled **"EVALUATION AND SELECTION OF SPRAY CHRYSANTHEMUM (*Chrysanthemum morifolium* Ramat) GENOTYPES SUITABLE FOR COMMERCIAL CULTIVATION UNDER COASTAL PLAIN ZONE OF ODISHA."**submitted by **TAKHELLAMBAM HENNY CHANU** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE AND LANDSCAPING)** has been approved by the students' advisory committee and external examiner.

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ABSTRACT

The present investigation entitled, **"**Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha." was conducted at Biotechnology-cum-tissue culture Laboratory, Department of Floriculture, College of Agriculture, Orissa University of Agriculture & Technology, Bhubaneswar, Odisha, India during 2017-18. The objective was to study the nature and extent of variability present in a set of nine genotypes and to identify and select elite genotypes suitable for Coastal plain zone of Odisha. Nine genotypes were evaluated by adopting RBD with three replications. The genotypes were evaluated for 15 parameters including, vegetative growth, flowering and yield attributing as well as flower quality parameters.

The genetic variability, character association and path analysis of thirteen growth and flowering related traits were studied for nine genotypes of spray chrysanthemum (*Chrysanthemum morifolium* Ramat). Analysis of variance for all traits showed highly significant differences among genotypes for all the growth and flowering related traits. The high genotypic and phenotypic coefficient of variation associated with high heritability coupled with high genetic advance expressed as per cent of mean was recorded for flower weight, number of ray florets per flower, weight of flowers per plant, number of flowers per plant and flower diameter. Hence, these characters need to be given more importance in selection for improvement of spray chrysanthemum. Weight of flowers per plant (yield) was significant and positively correlated both at genotypic and phenotypic levels with plant height, plant spread in both directions, number of primary branches per plant, number of days taken for flower bud appearance and opening, flower diameter, number of ray florets per flower and flower weightindicating selection for the improvement of one character will lead to simultaneous improvement for yield per plant. Average flower weight contributed the highest positive direct effect on flower yield per plant followed by duration of flowering, number of flowers per plant and plant height. Hence, direct selection for these traits would be highly effective in improving yield per plant of spray chrysanthemum. On an average, Bidhan Madhuri, Arka Chandrika and Bidhan Jayanti were recommended genotypes for the commercial cultivation under the coastal plain zone of Odisha.

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ABBREVIATIONS USED

%	:	Per cent
Mm	:	millimeters
cm	:	Centimeters
g	:	Gram
@	:	At the rate
Kg	:	Kilogram
Ha	:	Hectare
MT	:	Million Tonnes
i.e.	:	(*Id est.*) that is
et al.	:	And others
^{o}N	:	Degree North
^{o}S	:	Degree South
N-S	:	North-South
E-W	:	East-West
C.D.	:	Critical Difference
ESS	:	Error sum of square
R.H.S.	:	Royal Horticultural Society
Via	:	Through
Viz.	:	(*Videlicet*) Namely
Ch	:	Character
FYM	:	Farm Yard Manure
N	:	Nitrogen
P	:	Phosphorus
K_2O	:	Potassium oxide
Min.	:	Minimum
Max.	:	Maximum
BSH	:	Brightness sunshine per hour
R.H.	:	Relative humidity
°C	:	Degree Celsius

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INTRODUCTION

Flowers have been associated with mankind since time immemorial. Flowers symbolize purity, beauty, peace, love and passion. Floriculture is fast emerging as a sunrise business activity. Enormous flower shops have materialized the markets in cities and towns across the country after westernization. Globally, more than 140 countries are involved in the cultivation of floricultural crops. In India, the flower growing states are West Bengal, Karnataka, Maharashtra, Tamil Nadu, and Andhra Pradesh.

In India, the total area under loose flower crop is 306000 ha in 2016-17. The total production of loose and cut flower in 2016-17 is 1699000 MT and 693000MT respectively. In Odisha, the estimated area under flower cultivation in 2017-18 is 640 ha with the estimated loose flower production of 2180 MT and estimated cut flower production of 5060 MT (NHB, 2017).

The country has exported 22,086.10 MT of floriculture products worth Rs. 548.74 crores in 2016- 17; out of which chrysanthemums contributed 13.21 MT with a value of Rs. 27.63 lacs (APEDA, 2017).

Chrysanthemum (Chrysos ‘golden’; anthos ‘flower’) the ‘Queen of the East’ is a popular flower crop of commercial importance, native to the northern hemisphere, chiefly Europe and Asia. Many authorities claim that it is originated in China (Carter, 1980). It belongs to the family Asteraceae, comprises of huge biodiversity in their growth habitat, flowering behaviour, flower and foliage colour, shape and size. The basic chromosome number of chrysanthemum cultivars has been reported to be 9 by several workers in different parts of the world e.g. in Europe (Dowrick, 1952) and in India (Nazeer and Khoshoo, 1982). The study of cultivars grown in India have displayed wide range of ploidy levels with 2n= 36, 45, 51 and 75.

Chrysanthemums are classic qualitative short-day plants, i.e., blooming controlled by the relative length of the day and night. The blooming period under traditional culture is short, few weeks or month, depending on the geographical location of growing area.

Environment/season is the most important limiting factor for growth and flowering of chrysanthemum (Raman *et al*., 1969). However, the performance of cultivars is also influenced by agro-climatic factors. The variations among chrysanthemum varieties are large in response to environment particularly temperature and the interaction between temperature and cultivar occur for every developmental trait (Pleog and Heuvelink, 2006).

Chrysanthemum is a multi-use flower crop and gaining more popularity for interior decoration and in bouquets; has high demand in both domestic and international market. It is very rich in varietal wealth and every year there is addition of new varieties. There is hardly any other garden flower which has such diverse and beautiful range of colour, shapes, and height as that of chrysanthemum. Apart from ornamentals, chrysanthemum is used for other purposes like essential oils, cosmetics, aromatherapy, dry flowers, pot pourries, natural dyes, medicines etc. It is considered as one among the five important commercially potential flower crops by the All India Coordinated Research Project on Floriculture Improvement Project (ICAR). The current number of chrysanthemum cultivars worldwide is reported to be 20,000 to 30,000 (Anderson, 2006).

The consumer preference has been changing from time to time for both traditional and cut flowers and there is demand for varieties based on colour, shape, size, shelf life, etc. stressed the importance of research in developing high yielding varieties with year round production in chrysanthemum. The utility and popularity of chrysanthemum have increased immensely with the introduction of technique of year round production based on scientific research in the field of photo-periodic and genetics.

In India, its germplasm has been screened but the information on the performance for the higher yield of the cut flower and yield contributing parameters of chrysanthemum is meager. Many cultivars have been developed from local material collected from different parts of the country. In spite of varietal development, there is a need to develop varieties/ genotypes with better yield, quality and their adaptation under different environment.

Flower yield, a complex character, is not only influenced by its associated characters but also are governed by a number of genes and environment. For effective selection, it is necessary to separate genetic variability from total variability, which enables breeders to adopt suitable breeding programmes. The assessment of genetic variability is necessary to evaluate the performance of the individual cultivars for making rapid improvement in yield and other desirable characters.

The correlation and path coefficient study furnishes information regarding the nature and magnitude of various character associations and help in the measurement of direct influence of one character on others. The correlation coefficient indicates the degree of relationship between quantitative characters. The path coefficient provides information regarding the direct and indirect influences of yield component; which is necessary for selecting suitable genotypes for improving the yield.

In the light of above information, the experiment entitled "Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha.'' was conducted to analyze and understand the nature and extent of variability present in a set of nine genotypes and to identify and select elite genotypes suitable for coastal plain zone of Odisha.

Thus, the present experiment was undertaken with the following objectives:

1. To study the extent of genetic variability with respect to flower production in spray chrysanthemum.
2. To study the extent of character association in relation to flower yield and its component traits.
3. Evaluation and selection of spray chrysanthemum genotypes suitable for coastal plain zone of Odisha.

REVIEW OF LITERATURES

A wide range of diversity exists in flower number, size, colour and flower duration in chrysanthemum cultivars. The growth and performance of these genotypes exhibit wide range of diversity with the prevailing climatic conditions of their growing habitat. The knowledge of the nature of association of flower yield and its components is very essential to improve the yield through selection of better varieties. The main objective of a breeding programme is improvement of quantitative and qualitative traits of a crop. Information on various quantitative and qualitative traits, with study of genetic variability, correlation, path coefficient analysis is of great interest for the plant breeders as they play a vital role in successful crop improvement programme.

The literature available pertinent to present investigation, **"**Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha." have been reviewed in this chapter under the following sub headings:

2.1 Variability, heritability and genetic advance

2.2 Correlation studies

2.3 Path coefficient analysis

2.4 Qualitative characters

2.1 Variability, heritability and genetic advance

The study of genetic variability is an important prerequisite in any successful breeding programme. The knowledge on nature and magnitude of genetic variation with respect to quantitative plant growth characters coupled with yield and its components is essential in efficient crop improvement programme. The effectiveness of the selection is primarily dependent upon the existence of genetic variability within or among the population subjected to selection. The variability in the population can be estimated by variability parameters like mean, range, genotypic and phenotypic

coefficient of variation i.e. GCV and PCV along with heritability and genetic advance.

Phenotypic selection is inadequate since it is the resultant of the interaction of genotype and environment which creates difficulty in ascertaining whether variability is heritable or non-heritable (environmental). This requires the partitioning of total variations or phenotypic variations into two groups such as heritable and non-heritable components as follows:

A) Heritable or genotypic variation:

a) Additive genetic variance (V_A), which results from additive or average effect of genes and is heritable.
b) Dominance variance (V_D), which arises from intra-allelic interaction and is also heritable.

B) Non-heritable or non-genotypic variation:

a) Epistatic variance (V_I) which results from the interaction of non-allelic genes and is referred as inter-allelic interaction.

b) Environmental variance (V_E) which results from non-genetic factor such as environmental fluctuations, sampling error and difference in cultural practices.

Coefficient of variation

Coefficient of variation is the measure of variation and is independent of unit of measurement which is used for comparing different populations. It is provided by the standard deviation expressed as percentage of mean. Phenotypic coefficient of variation (PCV) is the phenotypic standard deviation expressed as percentage of mean and genotypic coefficient of variation (GCV) is the genotypic standard deviation expressed as percentage of mean. A slight difference between phenotypic and genotypic standard deviation suggested negligible influence of environment on that particular character (Choudhary *et al*., 1973).

Heritability

The degree at which variability of a character may be transmitted to the progeny is referred to as heritability. Heritability is a useful measure to determine the amount of genetic variance over total variance. Robinson (1966) defined heritability in broad sense as "the ratio of total genotypic variance to total phenotypic variance". Higher magnitude of heritability suggested the major role of the genetic factors in the expression of the characters. It is generally expressed in percentage. Johnson *et al.* (1955) hypothesized that heritability estimates, when studied in conjunction with genetic advance would provide more appropriate information than the study of heritability. Allard (1960) viewed that characters, which had low heritability are, not dependable because their genotypic expression is super imposed by the environmental influences.

Heritability always emphasizes about the selection in relation to the genetic traits. Heritability in broad sense reflects the functioning of genotypes as a whole. In narrow sense, it is that part of observed variance which is caused by additive genetic variance. It guides the plant breeder with respect of selecting the individual from segregating generations for effective improvement. Therefore, it is a pre-requisite for planning of any crop improvement programme based on selection technique.

Genetic Advance

Genetic advance (GA) or genetic gain (GG) is still more useful tool to estimate the nature of the crop. GA is directly related with the heritability as it gives an idea about the expected genetic changes on account of selection applied for a particular trait. Heritability often fails to provide the estimates of absolute variability. The estimate of the GA as per cent of mean provides more reliable information regarding the effectiveness of selection in improving a trait because its estimate is derived by involving heritability phenotypic standard deviation selection intensity thus the estimate of heritability and GA are of a great significance to plant breeders in developing suitable selection strategies.

The success of genetic advance under selection depends on three factors; (i) genetic variability (ii) heritability and (iii) selection intensity. The GA is generally high

with the characters having high heritability. Estimates of GA help in understanding the type of gene action involved in the expression of various polygenic characters. High values of GA are indicative of additive gene action and low values are indicative of non-additive gene action.

A brief research work carried out on the genetic variability, heritability and genetic advance of chrysanthemum and other crops aredescribed here under:-

Jung (1984) studied the number of days to flowering and the number of flowers per plant at 12^{o}, 13^{o}, 15^{o} and 17^{o} C night temperature in 79 F_1 populations from 15 parents and analyses genetically and recorded a broad sense heritability of 70 %, for days to flowering and flower number and a highly significant GCA effect for days to flowering.

Raghava *et al.* (1992) revealed high genotypic coefficient of variation for flower yield per plant, number of flowers per plant and flower size in chrysanthemum. They recorded high heritability and genetic advance for number of flowers per plant and flower yield per plant.

Beura*et al*., (1995) studied fifteen genotypes of dahlia and reported that there were significant genotypic differences for total flower production and its components. They observed high GCV and heritability associated with high GA for total flowers per plant.

Fifty-seven genotypes of chrysanthemum (*Dendranthema grandiflora*) were evaluated by Sirohi and Behera (2000) during the winter season and found out that the higher GCV and PCV estimates were found for number of flowers per plant followed by number of branches per plant and disc diameter. The high heritability with high genetic advance was observed for number of branches per plant, disc diameter, number of petals per flower and flower yield.

A total of six standard cultivars namely, Alfred Simson, Cossa Grandi, Grape Bowl, Litter Pink, Snow Ball and Temptation of chrysanthemum (*D. grandiflora*) were evaluated by Deka and Paswan (2001). They obtained significant differences among the cultivars for morphological character (plant height) and floral characters

(days to bud visibility, days to flowering, flower size, shelf life, and flower colour and flower type). Analysis of these characters revealed that the cultivars Snow Ball and Temptation were the best cultivars suitable as pot plant for exhibition or decoration purposes.

Pal and George (2002) studied vegetative and flowering characteristics in 2 indigenous (Sonar Bangla and Pride of Jamshedpore) and 10 exotic (Kenroku Kangiku, Balcombe Perfection, Snow Ball, Chandrama, Okaihama, Melody Lane, Pink Cloud, Silk Brocade Pink, Ghenzyskhan, and Gambit) chrysanthemum (*Dendranthema morifolium*) cultivars. They observed significant variation for plant height, days to flower bud emergence, and shelf-life of flowers; high heritability associated with high genetic advance as the percentage of mean for flower weight, indicating the presence of additive gene action.

Eleven genotypes of China aster were evaluated for fourteen quantitative characters by Kumar *et al.* (2003). They observed the genotypic coefficient of variation was high for spread of plant, average weight of fresh flower and flower yield per plant; heritability estimates for plant spread, average weight of fresh flowers and flower yield per plant were also relatively high and show high expected genetic advance.

Genetic variation for growth and flower characteristics was studied by Talukdar *et al*. (2003) in 11 chrysanthemum cultivars (Prof. Harris, Anupam, Red Anemone, Charming, Yellow Button (Indramalati), White Decorative, Rajkumari, Purple Decorative, Nirod, Marble Queen and Yellow Decorative) and concluded the highest genetic and phenotypic coefficients of variation were recorded for number of flowers per plant.

Ghimiray *et al.* (2005) studied 12 chrysanthemum (*Chrysanthemum morifolium*) cultivars (Aparajita, White Prolifica, BirbalSahni, Flirt, Jaya, Mercury, Mountaineer, Nanako, Punjab Anuradha, Raja, Ravi Kiran and Vasantika) under two environmental conditions open field and polyhouse for various growth and floral characters. They reported the phenotypic coefficients of variation were higher than those of genotypic coefficients of variation for all the characters; high heritability coupled with high genetic advance was observed in the yield of flowers per plant(g)

and the number of branches per plantover environments, flower freshness after full bloom (days) under open field and flower diameter (cm) under protected condition.

The genetic characters in 27 cultivars of spray type chrysanthemum (*Chrysanthemum morifolium*) were estimated by Mishra *et al.* (2006). They observed wide range of variability for flower yield and 8 related quantitative characters. They found the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all characters. They estimated genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance exhibited higher values for number of branches per plant, average flower weight, number of flowers per spray and number of flowers per plant suggesting additive gene action for expression of these characters.

Baskaran *et al.* (2009) studied the genetic variability, heritability and genetic advance among ten genotypes of chrysanthemum. The high phenotypic and genotypic co-efficient of variation for trait, i.e., flower disc diameter (GCV=63.19; PCV= 66.76) was observed. In high heritability estimate coupled with high genetic advance as per cent of mean was observed for flower disc diameter (123.23) and number of flowers per plant (114.81).

Hegde and Mathad (2009) evaluated thirty one accessions of African marigold and indicate the phenotypic and genotypic variances were low; very high estimates of variability (99.9%) and genetic advance over percentage of mean (124.2%) values were associated with high PCV and GCV values; they also found wide variability for morpho-economic characters.

Kavitha and Anburani (2010) assess the genetic variability present in 30 germplasm of African marigold and revealed that the coefficients of variation both at genotypic and phenotypic levels was maximum for number of flowers per plant; heritability estimates for the characters like number of flowers per plant, number of laterals per plant were very high. High heritability along with high genetic advance as per cent of mean was observed for number of flowers per plant.

Anuja and Jahnavi (2012) revealed that the values of PCV were higher as compared to GCV due to influence of environment. They found high genotypic

coefficient of variation was observed for flower head weight and flower yield per plant; high heritability were coupled with high genetic advance (as per cent of mean) was observed for number of flowers per plant, flower yield per plant and stem height.

Panwar *et al.* (2013) reported the high genotypic and phenotypic coefficient of variation was observed for flower yield per plant and fresh weight per flower whereas lowest value for both GCV and PCV were obtained by days to flowering. They recorded high heritability (>70%) for flower diameter, fresh weight per flower, dry weight per flower and flower yield per plant; high genetic advance as per cent of mean was observed for flower yield per plant followed by fresh weight per flower.

Diversity among 50 genotypes of *Chrysanthemum morifolium* was analyzed by Asil *et al.* (2014). They identified that the coefficient of genetic variations for most traits was greater than 40%. The highest general heritability belonged to days to bud coloring (h^2=90.59%) and post-production longevity (h^2=88.3%). The lowest heritability (h^2=6.05%) was related to disc floret opening.

Studies on genetic variability in twenty one genotypes of small flowered chrysanthemum obtained from diverse sources was conducted by Sahu and Sharma (2014); revealed high magnitude of GCV and PCV for number of ray florets per flower, average flower weight, number of branches per plant, number of flowers per plant and plant spread. The PCV was higher in magnitude than the GCV for all the characters like plant height, plant spread, average flower weight and number of flowers per plant. High heritability coupled with high genetic advance was noticed for number of ray florets per flower, number of flowers per plant, average flower weight, flower diameter, plant height, plant spread and days to first bud appearance.

Kameswari *et al*. (2015) evaluated one hundred and four divergent genotypes of chrysanthemum; they observed high GCV and PCV for plant spread, number of primary branches per plant, disc diameter and number of flowers per plant; high heritability coupled with high genetic advance as percentage of mean was recorded for quantitative characters except for duration of flowering.

A total number of 24 genotypes of chrysanthemum were evaluated by Kumar *et al.* (2015) and found that number of flower per plant, flower size and plant spread

showed the highest phenotypic and genotypic co efficient of variation closely followed by plant height (at flower bud initiation and after full bloom stage). The GCV and PCV values for most of the characters were found to be very distant to each-other, indicated that characters much influenced by environmental factor. The heritability estimates in broad sense were high for number of flowers per plant, flower size and plant height after full bloom, while low heritability estimates were observed for days to flower bud initiation, plant spread and number of primary branches per plant. The genetic advance as percentage of mean was high for number of flowers per plant, flower size, plant height and plant spread. High heritability coupled with high genetic advance was observed for number of flowers per plant, flower size and plant height indicating that they are governed by additive genes and could be effectively improved through selection.

Sheshaiah and Shankergoud (2015) recorded high GCV and PCV for plant height; high heritability coupled with high GAM for plant height, stem girth, fresh flower weight.

Chauhan *et al.* (2017) carried out an experiment with fifty carnation (*Dianthus caryophyllus* L.) genotypes. They found the widest range of variation was recorded by plant height (68.15 to 99.85 cm), followed by number of days to bud formation (131.92 to 148.00), number of days to first flowering (156.54 to 174.20), flower size (5.81 to 7.78 cm), duration of flowering (11.84 to 15.71 days) and vase life (8.84 to 11.79 days); whereas, narrowest range was observed for number of flower stems per plant (4.76 to 7.72). A moderate value of PCV along with GCV was observed for plant height and number of flowers per plant. High values for heritability was recorded for plant height followed by flower size. High heritability associated with high values of genetic advance was observed in plant height.

An investigation was carried out by Choudhary *et al.* (2017) with thirty genotypes of marigold and reported the mean sums of squares were highly significant for characters like plant height, plant spread, number of primary branches per plant, days to first flower opening, duration of flowering, number of flowers per plant, flower diameter, fresh weight of flower and flower yield per plant, indicating the presence of variability. They also found that highest range of variation was reported with fresh weight of plant followed by flower yield per plant, whereas dry weight of

flower exhibited minimum range of variation. The PCV was higher in magnitude than the GCV for all the characters. They also reported the high genotypic and phenotypic coefficient of variation were recorded for flowers per plant, whereas, low genotypic and phenotypic coefficient of variation were recorded for flower diameter and days taken to first flower opening. High heritability with high genetic advance was found with number of flowers per plant. High genetic advance as per cent was observed for number of flowers per plant revealing the importance of additive gene effects for these traits.

Eight genotypes of China aster were evaluated by Kumari *et al.* (2017) and reported high heritability (>60%) was recorded for plant height, days to first flowering, duration of flowering, number of flowers per plant, weight of per flowers, vase life.

Studies on genetic variability, heritability and genetic advance were carried out among twenty genotypes of chrysanthemum. The results showed high phenotypic and genotypic co-efficient of variation for traits like number of flowers per plant (GCV = 49.33; PCV = 49.34) and flower size (GCV = 37.40; PCV = 37.43). The high heritability values were obtained number of flowers per plant, flower size, flower size and number of primary branches per plant. In high heritability estimate coupled with high genetic advance as per cent of mean was observed for number of flowers per plant (101.61), flower size (76.97) and number of primary branches per plant (55.82) (Prakash, 2017).

Rani *et al.* (2017) evaluated 50 sunflower genotypes and reported that high estimates of heritability along with moderate variation were found for plant height and head diameter.

Genetic variability was carried out with sixty chrysanthemum genotypes by Telem *et al.* (2017) and reported high phenotypic and genotypic coefficient of variation for the character such as number of flower per plant, number of primary branches, plant spread and plant height. They observed that high heritability coupled with high expected genetic advance for number of flower per plant.

2.2 Correlation studies

In crop plants the most important economic character is yield, which is complex one and is dependent on a number of direct or indirect components. Therefore the knowledge of nature of association of those components is essential because selection for yield involves selection for one of its components.

Correlation coefficient is a statistical measure which is used to find out the size and direction of relationship between two or more variables. Correlation coefficient measures the degree of association either in positive or negative direction. Phenotypic correlation is the observable correlation between two variables while genotypic correlation is inherent association between two variables; it may be either due to pleiotropic action of gene, linkage or both or due to developmentally induced relationships. Correlations are helpful to ascertain the real components of yield which is a complex character.

Direct selection for yield is often misleading as yield is polygenically controlled and also subjected to the effect of fluctuating environment. Efficiency of selection in any breeding programme is enhanced and mainly depends on the knowledge of association of characters. The work done for association of relationship between yield and yield contributing characters of chrysanthemum and related crops is reviewed as below:

Pandita and Bhan (1989) reported there is significant positive genotypic and phenotypic correlation between the number of flowers per plant and flower yield in pyrethrum (*Chrysanthemum cinerarifolium*).

Chattopadhyay *et al*. (1991) conducted correlation studies in eleven chrysanthemum cultivars and observed positive and significant correlation between number of flowers per plant and number of branches per plant.

Beura *et al*., (1995) studied fifteen genotypes of dahlia and reported that total flowers per plant showed significant positive association with span of flowering, and significant negative association with days to first flowering.

Deka and Paswan (2002) reported positive and significant correlation of flower yield with number of branches in chrysanthemum.

Pal and George (2002) studied correlation for vegetative and flowering characteristics in 2 indigenous (Sonar Bangla and Pride of Jamshedpore) and 10 exotic (Kenroku Kangiku, Balcombe Perfection, Snow Ball, Chandrama, Okaihama, Melody Lane, Pink Cloud, Silk Brocade Pink, Ghenzyskhan, and Gambit) chrysanthemum (*Dendranthema morifolium*) cultivars. They observed flower diameter and weight were significantly correlated with plant height and flower diameter.

A correlation study of eleven genotypes of China aster for fourteen quantitative characters was performed by Kumar *et al.* (2003). They revealed that flower yield was positively and significantly correlated with diameter of flower and number of flowers per plant.

Correlation analysis was carried out among ten genotypes of chrysanthemum. The number of branches per plant showed positive and significant association with number of flowers per plant at genotypic (0.829) and phenotypic (0.734) level. Plant spread showed negative and significant correlation with disc diameter at the genotypic level (-0.648). Number of flowers per plant showed positive and non-significant association with number of ray florets, while flower weight recorded negative and non-significant association at both levels (-0.493, -0.359). Flower weight recorded negative and non-significant association with number of ray florets at genotypic and phenotypic levels (Baskaran *et al*., 2004).

A correlation studies was conducted in china aster by Poornima *et al.* (2006) and indicated flower yield per plant was significantly and positively associated with plant spread, number of branches and number of leaves per plant.

A total of forty four germplasm of three species of marigold were evaluated under conditions of Uttarakhand by Singh and Kumar (2008) and found significant positive correlation between number of flowers per plant, days taken to bud initiation and flower diameter, days taken to flowering and average fresh weight of flower.

A correlation analysis was conducted on 15 diverse *Chrysanthemum morifolium* genotypes of spray chrysanthemum by Gantajit and Pal (2009). The results indicated that most of the growth and yield parameters showed highly positive correlation among themselves; flower yield, flower size was positively correlated with most of the growth parameters.

Singh *et al.* (2009) determine the association between various quantitative traits, of 20 germplasm of marigold (*T. erecta*). They observed the genotypic correlation coefficients were generally higher than the corresponding phenotypic correlation coefficients; the yield of flowers per plant exhibited highly significant and positive correlation with number of number of flowers per plant and number of primary branches; the number of flowers per plant showed highly significant and positive correlation with number of primary branches per plant; the diameter of flower showed highly significant and positive correlation with ten flower weight.

An investigation was carried out with 34 genotypes of African marigold by Karuppaiah and Kumar (2010). The results indicates that the flower yield per plant was found to be significantly and positively correlated with number of branches per plant, flower size, flower weight and number of flowers per plant. Days to first flowering showed a negative association with flower yield per plant.

Kavitha and Anburani (2010) reported the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients. The flower yield per plant exhibited highly significant and positive correlation with number of flowers per plant, flower head size and plant height; the traits like days to first flowering exhibit high significant and positive correlation with flower yield per plant.

Correlation analysis was carried out in 24 genotypes of chrysanthemum by Kumar *et al.* (2012). The results indicate that the primary branches per plant, plant spread and flowering duration showed positive significant correlation with number of flowers per plant at both genotypic and phenotypic level.

Kumari *et al. (*2013) showed that number of flowers per plant had significant positive correlation with plant height at both phenotypic and genotypic levels; the flower diameter had positive correlation with fresh weight of flower.

Misra *et al.* (2013) studied the variability of 25 germplasm of spray chrysanthemum and found that the number of primary branches per plant had the highest correlation (0.998) with yield of flowers per plant.

Sahu and Sharma (2014) performed correlation analysis in twenty one genotypes of small flowered chrysanthemum; reported the values of correlation coefficient at the genotypic levels were higher than the phenotypic correlation coefficient indicating an inherent association among various characters like plant height, plant spread and number of flowers per plant, and the genotypic superiority. Number of flowers per plant had highly positive significant association with number of branches per plant and positive significant association with plant spread at genotypic level.

A total of one hundred and four divergent genotypes of chrysanthemum were evaluated by Kameswari *et al*. (2015). They recorded significant positive correlation both at genotypic and phenotypic levels between flower yield and plant attributes viz., plant spread at both the directions, number of primary branches per plant, spray length and number of flowers per spray.

Eight genotypes of China aster were evaluated by Kumari *et al.* (2017) and reported weight of flowers per plant was significant and positively correlated both at genotypic and phenotypic level for earliness, duration of flowering, and number of flowers per plant.

A character association analysis was conducted by Telem *et al. (*2017) with sixty chrysanthemum genotypes, revealed genotypic correlation coefficients were found to be higher than the phenotypic correlations for most of the characters like number of flowers per plant, plant spread and number of primary branches. The number of flowers per plant showed highly positive significant correlation at both genotypic and phenotypic level with plant spread (0.977,0.974), number of primary branches (0.952,0,828) and number of flower per spray (0.932, 0.821).

2.3 Path coefficient analysis

Wright (1921) defined the path coefficient technique as the ratio of the standard deviation of the effect to the total standard deviation, in which all the causes are constant except that one in question, the variability of which kept unchanged. The concept of path coefficient analysis was originally developed by Wright (1921), but the technique was first used for plant selection by Dewey and Lu (1959).Path coefficient is the measure of direct influence of one variable upon another which permits the separation of correlation coefficient into component of direct and indirect effects. The use of path coefficient analysis requires a cause and effect situation among variables. Information on correlation and path coefficient may be advantageously used for the identification of characters which are useful indices for consideration in the improvement of yield. Works pertaining to path analysis in chrysanthemum and other crops have been reviewed below:

A path analysis conducted by Raghava *et al.* (1992) revealed that days to flower and flowers per plant had direct effect on flower yield per plant and 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.

Sirohi and Behera (1999) observed indirect effect in case of the number of branches per plant followed by plant spread through number of flowers per plant. At the phenotypic level, the number of flowers per plant and diameter of flowers indirectly influenced weight of flowers; number of main branches per plant had larger indirect effect followed by plant spread through number of flowers per plant. They also revealed number of flowers per plant had high direct effect on yield through number of branches per plant in chrysanthemum.

A path coefficient analysis was conducted in chrysanthemum genotypes by Deka and Paswan (2002) and revealed that a positive effect of size of flowers was observed on flower yield followed by number of flowers, plant height and duration of flowering.

Singh *et al.* (2009) determined the association between various quantitative traits, of 20 germplasm of marigold (*T. erecta*) collected from different parts of Uttar Pradesh. They revealed the number of flowers per plant had the maximum positive direct effect towards yield of flowers per plant, whereas the number of secondary branches per plant showed the maximum indirect effect via number of flowers per plant.

Karuppaiah and Kumar (2010) conducted path analysis of 34 genotypes of African marigold and shown that number of flowers per plant showed high positive direct effects; flower diameter showed medium level of direct effect.

Kavitha and Anburani (2010) reported the number of flowers per plant had maximum positive direct effect towards flower yield per plant, whereas number of laterals per plant showed maximum indirect effect via number of flowers per plant.

A path analysis was carried out in 24 genotypes of chrysanthemum by Kumar *et al*. (2012). They conclude the path coefficient analysis at genotypic level revealed that day to flowering, number of primary branches per plant and plant spread had highest direct positive effect on number of flowers per plant. At phenotypic level, flowering duration, number of primary branches per plant and plant spread showed highest direct positive effect on number of flowers per plant. Highest direct negative effect was observed via plant height after full bloom on number of flowers per plant at phenotypic level whereas at genotypic level it was observed via days to flower bud initiation followed by plant height at flower bud initiation stage.

A path coefficient analysis was studied by Misra *et al.* (2013) and revealed that number of primary branches per plant had the highest direct effect on flower yield per plant.

A path coefficient analysis of total one hundred and four divergent genotypes of chrysanthemum was performed by Kameswari *et al*. (2015) and revealed that plant spread in NS direction recorded the highest direct effect on flower yield per plant followed by number of primary branches per plant, average flower weight and duration of flowering.

A total of eight genotypes were taken for path coefficient analysis using correlation coefficients by Kumari *et al.* (2017) and revealed that 100 flowers weight contributed highest positive direct effect on weight of flowers/plant followed number of flowers per plant.

A path analysis was conducted in 50 sunflower genotypes by Rani *et al.* (2017) and revealed that day to maturity, plant height and head diameter had positive and direct effects on seed yield per plant, while days to flowering showed direct negative effects.

A path analysis was conducted by Telem *et al. (*2017) with sixty chrysanthemum genotypes revealed that plant spread and number of primary branches had highest positive and direct effects on number of flowers per plant at genotypic and phenotypic levels.

2.4 Qualitative characters

Singh *et al.* (2008) evaluated twenty open pollinated chrysanthemum cultivars for various floral characters and found mostly Korean double, Korean semi-double and decorative flower types (B-1, B-2, B-5, and B-6) were found suitable for loose flower purpose. The accession B-11 was found to be suitable for pot culture on account of its compact and dwarf growth.

Swaroop *et al.* (2008) evaluated twenty genotypes of chrysanthemum for different characters for cut flower and other purposes under Delhi conditions. On the basis of morphological characters, Thaichain Queen, Tata Centenary, Snow Ball and Snow Don could be grouped as cut flower genotypes while remaining could be as pot mums, decorative and loose flowers.

Bantu (2013) evaluated thirteen cultivars, and found seven cultivars viz., Rekha, Raichur, Silper, Pusa Semidouble, Yellow Double and Chandini were yellow in colour. Three cultivars viz., PAU-B-107, Pusa Anmol and Rajmundry were white in colour. The cv.Co-3 was yellowish brown in colour, Shanthi was Pinkish cream in colour and Geethanjali was lemon yellow colour.

MATERIALS AND METHODS

The present experiment entitled "Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha.'' was carried out at Biotechnology-cum-Tissue Culture Laboratory, Department of Floriculture and Landscaping, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, during the year 2017-18. This chapter describes information regarding the materials used and techniques involved during the course of investigation.

3.1 Experimental site

The experimental site is located at Biotechnology-cum-Tissue Culture Laboratory, Department of Floriculture, College of Agriculture, O.U.A.T., Bhubaneswar, Odisha during the year 2017-18. This study comprised of nine genotypes of chrysanthemum. The details and source of these genotypes are mentioned in table 3.1. The topography of the experimental area is uniform with adequate irrigation and drainage facilities.

3.2 Geographical location

Bhubaneswar is in Khordha district of Odisha. It is in the eastern coastal plains, along the axis of the Eastern Ghats Mountains. The city has an average altitude of 45 metres (148 feet) above mean sea level, is located at the latitude of 20.27^{o}N, longitude of 85.84^{o}E. It lies southwest of the Mahanadi River.

3.3 Climate

Bhubaneswar has a tropical Savanna climate, designated *Aw* under the Köppen climate classification. The city enjoys rainy season from June to September having mild winter for 4 months after which the summer season begins. The source of rainfall is South-West summer monsoon. It received an average annual rainfall of 1,542 mm (61 in), most of which is received between June and September.

3.4 Weather during crop growth period

The meteorological data pertaining to monthly mean rainfall, sunshine hours, average minimum and maximum temperatures and relative humidity during the period of experimentation (July 2017 to February 2018) were collected from AICRP on Agro- meteorology and presented in Appendix I and depicted through Figure 3.1.

3.5 Experiment details

3.5.1 Experimental materials

The experimental material consisted of 9 treatments representing eight spray genotypes of chrysanthemum obtained from All India Coordinated Research Project on Floriculture, OUAT, along with one check genotype, i.e., Flirt.

Table 3.1 Name of the genotypes of chrysanthemum

Treatment/ genotypes	Genotype name	Source
T_1	HCC – 1	AICRP on Floriculture, Hyderabad Centre
T_2	HCC – 2	AICRP on Floriculture, Hyderabad Centre
T_3	HCC – 3	AICRP on Floriculture, Hyderabad Centre
T_4	Bidhan Madhuri	BCKV
T_5	Bidhan Jayanti	BCKV
T_6	Bidhan Purna	BCKV
T_7	Arka Gold	IIHR
T_8	Arka Chandrika	IIHR
T_9	Flirt (Check)	IIHR

3.5.2 Designs and layout of experiment

The present field experiment was laid out with 9 treatments and 3 replications in Randomized Block Design. Thirty plants of each genotype were planted in each replication. All the treatments were randomized separately in each replication. Irrigation and drainage channels were laid out for efficient intercultural operations. The layout plan is illustrated in Fig. 3.2.

Details of Layout

Location	:	Biotechnology-cum-Tissue Culture Laboratory
Crop	:	Chrysanthemum (*Chrysanthemum morifolium* Ramat)
Design	:	RBD (Randomized Block Design)
Genotypes	:	9 (8 + 1 check)
Number of treatments	:	9
Number of replications	:	3
Plot size	:	2.0 m× 1.8 m
Spacing	:	40 cm × 30 cm
Season	:	Kharif, 2017-18

3.6 Cultural practices

3.6.1 Characteristics of the soil

The soil of the experimental site is sandy loam in texture, well drained with medium fertility status. The physio-chemical properties of the soil obtained from the chemical analysis are given in Table 3.2.

Table 3.2 Physio-chemical properties of the soil

Parameters	Test Value	Methods Used	Status
Textural Class	Sandy loam	Bouycans hydrometric method	
pH	8.09	pH meter method (Jackson, 1973)	Neutral
EC (dSm-1)	0.27	Conductivity bridge method	
Organic carbon(g/Kg soil)	4.8	Rapid titration method, Walkey and Black method (Jackson, 1973)	
Available N (kg/ha)	353.0	Modified Kjeldhal's technique (Jackson, 1973)	
Available P (kg/ha)	101	Olsen method (Olsen *et al.,* 1954) and stated by Jackson, 1973	
Available K (kg/ha)	1474	Flame photometric method(Muhr *et al.,* 1965)as stated by Jackson, 1967	Very high

3.6.2 Land preparation

Chrysanthemum requires well prepared soil for proper growth and development. Addition of organic matter in the form of peat or rotten manure improves the soil structure and helps in the development of plants. The soil should be well drained. The experimental field was ploughed thoroughly and incorporated with well decomposed FYM @ 20 ton/ha. The unwanted objects such as crop residues, grasses, weeds, and foreign materials, etc. were removed. The beds measuring2.0 m $\times$ 1.8 m were laid out with help of measuring tape, rope and bamboo pegs.

3.6.3 Raising of Planting Materials

Chrysanthemum is an annual plant. It is mostly propagated by suckers and meristematic stem cuttings. For the present investigation, the planting materials were raised from terminal stem cuttings taken from stock plants and was depicted in Fig3.3.Cuttings of 4 – 6inch were collected, the end of cuttings were dipped in rooting hormone, i.e., rootex and planted in sand medium. The cuttings were taken during 1st to 15th of July. Healthy, one month old rooted cuttings were transplanted in polythene bags consisting of soil mixture during 1st to 15th of August.

3.6.4 Pinching

The first pinching was done in 1st week of September, the second pinching in last week of September.

3.6.5 Manures and Fertilizers Application

Well rotten FYM @ 20 tones/ha was incorporated at the time of field preparation. A fertilizer dose of 300 : 200 : 200 kg N : P_2O_5 : K_2O was applied to the beds during bed preparation.

3.6.6 Planting

The beds were prepared to fine tilth with incorporation of well rotten FYM and fertilizer. The healthy, well established plants in polybags were planted on 18th October 2017, at a spacing of 40 cm x 30cm @ 30 seedlings per bed. Irrigation was

given immediately after transplanting thereby subsequent irrigation was given depending on soil and weather condition.

3.6.7 Irrigation

The first irrigation was given just after planting in the evening hours, and subsequent irrigation were given at an interval of 3 to 4 days or depending on the weather and moisture condition of soil.

3.6.8 Weeding and Hoeing

Uniform cultural operations were carried out for all the treatments. The first hand weeding was done at 20 days after transplanting and subsequent weeding was carried out at regular intervals. A total of six weeding were done throughout the experimental period to keep the plots clean and free from weeds. Hoeing was done one month after planting. It improves aeration inside the soil, leading to better plant growth.

3.6.9 Plant Protection

At vegetative stage there was no infestation of bud borer (*Spodoptera litura*) but the infestation was observed at flower bud initiation. The infestation of aphid can also be observed during the period of experimentation.

The prophylactic measures were taken for prevention of pest and disease attack.

3.7 Harvesting

Flowers were harvested when the florets are fully open.

3.8 Biometric observations

Five plants were selected randomly in each plot leaving the border plants and tagged for recording the data. All the observations were taken from the tagged plants. The details of biometric observations studied during the period of observation were presented below.

3.8.1 Vegetative characters

The vegetative characters of all the genotypes evaluated were recorded and statistically analyzed

3.8.1.1 Plant height at first flower bud appearance (cm)

Height of the plant was measured from the ground level to the highest point of growth by a metre scale. The average height was computed and expressed in centimeters.

3.8.1.2 Plant spread (cm)

The plant spread was obtained by measuring the canopy spread in North-South and East-West directions of five tagged plants at bud initiation stage and the mean was calculated and expressed in centimetres.

3.8.1.3 Number of primary branches per plant

The total numbers of primary branches emerging from main stem of five tagged plants were counted at bud initiation stage; averages were worked out and recorded.

3.8.2 Flower Characters

The important parameters like number of days taken for first bud appearance, number of days taken for first flower opening and vase life were measured and analyzed statistically.

3.8.2.1 Number of days taken for flower bud appearance

The number of days taken for first bud appearance was counted from the date of planting to the first appearance of flower bud in each plot. The mean was computed and expressed in days.

3.8.2.2 Number of days taken for flower bud opening

The average number of days taken from the day of planting to the days taken by plants to bloom fully in each plot was recorded. The mean was calculated and expressed in days.

3.8.2.3 Vase Life of Flowers

The number of days of useful vase life of the flowers was determined in tap water in ambient condition (fig. 3.4). The mean was calculated and expressed in days.

3.8.2.4 Flower type

Flower type of each genotype was determined following the description of American Chrysanthemum Society.

3.8.2.5 Flower colour

Flower colour of each genotype was determined as per the R.H.S. colour chart**.**

3.8.3 Yield attributing traits

3.8.3.1 Flower diameter

The flower diameter was measured from the peripheral end of the one petal to peripheral end of the opposite petal with the help of slide calipers and was expressed in centimeters.

3.8.3.2 Number of flowers per plant

The total number of flowers produced per plant was recorded in each replication in a treatment and average number of flowers per plant was computed.

3.8.3.3 Flower Weight (g)

Individual weight of five flowers from each plot was recorded and the mean was computed and expressed in grams.

3.8.3.4 Weight of flowers per plant

From the tagged plants, the fresh weight of fully opened flowers was recorded and average weight of flowers per plant was computed.

3.8.3.5 Duration of Flowering

The number of days taken from the first flower opening to the fading of the last flower was recorded as the total duration of flowering. The mean was calculated and expressed in days.

3.8.3.6 Number of ray florets per plant

The number of ray florets per plant was recorded by counting the individual ray florets from the five randomly selected flowers per replication and the mean were computed.

3.9 Statistical analysis

The data for each character in each individual plot were summed up and mean values for each character were estimated and subjected to statistical analysis (Gomez and Gomez, 1984). The mean values of five plants were computed, for each of the genotype, for fifteen characters and were subjected to statistical analysis.

3.9.1 Analysis of Variance

The analysis of variance for each of the characters stated was done to find out varietal differences amongst all the treatments. The data were analysed by the methods as suggested by Panse and Sukhatme (1985). The model of analysis of variance table adopted is given below.

The data for different characters were statistically analysed on the basis of the model suggested by Cochran and Cox (1950) for RBD.

$Y_{ij} = \mu + b_i + t_j + e_{ij}$

Where,

Y_{ij}= Performance of the i^{th} genotype in the j^{th} replication

μ = general mean

b_i = true effect of i^{th} genotypes

t_j = true effect of j^{th} replication

e_{ij} = random error associated with i^{th} genotypes inj^{th} replication

The analysis of variance for each character was carried out as indicated below

Table 3.3Analysis of variance and expected mean sum of square under model RBD

Sources of variation	Degree of freedom	SS	MSS	F ratio	Expected mean sum of square
Replications	r – 1	RSS	RMSS	RMSS/EMSS	$\sigma^2_e + g\sigma^2_r$
Genotypes	g – 1	GSS	GMSS	GMSS/EMSS	$\sigma^2_e + r\sigma^2_g$
Error	(r – 1) (g – 1)	ESS	EMSS		σ^2_e
Total	(rg – 1)	TSS			

Where,

r = Number of replications

g = Number of genotypes or treatments

SS = sum of squares

MSS = Mean sum of squares

RSS = Replication Sum of squares

GSS = Treatment sum of squares

ESS = Error sum of squares

TSS = Total sum of squares

RMSS = Mean sum of squares due to replications

GMSS = Mean sum of squares due to treatments

EMSS = Mean sum of squares due to error

The test of significance was carried out by 'F' table values given by Fisher and Yates (1963). The significance of the different treatments was judged at 5 per cent level of "F" test.

Standard Error of Means (SEM) and Critical Difference (CD) were worked out using the appropriate formulae for comparing varietal means.

3.9.2 Mean, Range, Standard Error, Critical Difference

Mean value of each characters were computed by dividing the total by corresponding number of observations while the highest and lowest values of various characters were taken as range. The S.E. and C.D. were calculated by using the formulae.

$$\text{Standard error mean} \quad SEM = \sqrt{\frac{EMSS}{r}}$$

Critical difference (C.D.)

$$= \sqrt{\frac{2EMSS}{r}} \times t \text{ value at error df at 5\% and 1\% level of significance}$$

3.9.3 Genotypic and Phenotypic variances

The genotypic and phenotypic variances were computed based on the expected mean sum of squares as follows:

$$\text{Genotypic variance} \quad GV = \sigma^2 g = \frac{TSS - EMSS}{\text{No. of replications } r}$$

$$\text{Phenotypic variance} \quad PV = \sigma^2 p = \frac{\sigma_g^2 + \sigma_e^2}{r}$$

$$\text{Error variance} \quad EV = \sigma_e^2 = EMSS$$

3.9.4 Genotypic and Phenotypic coefficient of variation

Genotypic and phenotypic co-efficient of variability for the character under considerations were computed by making use of the method suggested by Burton and Devane (1953).

Genotypic Co-efficient of Variability (GCV %)

$$GCV = \frac{\text{Genotypic standard deviation}}{\text{General mean of the character}} \times 100$$

Phenotypic Co-efficient of Variability (PCV %)

$$PCV = \frac{\text{Phenotypic standard deviation}}{\text{Grand mean}} \times 100$$

Further, the PCV and GCV were classified as suggested by Sivasubramanian and Madhavamenon (1973):

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

3.9.5 Heritability (Broad sense)

Degree of correspondence between phenotypic value and breeding value is measured by the heritability estimate. It was estimated by the formula suggested by

Hanson *et al.* (1956). This was expressed in percentage according to Weber and Moorty (1952).

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

$$h^2 \text{ (broad sense in percentage)} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$$

3.9.6 Genetic Advance

Genetic advance for each character was estimated by adopting the formula given by Johnson *et al.*(1955).

$GA = h^2 k \sigma_p$

Where,

h^2 = Heritability (broad sense)

σ_p = Phenotypic standard deviation of the trait

k = Standard selection differential in standard units (which is equal to 2.06 at 5 per cent of selection intensity)

Genetic advance (GA) expressed as per cent mean (GA as % mean) is calculated by the following formula.

$$GA \text{ GA as \% mean } = \frac{GA}{X} \times 100$$

Where, GA = Genetic Advance

X = General mean of characters

3.9.7 Correlation Coefficient Analysis

Analysis of variance and covariance for individual character and for character pairs respectively were done following Panse and Sukhatme (1967). Correlation

coefficients at phenotypic (r_p) and genotypic (r_g) were calculated using the formula suggested by Al-jibouri *et al.* (1958).

Genotypic correlation (r_g) = $\frac{\sigma_g \ xy}{\sigma_g \ x} \times \sigma_g \ y$

Phenotypic correlation (r_p) = $\frac{\sigma_p \ xy}{\sigma_p \ x} \times \sigma_p \ y$

Where,

$\sigma_g(xy)$ = Genotypic co-variance between the two traits x and y.

$\sigma_p(xy)$ = Phenotypic co-variance between the two traits x and y.

$\sigma_g(x)$ and σ_g (y) = Genotypic standard deviation for x and y respectively.

$\sigma_p(x)$ and σ_p (y) = Phenotypic standard deviation for x and y respectively.

Test of Significance

To test the significance of correlation coefficients at phenotypic level, the estimated values were compared with the table value (Fisher and Yates, 1963) at (n – 2) degree of freedom at 5% and 1% level of significance where n denotes the total number of pairs of observations used in the calculation.

$$t = \frac{r}{\sqrt{1 - r^2}} \sqrt{n - 2}$$

t = test of significance

r = correlation coefficient

n = number of paired observations

3.9.8 Path Coefficient Analysis

The cause and effect relationship among the various correlated characters are determined by path co-efficient analysis. Path co-efficient were standardized by

partial regression coefficients which individually provide a measure of direct effect of the casual factors on the effect variable. These permit partitioning of the correlation between casual factors and the effect of variables into components of direct and indirect effect and thus give a better picture of the association of the casual factors with the effect variable.

In the present investigation, weight of flowers per plant (yield per plant) was taken as the effect with other characters like plant height, plant spread, number of primary branches per plant, flower diameter and flower weight, related to yield as the casual factor.

The path coefficients were obtained by solving the following the simultaneous equations which give the basic relationship between correlations and path coefficients in a system of correlated causes (Dewey and Lu, 1959).

$$r_{112} = r_{11}p_{112} + r_{12}p_{112} + r_{13}p_{112} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + r_{111}p_{1112}$$

$$r_{212} = r_{21}p_{112} + r_{22}p_{112} + r_{23}p_{112} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + r_{211}p_{1112}$$

$$r_{312} = r_{31}p_{112} + r_{32}p_{112} + r_{33}p_{112} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + r_{311}p_{1112}$$

Where,

r_{ij} is the coefficient of correlation between i^{th} and j^{th} characters and p_{qi} is the path coefficient (direct effect of i^{th} character total yield per plant (1, 2).

The solutions for path coefficients, direct and indirect effects of the casual factors were estimated as the values of the individual terms of the above equations in R.H.S.

The coefficient of determination (R^2) and the residual effect ($p_{12.R}$) were calculated as follows:

$$I = p^2_{12.R} + \sum p_{iy}r_{iy}$$

$$R^2 = \sum p_{iy}r_{iy}$$

$$= p_{112}r_{112} + p_{212}r_{212} + p_{312}r_{312} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + p_{1112}r_{1112}$$

$$P_{12.R} = \sqrt{1 - R^2}$$

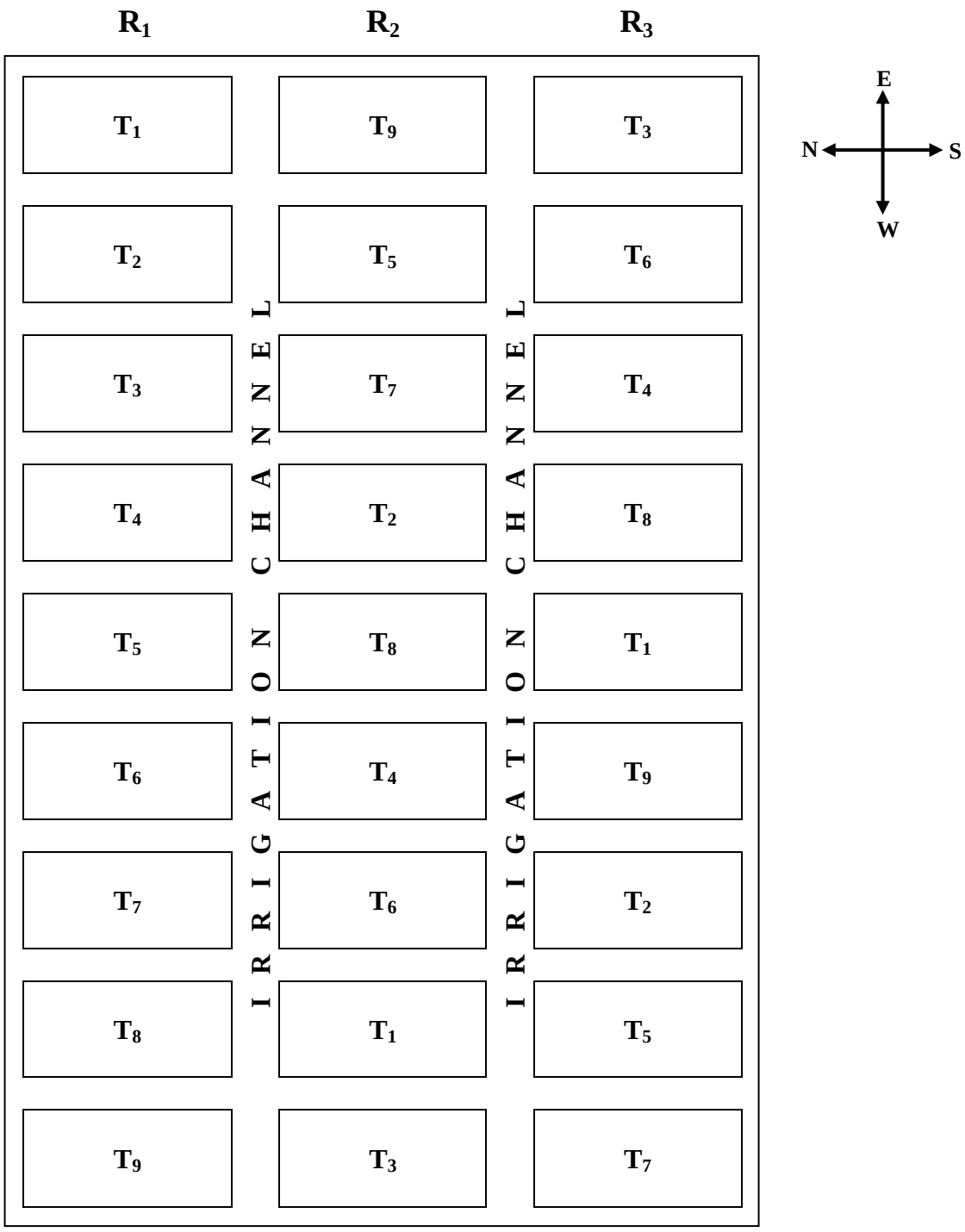


Fig. Layout plan of experimental plot

Design : R.B.D. Treatments : Nine Replications : Three

Plate – I (HCC-1)

Plate - II (HCC-2)

Plate – III (HCC-3)

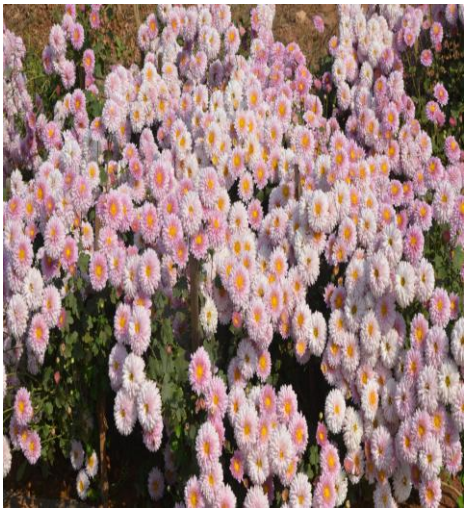


Plate – IV (Bidhan Madhuri)

Plate – IX (Flirt)

Fig. 3.4 Checking the vase life of different genotypes

General view of experimental site

Plate –V (Bidhan Jayanti)

Plate – VI (Bidhan Purna)

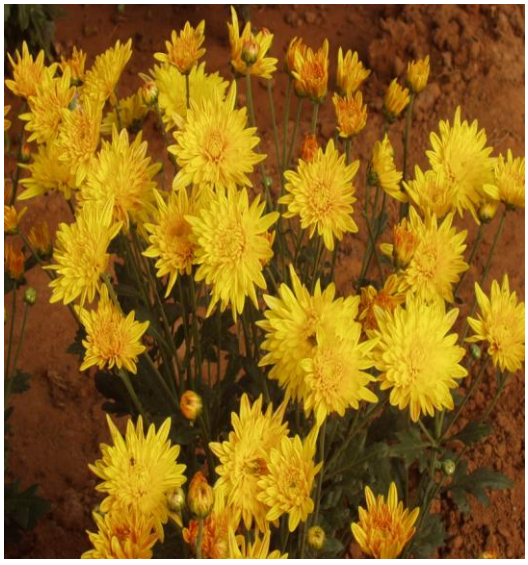


Plate – VI (Arka Gold)

Plate VII (Arka Chandrika)





Fig. 3.3 Raising of planting materials

EXPERIMENTAL RESULTS

The investigation was undertaken to assess the relative performance of nine genotypes of chrysanthemum and the magnitude of genetic variability present among them and the extent of character association. The salient findings as revealed from the investigation are presented under the following sub-headings:

4.1 Analysis of variance

The variances (mean square values) between genotypes for 13 characters are presented in Table 4.1. The data revealed the existence of significant differences among the genotypes for all the characters studied.

4.2 Mean performance of different characters

The mean performances of the genotypes for 13 characters are presented in Table 4.2.

4.2.1 Vegetative characters

Plant height

A range of 45.36cm to 67.03cm was observed among the genotypes. The maximum plant height was recorded by Flirt (67.03 cm) and is statistically at par with Bidhan Madhuri (66.42 cm), Bidhan Purna (66.09 cm) and Arka Chandrika (65.24 cm) whereas the minimum plant height was recorded by HCC-2 (45.36 cm).

Plant spread (N-S)

The genotypes exhibited a range of 24.59 cm to 42.06 cm in plant spread (N-S). The genotype Bidhan Madhuri (42.06 cm) showed maximum plant spread (N-S) and is statistical parity with Flirt (41.20 cm). The minimum plant spread (N-S) was recorded in HCC-2 (24.59 cm).

Table 4.1 Analysis of variance for 13 characters of 9 genotypes of spray chrysanthemum

Sl. No.	Characters	Mean sum of squares		
		Replication (2)	Genotypes (8)	Error (16)
1.	Plant height	0.86	215.24**	2.43
2.	Plant spread (N-S)	2.02	129.90**	3.03
3.	Plant spread (E-W)	4.60	126.77**	2.69
4.	No. of primary branches per plant	0.29	0.95*	0.31
5.	No. of days taken for bud appearance	0.11	37.83**	0.61
6.	No. of days taken for bud opening	2.11	167.75**	1.52
7.	Vase life	5.45**	29.78**	0.61
8.	Flower diameter	0.041	6.98**	0.06
9.	No. of flowers per plant	130.59	8188.86**	37.57
10.	Flower weight	0.03	4.37**	0.03
11.	Weight of flowers per plant	923.37	42660.03**	401.89
12.	Duration of flowering	1.15	40.04**	1.40
13.	No. of ray florets per flower	33.69	23509.11**	14.53

* Significant at 5% level; ** Significant at 1% level

Table 4.2 Mean performance of 9 genotype of chrysanthemum for quantitative parameters

Sl. No.	Genotypes	Characters												
		Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8	Ch9	Ch10	Ch11	Ch12	Ch13
1.	HCC-1	54.55	29.27	28.10	3.07	34.67	64.33	15.33	6.11	117.13	1.86	217.87	33.00	81.87
2.	HCC-2	45.36	24.59	25.08	3.13	34.33	64.33	21.44	2.57	263.06	0.40	102.42	32.33	192.27
3.	HCC-3	46.72	25.02	26.48	2.73	33.67	66.33	20.88	4.55	182.73	1.57	291.97	32.67	196.13
4.	Bidhan Madhuri	66.42	42.06	41.39	4.60	41.33	73.00	21.44	6.15	135.67	3.55	487.32	34.67	187.60
5.	Bidhan Jayanti	55.83	35.41	34.79	3.07	34.67	62.67	18.78	6.50	126.26	3.17	409.59	30.67	363.13
6.	Bidhan Purna	66.09	36.11	34.93	2.73	33.33	59.67	19.55	6.96	155.00	1.61	238.35	39.00	71.87
7.	Arka Gold	57.16	37.18	38.77	3.27	42.33	63.33	12.67	6.69	107.47	3.40	375.08	30.67	197.27
8.	Arka Chandrika	65.24	38.78	39.26	3.47	40.33	79.00	19.66	6.85	119.60	3.43	412.66	28.33	272.47
9.	Flirt	67.03	41.20	41.96	3.47	37.33	80.33	15.33	7.52	89.20	3.90	349.94	26.33	216.33
SEm (±)		0.90	1.01	0.95	0.32	0.45	0.71	0.45	0.14	3.53	0.11	11.57	0.68	2.20
C.D. (5%)		2.70	3.02	2.84	0.97	1.35	2.14	1.36	0.42	10.61	0.32	34.69	2.05	6.60

Ch1 - Plant height Ch2 - Plant spread (N-S)Ch3 - Plant spread (E-W)
Ch4 - No. of primary branches per plant Ch5 -No. of days taken for bud appearanceCh6 - No. of days taken for bud opening
Ch7 - Vase life Ch8 - Flower diameter Ch9 - No. of flowers per plant
Ch10 -Flower weight Ch11 - Weight of flowers per plant Ch12 - Duration of flowering
Ch13 - No. of ray florets per flower

Plant spread (E-W)

The genotypes under study attained a range of 25.08 cm to 41.96 cm in plant spread (E-W). Flirt (41.96 cm) exhibited maximum plant spread and is statistically at par with Bidhan Madhuri (41.39 cm). The genotype HCC-2 (25.08 cm) attained minimum plant spread (25.08 cm).

Number of primary branches per plant

The results on number of primary branches per plant revealed significant variation among the genotypes, varied from 2.73 to 4.60. Number of primary branches per plant was highest for Bidhan Madhuri (4.60) followed by Arka Chandrika and Flirt (3.47) and was lowest for HCC-3 and Bidhan Purna (2.73).

4.2.2 Flower characters

Number of days taken for bud appearance

The number of days taken to first flower bud appearance ranged from 33.33 to 42.33. Flower bud initiation was earliest in Bidhan Purna (33.33 days) and is statistically par with HCC-3 and HCC-2 (34.33 days), HCC-1 (34.67 days) and Bidhan Jayanti (34.67 days) while it was latest in Arka Gold (42.33 days).

Number of days taken for bud opening

Days taken for flower bud opening ranged from 59.67 days to 80.33 days. The minimum days for flower opening were recorded by Bidhan Purna (59.67 days) and maximum days by Flirt (80.33 days).

Vase life

A range of 12.67 days to 21.44 days was noted for vase life of flowers. The genotype Bidhan Madhuri and HCC-2 (21.44 days) noted maximum vase life and showed statistical parity with HCC-3 (20.88 days) whereas Arka Gold (12.67 days) noted minimum vase life.

4.2.3 Yield attributing traits

Flower diameter

The diameter of flower recorded a range of 2.57 cm to 7.52 cm amongst genotypes. The largest diameter of flower was observed by Flirt (7.52 cm), followed by Bidhan Purna and Arka Gold (6.96 cm) but the smallest diameter of flower was showed by HCC-2 (2.57 cm).

Number of flowers per plant

A range of 89.20 to 263.06 were recorded for number of flower per plant by the genotypes studied. HCC-2 (263.06) noted the highest number of flowers per plant while Flirt (89.20) recorded the lowest.

Flower weight

The data collected for individual flower weight ranged from 0.40 g and 3.90 g; the maximum flower weight (3.90 g) was recorded by Flirt closely followed by Bidhan Madhuri (3.55 g) and Arka Chandrika (3.43 g) while the minimum was recorded by HCC-2 (0.40 g).

Weight of flowers per plant

The data for weight of flowers per plant (yield) ranged from 102.42 g to 487.32 g. Bidhan Madhuri (487.32 g) recorded the highest yield followed by Arka Chandrika (412.66 g) and Bidhan Jayanti (409.59 g) on the contrary the lowest yield was recorded by HCC-2 (102.42 g).

Duration of flowering

From the data recorded, it was observed that there is significant difference amongst genotypes in duration of flowering. A range of 26.33 days to 39.00 days were observed for the duration of flowering. The longest duration of flowering was noted by Bidhan Purna (39.00 days); however, the shortest duration of flowering was recorded by Flirt (26.33 days).

Number of ray florets per flower

The number of ray florets noted a range of 71.87 to 363.13 amongst genotypes. The maximum number of ray florets per flower was observed by Bidhan Jayanti (363.13) followed by Arka Chandrika (272.47) and Flirt (216.33) while the minimum was noted in Bidhan Purna (71.87).

4.3 Range

The estimates for range are presented in Table no. 4.3. From the table, the maximum mean range of 71.87 to 363.13 was noted for numbers of ray florets per flower while the minimum mean range of 0.40 g to 3.90 g was recorded for flower weight.

4.4 Estimates of genetic parameters

The estimates of genetic parameters like coefficient of phenotypic variation, genotypic coefficient of variation, broad sense heritability, genetic advance and genetic advance as per cent of mean for thirteen characters are given in Table 4.3.

Phenotypic coefficient of variation and Genotypic coefficient of variation

The data in Table 4.3 showed that the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters studied. The highest PCV and GCV was observed for flower weight (47.82%, 47.27%) followed by number of ray florets per plant (44.81%, 44.77%). The lowest PCV was noted for number of days taken for bud appearance (9.78%, 9.55%). The characters can be grouped into three groups based on PCV and GCV value estimates. The number of days taken for flower bud appearance having PCV and GCV value 9.78% and 9.55% respectively can be grouped into low; characters like duration of flowering (11.82%, 11.23%), vase life (17.53%, 16.99%), number of days taken for bud opening (11.08%, 10.93%), plant spread (N-S) (19.57%, 18.62%), plant spread (E-W) (19.22%, 18.62%) and plant height (14.70%, 14.45%) are grouped into moderate; characters namely flower weight (47.82%, 47.27%), number of ray florets per flower (44.81%, 44.77%), weight of flowers per plant (37.55%, 37.02%), number of flowers per plant (36.44%, 36.19%) and flower diameter (25.68%, 25.36%) are grouped into PCV and GCV having high estimates.

Table 4.3 Estimation of variability and genetic advances under selection (5%) for 13 characters in 9 genotypes of spray chrysanthemum

Sl. No.	Characters	Range	Mean	Variance		Coefficient of variation (%)		Heritability (bs)	GA	GA as % of mean
				Phenotypic	Genotypic	PCV	GCV			
1.	Ch1	45.36 - 67.03	58.27	73.36	70.93	14.70	14.45	96.68	17.06	29.28
2.	Ch2	24.59 - 42.06	34.41	45.32	42.28	19.57	18.90	93.29	12.94	37.60
3.	Ch3	25.08 - 41.96	34.53	44.04	41.36	19.22	18.62	93.90	12.84	37.17
4.	Ch4	2.73 - 4.60	3.28	0.52	0.21	22.04	14.01	40.44	0.60	18.36
5.	Ch5	33.33 - 42.33	36.89	13.01	12.40	9.78	9.55	95.31	7.08	19.20
6.	Ch6	59.67 - 80.33	68.11	56.93	55.40	11.08	10.93	97.32	15.13	22.21
7.	Ch7	12.67 - 21.44	18.34	10.33	9.72	17.53	16.99	94.03	6.23	33.95
8.	Ch8	2.57 - 7.52	5.99	2.36	2.30	25.68	25.36	97.50	3.09	51.59
9.	Ch9	89.20 - 263.06	144.01	2754.68	2717.09	36.44	36.19	98.63	106.64	74.05
10.	Ch10	0.40 - 3.90	2.54	1.48	1.44	47.82	47.27	97.72	2.45	96.27
11.	Ch11	102.42 - 487.32	320.58	14487.94	14086.05	37.55	37.02	97.23	241.07	75.20
12.	Ch12	26.33 - 39.00	31.96	14.27	12.87	11.82	11.23	90.21	7.02	21.97
13.	Ch13	71.87 - 363.13	197.66	7846.05	7831.52	44.81	44.77	99.81	182.13	92.14

Ch1 - Plant height

Ch2 - Plant spread (N-S)

Ch3 - Plant spread (E-W)

Ch4 - No. of primary branches per plant

Ch5 -No. of days taken for bud appearance

Ch6 - No. of days taken for bud opening

Ch7 - Vase life

Ch8 - Flower diameter

Ch9 - No. of flowers per plant

Ch10 -Flower weight

Ch11 - Weight of flowers per plant

Ch12 - Duration of flowering

Ch13 - No. of ray florets per flower

There was larger difference in magnitude of GCV and PCV for number of primary branches per plant (14.01 – 22.04 %) but relatively low difference of GCV and PCV for characters like plant height, plant spread in both directions, number of days taken for bud appearance, number of buds taken for bud opening, vase life, flower diameter, number of flowers per plant, flower weight, weight of flowers per plant, duration of flowering and number of ray florets per flower.

Heritability

The heritability in broad sense estimates (Table 4.3) ranged from 40.44% for number of primary branches per plant to 99.81% for number of ray florets per flower. In general, high heritability (>60%) was estimated for all the characters studied except moderate heritability was estimated in number of primary branches per plant (40.44%).

Genetic advance

The genetic advance varied from 0.60% (number of primary branches per plant) to 241.07% (weight of flowers per plant). The characters showing high genetic advance (more than 20 percent) were number of flowers per plant, weight of flowers per pant and number of ray florets per flower; moderate genetic advance (between 10 to 20 per cent) were plant height, plant spread (N-S), plant spread (E-W), number of days taken for bud opening; and rest characters showed low genetic advance (less than 10 percent).

The predicted genetic advance expressed as per cent of population mean was estimated for different characters and results were presented in Table 4.3 and ranged from 18.36 (number of primary branches per plant) to 96.27(flower weight).

High heritability coupled with high predicted genetic advance expressed as per cent of mean was observed for flower diameter, number of flowers per plant, flower weight, weight of flower weight per plant, number of ray florets per plant.

4.5 Correlation studies

The genotypic and phenotypic correlation coefficients are worked out in order to find out the degree and direction of association between flower yield per plant and

yield contributing characters and between yield contributing characters among themselves. The phenotypic and genotypic correlation coefficients value estimates are presented in Table 4.4 and 4.5 respectively.

Phenotypic correlation

Plant height exhibited highly significant and positive correlation with plant spread (N-S) (r = 0.891), plant spread (E-W) (r = 0.853), flower diameter (r = 0.825), flower weight (r = 0.694), number of days taken for flower bud opening (r = 0.516) and weight of flowers per plant (r = 0.587); but showed negative and significant association with number of flowers per plant (r = -0.677).

Plant spread (N-S) showed high significant and positive correlation with plant spread (E-W) (r = 0.951), number of primary branches per plant, number of days taken for bud appearance, number of days taken for bud opening , flower diameter, flower weight and weight of flowers per plant. The character showed negative and high significant correlation with number of flowers per plant (r = -0.722).

Pant spread (E-W) noted positive and high significant correlation with number of days taken for flower bud appearance (r = 0.709), number of days taken for flower bud opening, flower diameter, flower weight and weight of flowers per plant; non - significant and positive correlation with number of ray florets per flower. However, the character exhibited high significant and negative correlation with number of flowers per plant (r = -0.774).

Number of primary branches per plant exhibited high significant and positive correlation with number of days taken for flower bud opening (r = 0.536).

Number of days taken for bud appearance showed highly significant and positive correlation with number of days taken for flower bud opening (r = 0.487), flower weight (r = 0.711) and weight of flowers per plant (r = 0.680); non-significant and positive correlation with flower diameter (r = 0.375) and number of ray florets per flower (r = 0.223).

Table 4.4 Phenotypic correlation coefficient among thirteen characters of 9 genotypes of spray chrysanthemum

Characters	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8	Ch9	Ch10	Ch11	Ch12	Ch13
Ch1	1.00	0.891**	0.853**	0.367	0.461*	0.516**	-0.147	0.825**	-0.677**	0.694**	0.587**	-0.058	-0.047
Ch2		1.00	0.951**	0.495**	0.659**	0.520**	-0.242	0.805**	-0.722**	0.858**	0.762**	-0.197	0.206
Ch3			1.00	0.460*	0.709**	0.548**	-0.293	0.774**	-0.710**	0.879**	0.775**	-0.273	0.261
Ch4				1.00	0.536**	0.407**	0.174	0.128	-0.227	0.479*	0.479**	-0.093	0.125
Ch5					1.00	0.487**	-0.304	0.375	-0.463*	0.711**	0.680**	-0.347	0.223
Ch6						1.00	0.016	0.323	-0.383*	0.602**	0.469*	-0.652**	0.301
Ch7							1.00	-0.513**	0.639**	-0.394*	-0.081	0.356	0.112
Ch8								1.00	-0.924**	0.781**	0.626**	-0.173	0.053
Ch9									1.00	-0.847**	-0.671**	0.364	-0.124
Ch10										1.00	0.897**	-0.507**	0.459*
Ch11											1.00	-0.271	0.517**
Ch12												1.00	-0.603**
Ch13													1.00

* Significant at 5% level ; ** Significant at 1% level

Ch1 - Plant height Ch2 - Plant spread (N-S) Ch3 - Plant spread (E-W)

Ch4 - No. of primary branches per plant Ch5 -No. of days taken for bud appearance Ch6 - No. of days taken for bud opening

Ch7 - Vase life Ch8 - Flower diameter Ch9 - No. of flowers per plant

Ch10 -Flower weight Ch11 - Weight of flowers per plant Ch12 - Duration of flowering

Ch13 - No. of ray florets per flower

Table 4.5 Genotypic correlation coefficient among thirteen characters of 9 genotypes of spray chrysanthemum

Characters	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8	Ch9	Ch10	Ch11	Ch12	Ch13
Ch1	1.00	0.949**	0.903**	0.623**	0.481*	0.512**	-0.175	0.845**	-0.691**	0.716**	0.609**	-0.029	-0.042
Ch2		1.00	1.005**	0.767**	0.679**	0.533**	-0.268	0.831**	-0.750**	0.891**	0.794**	-0.229	0.215
Ch3			1.00	0.776**	0.746**	0.594**	-0.299	0.808**	-0.748**	0.925**	0.814**	-0.332	0.267
Ch4				1.00	0.904**	0.713**	0.106	0.240	-0.292	0.674**	0.762**	-0.191	0.195
Ch5					1.00	0.494**	-0.327	0.391*	-0.489**	0.732**	0.696**	-0.371	0.230
Ch6						1.00	0.010	0.326	-0.391*	0.613**	0.478*	-0.689**	0.307
Ch7							1.00	-0.531**	0.670**	-0.421*	-0.089	0.404*	0.119
Ch8								1.00	-0.942**	-0.798**	0.666**	-0.191	0.056
Ch9									1.00	-0.859**	-0.688**	0.373	-0.126
Ch10										1.00	0.899**	-0.547**	0.462*
Ch11											1.00	-0.304	0.521**
Ch12												1.00	-0.642**
Ch13													1.00

*Significant at 5% level; ** Significant at 1% level

Ch1 - Plant height Ch2 - Plant spread (N-S) Ch3 - Plant spread (E-W)

Ch4 - No. of primary branches per plant Ch5 -No. of days taken for bud appearance Ch6 - No. of days taken for bud opening

Ch7 - Vase life Ch8 - Flower diameter Ch9 - No. of flowers per plant

Ch10 -Flower weight Ch11 - Weight of flowers per plant Ch12 - Duration of flowering

Ch13 - No. of ray florets per flower

Number of days taken for bud opening exhibited high significant and positive correlation with flower weight (r = 0.602); non-significant and positive correlation with number of ray florets per flower, flower diameter and vase life. On the contrary, the character exhibited high significant and negative correlation with duration of flowering (r = -0.652).

Vase life showed high significant and positive correlation with number of flowers per plant (r = 0.639); non-significant and positive correlation with duration of flowering (r = 0.356) and number of ray florets per flower (r = 0.112). On the contrary, the character exhibited high significant and negative correlation with flower diameter (r = -0.513).

Flower diameter exhibited high significant and positive correlation with weight of flowers per plant (r = 0.626) and flower weight (r = 0.781) while the trait showed high significant and negative correlation with number of flowers per plant (r = -0.924).

Number of flowers per plant exhibited non-significant and positive correlation with duration of flowering (r = 0.364). The trait number of flowers per plant showed high significant and negative correlation with flower weight (r = -0.847) and weight of flowers per plant (r = -0.671).

Flower weight exhibited high significant and positive correlation with weight of flowers per plant (r = 0.897). However, flower weight showed high significant and negative correlation with duration of flowering (r = -0.507).

Weight of flowers per plant exhibited high significant and positive correlation with number of ray florets per flower (r = 0.517) while non-significant and negative correlation with duration of flowering (r = -0.271).

Duration of flowering showed high significant and negative correlation with number of ray florets per flower (r = -0.603).

Genotypic correlation

Plant height noticed highly significant and positive genotypic correlation with plant spread (N-S) and (E-W) (r = 0.949 and 0.903 respectively), number of days taken for flower bud appearance (r = 0.512), flower diameter (r = 0.845), flower weight (r = 0.716), weight of flowers per plant (r = 0.609). The character, plant height showed highly significant and negative correlation with number of flowers per plant (r = -0.691).

Plant spread (N-S) showed positive correlation and highly significant with plant spread (E-W), number of primary branches per plant, number of days taken for bud appearance, number of days taken for bud opening, flower diameter, flower weight, weight of flowers per plant ; non-significant and positive correlation with number of ray florets per flower. On the contrary, it noticed negative correlation and highly significant with number of flowers per plant (r = -0.750).

Plant spread (E-W) exhibited highly significant and positive correlation with number of primary branches per plant (r = 0.776), number of days taken for flower bud appearance (r = 0.746), number of days taken for flower bud opening (r = 0.594), flower diameter (r = 0.808), flower weight (r = 0.925) and weight of flowers per plant (r = 0.814); non-significant and positive correlation with number of ray florets per flower (r = 0.267). Plant spread (E-W) showed highly significant and negative correlation with number of flowers per plant (r = -0.748).

Number of primary branches per plant showed positive correlation and highly significant with number of days taken for flower bud appearance (r = 0.904), number of days taken for flower bud opening (r = 0.713), flower weight (r = 0.674) and weight of flowers per plant (r = 0.762); positive correlation and non-significant with vase life (r = 0.106), flower diameter(r = 0.240), number of ray florets per flower (r = 0.195).

Number of days taken for flower bud appearance noted positive correlation and highly significant with number of days taken for flower bud opening (r = 0.494), flower weight (r = 0.732), weight of flowers per plant (r = 0.696); non-significant and positive correlation with number of ray florets per flower (r = 0.230). The character exhibited highly significant and negative correlation with number of flowers per plant (r = -0.489).

Number of days taken for flower bud opening had positive correlation and highly significant with flower weight (r = 0.613); moderately significant and positively correlated with weight of flowers per plant (r = 0.478); non-significant and positive correlation with number of ray florets per flower (r = 0.307) vase life (r = 0.010) and flower diameter (r = 0.326). However, the character had high significant and negative correlation with duration of flowering (r = -0.689); moderate significant and negative correlation with number of flowers per plant (r = -0.391).

Vase life had positive and high significant value with number of flowers per plant (r = 0.670); moderately significant value and positive correlation with duration of flowering (r = 0.404). The character exhibited highly significant and negative correlation with flower diameter (r = -0.531); moderately significant and negative correlation with flower weight (r = -0.421); non-significant and negative correlation with weight of flowers per plant (r = -0.089).

Flower diameter showed positive and high significant with flower weight (r = 0.798) and weight of flowers per plant (r = 0.646); non-significant and positive correlation with number of ray florets per flower (r = 0.056); highly significant and negative correlation with number of flowers per plant (r = -0.942) and non-significant and negative correlation with duration of flowering (r = -0.191).

The number of flowers per plant exhibited non-significant and positive correlation with duration of flowering (r = 0.373). The character showed highly significant and negative correlation with flower weight (r = -0.859) and weight of flowers per plant (r = -0.688); non-significant and negative correlation with number of ray florets per flower (r = -0.126).

Flower weight showed positive correlation and high significant with weight of flowers per plant (r = 0.899); moderately significant and positive correlation with number of ray florets per flower (r = 0.462); highly significant and negative correlation with duration of flowering (r = -0.547).

Weight of flowers per plant noticed highly significant and positive correlation with number of ray florets per flower (r = 0.521). The character exhibited non-significant and negative correlation with duration of flowering (r = -0.304).

Duration of flowering showed highly significant and positive correlation with number of ray florets per flower (r = -0.642).

4.6 Path Coefficient Analysis

The association between two characters is generally through a complicated pathway involving various attributes, which may have direct or indirect effects on the resultant trait. Therefore, path coefficient analysis was conducted to obtain the information on direct and indirect contribution of different quantitative characters on weight of flowers per plant. The yield characters were divided into direct and indirect effects by path coefficient analysis (Tables 4.6).

The weight of flowers per plant (flower yield per plant) was considered as effect dependent on eight independent variables, which are considered as cause. The independent characters were plant height, plant spread (N-S) and (E-W), number of primary branches per plant, flower diameter, number of flowers per plant, flower weight, and duration of flowering.

Direct effects

The characters like plant height, number of flowers per plant, flower weight and duration of flowering were noticed to influence the flower yield per plant (weight of flowers per plant) directly.

At phenotypic level, duration of flowering (0.488), number of flowers per plant (0.270) flower weight (2.092), and plant height (0.199) recorded positive and direct effects on weight of flowers per plant; however, flower diameter (-0.399), plant spread (E-W) (-0.330), plant spread (N-S) (-0.199) and number of primary branches per plant (-0.168) exhibited negative and direct effects on weight of flowers per plant.

Table 4.6 Estimates of direct and indirect effects of component characters on flower yield at phenotypic level of spray chrysanthemum

Sl. No.	Character	Plant height	Plant spread (N-S)	Plant spread (E-W)	No. of primary branches per plant	Flower diameter	No. of flowers per plant	Flower weight (g)	Duration of Flowering
1	Plant height	**0.199**	0.177	0.169	0.073	0.164	-0.134	0.138	-0.011
2	Plant spread (N-S)	-0.178	**-0.199**	-0.190	-0.099	-0.160	0.144	-0.171	0.039
3	Plant spread (E-W)	-0.281	-0.313	**-0.330**	-0.152	-0.255	0.234	-0.290	0.090
4	No. of primary branches per plant	-0.061	-0.083	-0.077	**-0.168**	-0.021	0.038	-0.080	0.015
5	Flower diameter	-0.329	-0.321	-0.309	-0.051	**-0.399**	0.369	-0.312	0.069
6	No. of flowers per plant	-0.183	-0.195	-0.192	-0.061	-0.250	**0.270**	-0.229	0.098
7	Flower weight	1.452	1.796	1.839	1.003	1.635	-1.772	**2.092**	-1.062
8	Duration of Flowering	-0.028	-0.096	-0.133	-0.045	-0.084	0.178	-0.248	**0.488**
9	Weight of Flowers Per Plant	0.587	0.762	0.775	0.497	0.626	-0.671	0.897	-0.271

Residual effect = 0.248 Bold figures indicate direct effect

Indirect effects

Plant height had very high positive indirect effect on weight of flowers per plant through average flower weight (1.452); while it exerted high negative indirect effect through flower diameter (-0.329); moderate negative indirect effect via plant spread (E-W) (-0.281); low negative indirect effect through plant spread (N-S) (-0.178) and number of flowers per plant (-0.183) and showed negligible indirect effects through number of primary branches per plant and duration of flowering.

Plant spread (N-S) imparted very high positive indirect effect on weight of flowers per plant through average flower weight (1.796); and low positive indirect effect through plant height (0.177); recorded high negative indirect effect on weight of flowers per plant through plant spread (E-W) (-0.313) and flower diameter; low negative indirect effect through number of flowers per plant and negligible indirect effects through number of primary branches per plant and duration of flowering.

Plant spread (E-W) noticed very high positive indirect effect on weight of flowers per plant via average flower weight (1.839); and low positive indirect effect through plant height (0.169); recorded high negative indirect effect through flower diameter (-0.309) and negligible indirect effects through number of primary branches per plant.

Number of primary branches per plant imparted very high positive indirect effect on weight of flowers per plant through average flower weight (1.003); and negligible positive indirect effect through plant height; low negative indirect effect via plant spread (E-W) (-0.152); showed negligible negative indirect effect through plant spread, flower diameter, number of flowers per plant, and duration of flowering.

The character ‘flower diameter’ showed very high positive indirect effect on weight of flowers per plant through average flower weight (1.635); and low positive indirect effect through plant height (0.164); exerted moderate negative indirect effect via plant spread (E-W) (-0.255) and number of flowers per plant (-0.250); low negative indirect effect through plant spread (N-S) (-0.160), number of primary branches per plant and duration of flowering.

A very high negative indirect effect was showed by number of flowers per plant via average flower weight (-1.772); low negative indirect effect through plant height (-0.144). High positive indirect effect was impacted by flower diameter (0.369); moderate positive indirect effect through plant spread (E-W) (0.234); low positive indirect effect through plant spread (N-S) (0.1444) and duration of flowering (0.178); negligible positive indirect effect was exhibited by number of flowers per plant through number of primary branches per plant.

Flower weight exhibited high negative indirect effect on yield of flowers per plant through flower diameter (-0.312); moderate negative indirect effect via plant spread (E-W) (-0.290), number of flowers per plant (-0.229) and duration of flowering (-0.248); low negative indirect effect through plant spread (N-S) (-0.171) and negligible negative indirect effect through number of primary branches per plant.

Duration of flowering impacted very high negative indirect effect on weight of flowers per plant via flower weight (-1.062) and negligible negative effect was showed through plant height. The duration of flowering exhibited positive indirect effect on yield of flowers per plant through plant spread (N-S), plant spread (E-W), number of primary branches per plant, flower diameter, number of flowers per plant.

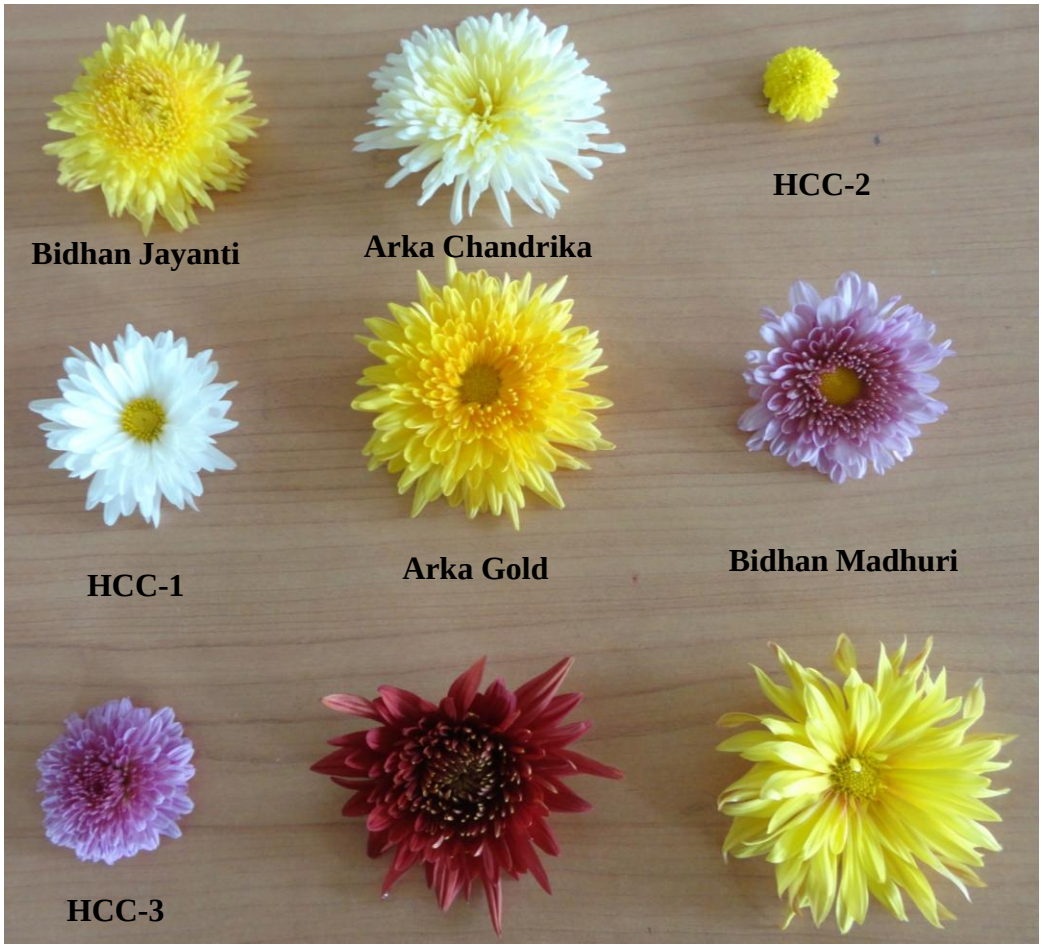
4.7 Qualitative characters

The flower type of nine genotypes was determined following the description of American Chrysanthemum Society and depicted in table 4.7. Five genotypes were decorative type. Bidhan Madhuri, HCC-1 and Bidhan Purna were double Korean type. HCC-2 showed single Korean type of flower.

Flower colour of different chrysanthemum genotypes was observed and recorded as per the R.H.S.C chart and presented in Table 4.7. Out of nine genotypes, four genotypes were yellow in colour. Two genotypes viz., HCC-3, Bidhan Madhuri were purple in colour. HCC-1, Arka Chandrika, Flirt was white, green-white and greyed red in colour respectively.

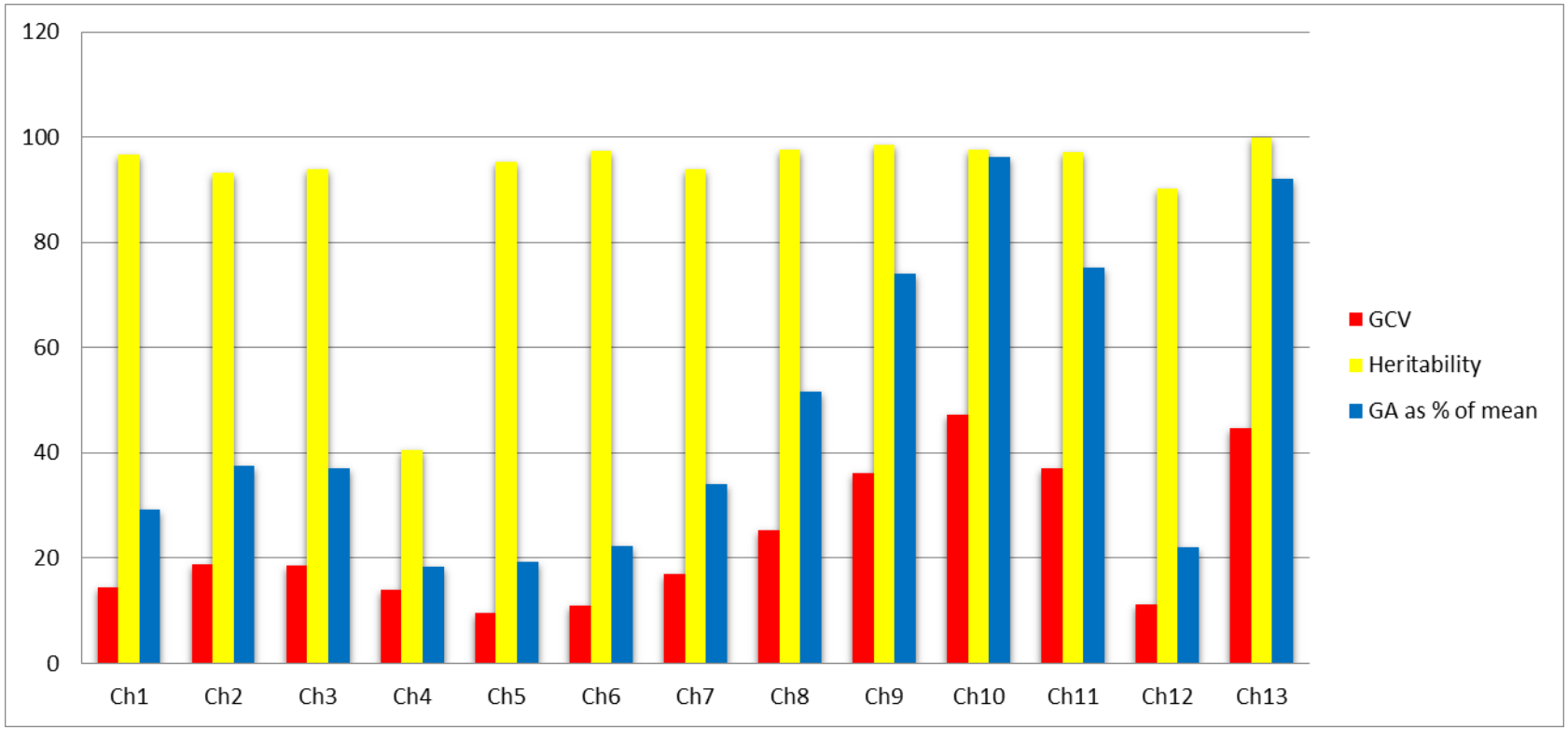
Table 4.7 Flower types and color of nine genotypes

Sl. No.	Genotypes	Flower type	Flower colour
1.	HCC-1	Double Korean type	White, 155A
2.	HCC-2	Single Korean type; Central disc pompon	Yellow, 1A
3.	HCC-3	Decorative	Purple, 78B
4.	Bidhan Madhuri	Double Korean	Purple, 78D
5.	Bidhan Jayanti	Decorative	Yellow, 3C
6.	Bidhan Purna	Double Korean	Yellow, 3A
7.	Arka Gold	Decorative	Yellow, 5A
8.	Arka Chandrika	Decorative	Green-white, 157D
9.	Flirt	Decorative	Greyed red, 181A



T1 – HCC-1
T2 – HCC-2
T3- HCC-3
T4 – Bidhan Madhuri
T5–BidhanJayanti
T6- Bidhan Purna
T7 – Arka Gold
T8 – Arka Chandrika
T9 – Flirt (Check)

Fig 4.1: Comparative view of flowers of different genotypes under study



Ch1 - Plant height
Ch2 - Plant spread (N-S)
Ch3 - Plant spread (E-W)
Ch4 - No. of primary branches per plant
Ch5 -No. of days taken for bud appearance
Ch6 - No. of days taken for bud opening
Ch7 - Vase life
Ch8 - Flower diameter
Ch9 - No. of flowers per plant
Ch10 - Flower weight
Ch11 - Weight of flowers per plant
Ch12 - Duration of flowering
Ch13 - No. of ray florets per flower

Fig. 4.2 GCV, heritability percentage and percentage and percentage of genetic advance for 13 characters of 9 chrysanthemum genotypes

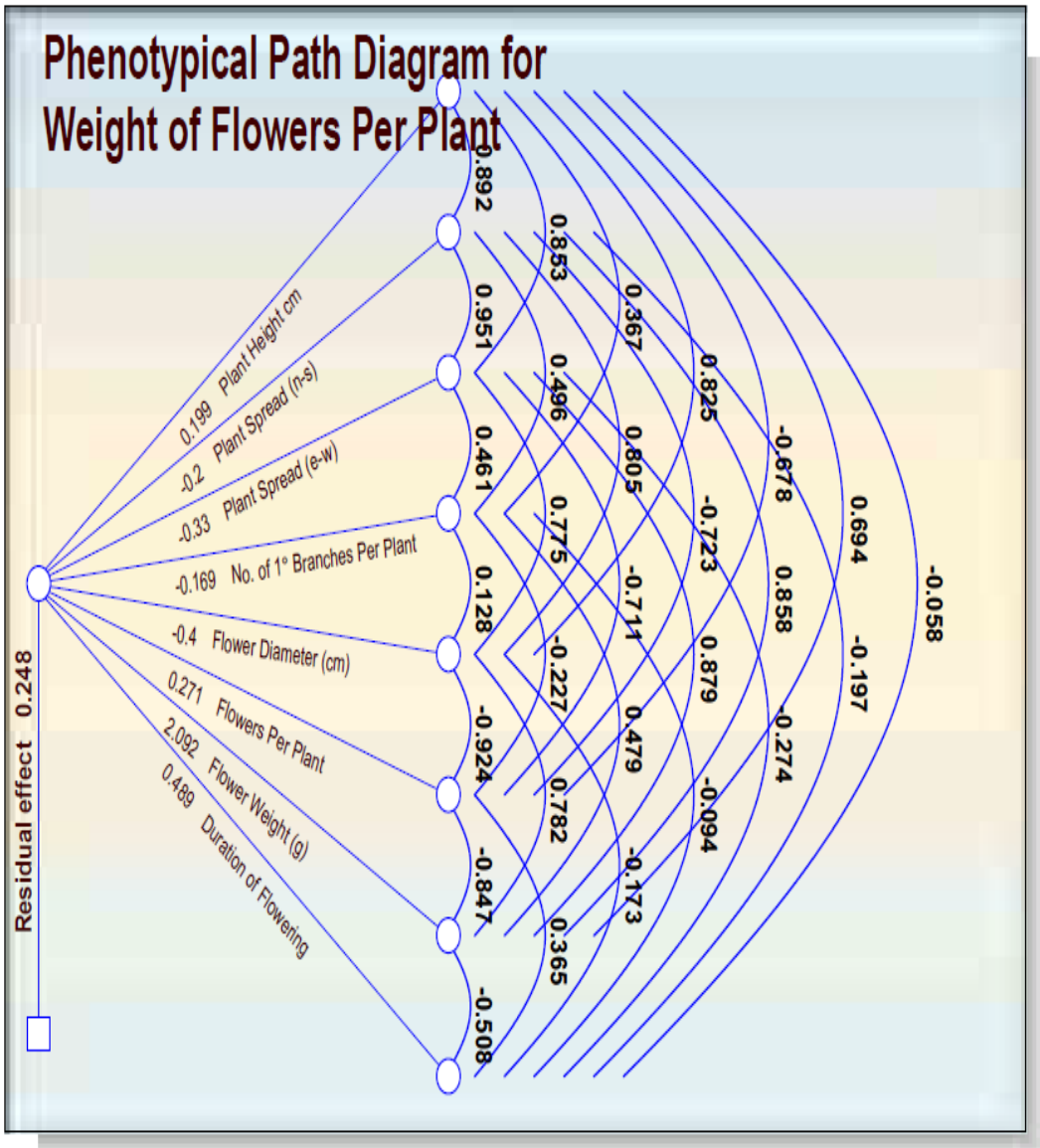


Fig 4.3 Path diagram of characters influencing yield in spray chrysanthemum

DISCUSSION

The improvement programme in any crop requires a thorough knowledge about the nature and extent of genetic variability present in the genotypes; which is important in planning for successful breeding programmes involving selection and hybridization. In flower breeding programme, improvement of yield and quality of cut and loose flowers are the ultimate objectives which essentially rely on the nature and magnitude of variability, environmental factors, inter-relationship between yield and its attributing characters and direct and indirect effects on yield by the quantitative characters. The genetic variability within the species for desired characters enables the breeder to determine the most potential parent.

Considering the importance of the above factors for improvement in chrysanthemum, the present investigation on, "Evaluation and selection of spray chrysanthemum (*Chrysanthemum morifolium* Ramat) suitable for coastal plain zone of Odisha" was carried out in Biotechnology-cum-Tissue Culture Laboratory, Baramunda, OUAT, Bhubaneswar during 2017-18 to select the superior genotypes to improve productivity and adaptability under Bhubaneswar conditions for the interest of farmers of Odisha. The salient findings as revealed from the investigation have been discussed under the following subheadings:

5.1 Pattern of variation in plant attributes

The most important economic characters in any crop are the yield. The other supporting characters influencing yield and its attributing characters are governed by polygenes which are quantitatively inherited.

5.1.1 Analysis of variance

On examining the ANOVA table 4.1, the nature and magnitude of variability for 13 different characters can be clearly visualized. The values indicate highly significant differences for all the characters studied, thereby suggesting existence of large amount of variation among the genotypes; so, there is considerable scope for improvement of the crop through the characters studied viz., plant height, plant spread (N-S) and (E-W), number of primary branches per plant, number of days taken for

bud appearance, number of days taken for bud opening, flower diameter, vase life, number of flowers per plant, flower weight, weight of flowers per plant (yield of flowers per plant), duration of flowering and number of ray florets per flower. Similar results were obtained by Ponnuswami *et al*. (1985), Panwar *et al.* (2013), Kameswari *et al.* (2015), Telem *et al.* (2017) who found wide variability in plant height, plant spread, number of flowers per plant, number of primary branches per plant, number of days taken for bud appearance, number of days taken for bud opening, duration of flowering, flower diameter, flower weight, flower yield per plant in chrysanthemum.

5.1.2 Mean Performance of Genotypes

Mean performance revealed that a single genotype was not superior for all traits. Hence, in the study different genotypes were identified to be superior for various growths and flowering related characters, this may be due to varied growth rate and their genetic make-up (Panwar *et al.* 2013). Number of days taken for flowering opening is an important character in chrysanthemum as early or late flowering genotypes may be useful for regular availability of flowers. However, earliness is the desirable trait in flower crops as early flowering is desirable to catch the early market for better remuneration and maximizing financial gain. The desirable genotype for early flower opening was observed in Bidhan Purna followed by Bidhan Jayanti whereas for late flower opening was observed in Flirt.

The maximum plant height was recorded in genotype Flirt and is statistical parity with Bidhan Madhuri, Bidhan Purna and Arka Chandrika; but minimum plant height was recorded in HCC-2. The maximum and minimum plant spread in North-South and East-West direction was noted in Bidhan Madhuri and HCC-2, Flirt and HCC-2, respectively. The number of primary branches per plant was highest in Bidhan Madhuri and lowest in HCC-3 and Bidhan Purna.

The minimum and maximum days taken for bud appearance were noted in Bidhan Purna and Arka Gold respectively. Bidhan Madhuri and HCC-2 have maximum vase life and showed statistical parity with HCC-3 whereas Arka Gold have minimum vase life.

HCC-2 noted the highest number of flowers per plant while Flirtre corded the lowest. The maximum flower weight was recorded by Flirt closely followed by Bidhan Madhuri and Arka Chandrika while the minimum was recorded by HCC-2.BidhanMadhuri recorded the highest yield followed by Arka Chandrika and Bidhan Jayanti; on the contrary the lowest yield was recorded by HCC-2.The longest duration of flowering was noted by Bidhan Purna; however, the shortest duration of flowering was recorded by Flirt. The maximum number of ray florets per flower was observed by Bidhan Jayanti followed by Arka Chandrika and Flirt while the minimum was noted in Bidhan Purna.

5.1.3 Range

The characters viz., number of flowers per plant, flower weight, weight of flowers per plant and number of ray florets per flower exhibited comparatively high range of variation while flower diameter and flower weight noted low range of variation (Table 4.3). The characters showing wider range would provide more opportunity for selection of better genotypes. The result were in agreement with results of Telem *et al.* (2017) for high range of characters such as plant height, plant spread, flower weight, weight of flowers per plant in spray chrysanthemum.

5.1.4 Co-efficient of variation

In comparing the PCV and GCV estimates from Table 4.3, the PCV estimates were greater than GCV with respect to all the quantitative characters indicating that the apparent variation was not only due to genotypes but also due to the influence of various environmental factors in the expression of characters. The results were in agreement with the results of Senapati *et al.* (2013), Sahu and Sharma (2014) and Panwar *et al.* (2013) for variability studies in *Gerbera jamesonii* Bolus, chrysanthemum, and African marigold, respectively.

High PCV and GCV was recorded for flower weight, number of ray florets per flower, weight of flowers per plant, number of flowers per plant, flower diameter, number of primary branches per plant. Similar results were obtained for flower weight, number of ray florets per flower, number of flowers per plant in chrysanthemum (Sahu and Sharma, 2014); flower weight and flower yield per plant in

marigold (Kishore and Raghava, 2001). The finding indicated the above mentioned characters were important and would impress the plant breeders for the effective utilization of the existing variability for further breeding programmes. The presence of enormous genetic variability could possibly be attributed to genetic diversity of parents which enter into ancestry and their selection under different environments. Moderate PCV and GCV was observed in plant spread (E-W) and (N-S), vase life, plant height, duration of flowering, number of days taken for flower bud opening. The low PCV and GCV were obtained in number of days taken for flower bud initiation. Baaskaran *et al.* (2009), Prakash *et al.* (2017) obtained lower values of PCV and GCV for number of days taken for flower bud initiation in chrysanthemum with similar agreement of results.

The narrow difference in PCV and GCV were obtained for most of the characters studied except number of primary branches per plant indicating the phenotypic expression of the genotypes may be under genetic control and environment might have slight influence suggesting that phenotypic variability could be reliable measure of genotypic variability (Singh and Mishra, 2010). Thus, these traits expressed the true genetic potential in varied environments implying that the genotypes can be improved and selected for the characters under study. Results of similar trend to the present findings have been reported by Sihori and Behera (2000), Kameswari *et al.* (2015) in chrysanthemum; Kavitha and Anburani (2010) in African marigold.

5.1.5 Heritability and genetic advance

The GCV alone does not provide reliable information about the assessment of variation that is heritable and therefore, estimation of heritability becomes imperative. Highest heritability values were noticed for all the characteristics except number of primary branches per plant. The highest heritability values were noted for number of ray florets per flower, followed by number of flowers per plant, flower weight. The high heritability indicated that the characters were less influence by environment. These results are in close conformity with the findings of Sihori and Behera (2000), Telem *et al.* (2017), Prakash *et al.*(2017), Baskaran *et al.*(2009) in chrysanthemum; Reena *et al.* (2005), Kavitha and Anburani (2010) in African marigold; Kumari *et al.* (2017) in china aster for characters such as plant height, plant spread, number of

flowers per plant, number of ray florets per flower, flower diameter, flower weight, weight of flowers per plant.

Though the study of heritability estimates is of importance, their scope is limited since they are estimated in broad sense and as the characters are proved to change due to environment. Johnson *et al.* (1955) reported that heritability estimates together with expected genetic gain are more reliable than either of these parameters alone in predicting the resultant effects of selecting the best individuals and therefore, the genetic advance should be considered along with heritability in streamlining the coherent selection in breeding programme. High heritability does not necessary mean that the character will show high genetic advance. This is due to the fact that a character may have very high heritability but very less phenotypic variation gives rise to very low genetic gain.

High heritability estimate coupled with high genetic advance as per cent of mean was observed flower diameter, number of flowers per plant, flower weight, weight of flowers per plant, and number of ray florets per flower suggesting that the gene action is mostly of additive type and therefore, direct selection of such traits will be rewarding in breeding programme. This result was in accordance with Peddi *et al.* (2009) for traits like number of flowers per plant and weight of flowers per plant. Similar results were obtained by Sahoo (2003) for characters like flower weight, number of flowers per plant in chrysanthemum, Kavitha and Anburani (2010) for weight of flowers per plant and flower diameter in marigold and Panwar *et al.* (2013) recorded for weight of flowers per plant and flower diameter in marigold.

The characters like number of days taken for flower opening and number of days taken for flower bud appearance had high heritability associated with low genetic gain which may be due to non-additive gene effects indicating that direct selection would be least effective for these traits. The high heritability is due to favourable influence of environmental factors rather than genotype and selection for such traits may not be rewarding. The result was similar to Kavitha and Anburani (2010) who observed high heritability associated with low genetic gain for day to first flowering in marigold.

5.2 Correlation studies

Data pertaining to correlation coefficient for the thirteen quantitative characters at genotypic and phenotypic level (Table 4.3 and 4.4) revealed the mutual relationship between the traits, which could be helpful in deciding the nature of selection to be followed for obtaining higher number of flowers per plant and yield per plant. It has been generally accepted that the correlation between different characters represent coordination of physiological process which is often achieved through gene linkage (Mather and Jinks, 1971). While formulating breeding programme, knowledge on the strength and type of such association between characters is very important prerequisite (Breese and Haywards, 1972) from this it would be possible to bring about genetic upgradation in one character by selection of the other.

In general, values of correlation coefficient at the genotypic levels were higher than the phenotypic levels indicating an inherent association among various characters and the genotypic superiority; less influence of environmental factors and relative stability of accessions. Similar results were reported by Telem *et al.* (2017), Bhaskaran *et al*. (2004), and Kumar *et al.* (2012) in chrysanthemum.

Weight of flowers per plant was taken as a measure of flower yield. A significant positive correlation both at genotypic and phenotypic levels was recorded between flower yield and its attributing traits viz., plant height, plant spread in both directions, number of primary branches per plant, number of days taken for flower bud appearance and opening, flower diameter, number of ray florets per flower and flower weight. Therefore, selection for the improvement of one character will lead to simultaneous improvement for the other character. These results are in agreement with the findings of Karuppaiah and Kumar (2010) in marigold for number of branches per plant, flower diameter and flower weight which are positively correlated with flower yield; Kavitha and Anburani (2010) also reported similar result in marigold for plant height, plant spread and number of laterals per plant, same trend also followed by Pal and George (2002), Sahu and Sharma (2014) in chrysanthemum.

On the other hand, vase life of flowers showed very low, negative and non-significant correlation with yield of flowers. It was also reported by Misra *et al*. (2013) in chrysanthemum.

5.3 Path coefficient analysis

Correlation coefficient which measures the association between two characters may not give true or comprehensive picture of a rather complex situation due to mutual relationship among different characters which may be positive or negative. In such situation, path coefficient analysis devised by Wright (1921) furnish a means of measuring direct and indirect effects of each individual variable through the other variables on the end product (yield of flowers per plant).

The correlation coefficient between flower yield per plant and its component characters were positioned into their corresponding direct and indirect effects through path coefficient analysis. The cause and effect relationship with values of correlation and path co-efficient for the components of yield is shown in fig:4.3 and the estimates for different attributes on flower yield per plant were presented in Table 4.5. Average flower weight recorded the highest direct effect on flower yield per plant followed by duration of flowering, number of flowers per plant and plant height. The maximum direct effect of these traits appeared to be the main factor for their strong association with flower yield per plant. Hence, direct selection for these traits would be highly effective in improving yield per plant. These results are in agreement with the findings of Karuppaiah and Kumar (2010) in marigold for flower diameter, number of flowers per plant having direct effect on yield of flowers per plant; Deka and Paswan (2002) and Kameswari *et al.* (2015)also reported similar results in chrysanthemum.

Negative direct effects on flower yield were observed with plant spread in both directions, number of primary branches per plant, flower diameter. This is in agreement with the findings of Telem *et al.* (2017), Bantu (2013) and Kameswari *et al.* (2015) in chrysanthemum.

Along with the high direct positive effect, flower weight exhibited a positive indirect effect to flower yield per plant via plant height, plant spread in both directions, and number of primary branches per plant and flower diameter. This

suggests the emphasis must be given on average flower weight while exercising selection to improve the flower yield.

The residual effect was 0.25 indicating that 80% of the variability in flower yield was contributed by the characters which show highest positive and direct effects studied in the path analysis. A similar finding was recorded by Telem *et al.* (2017).

5.4 Qualitative characters

There was variation of flower types amongst nine genotypes of chrysanthemum. Wide ranges of flower colour were observed among nine genotypes of chrysanthemum which were categorized as per colour codes described in R.H.S.C.C, London (Table 4.7). Similar observations were also recorded by various workers on varietal evaluation of chrysanthemum cultivars on the basis of colour of the flower (Wilfert and Harbaugh 1980, Chaudhary 1997 and Bantu, 2013).

SUMMARY ANDCONCLUSION

The present investigation entitled "Evaluation and Selection of Spray Chrysanthemum (*Chrysanthemum morifolium* Ramat) Genotypes Suitable for Commercial Cultivation under Coastal Plain Zone of Odisha.'' was carried out at Biotechnology cum Tissue Culture Laboratory, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, during the year 2017–18; with the objective of assessing variability present in nine genotypes which were evaluated for their performance with respect to different desirable traits and to study nature and extent of genetic variability and character association.

The experimental materials under study constituted nine genotypes of chrysanthemum. The genotypes were evaluated in a randomized block design with three replications. All the agronomic package of practices was provided as per prescription at appropriate intervals. Adequate plant protection measures in terms of prophylactic sprays were taken up to keep up the sanitation of the plants.

Observations were recorded for various quantitative characters. Data was subjected to standard statistical analysis and the results obtained are summarized in the present chapter.

- Analysis of variance indicated the treatment mean squares were highly significant in respect of all the characters studied suggesting existence of large amount of variation among genotypes.
- Wide differences were found in mean performance of genotypes for most of the characters under study.
- Mean performance of genotypes revealed that each variety possessed some desirable factors. Flirt attained the maximum height, plant spread (E-W); observed maximum flower diameter and average flower weight but was late to flower. The minimum plant height, plant spread in both direction, flower diameter, flower weight and weight of flowers per plant was recorded by HCC-2. HCC-3 had maximum plant spread in N-S direction, minimum number of primary branches per plant; Bidhan Purna was early to first flower initiation and opening and has longest duration of flowering. The highest number of flowers per plant was noted by HCC-2 and lowest by Flirt. HCC-2 and Bidhan Madhuri recorded the maximum vase life while Flirt recorded the lowest.

- Maximum range of variation was observed for yield of flowers per plant, followed by number of ray florets per flower and number of flowers per plant.
- The PCV estimates were greater than GCV with respect to all the quantitative characters indicating that the apparent variation was not only due to genotypes but also due to the influence of environment in the expression of characters. The high estimates of PCV and GCV was recorded for flower weight, number of ray florets per flower, weight of flowers per plant, number of flowers per plant, flower diameter, number of primary branches per plant. The low PCV and GCV were obtained in number of days taken for flower bud initiation. The narrow difference in PCV and GCV were obtained for most of the characters except number of primary branches per plant.
- Highest heritability values were noticed for all the characteristics except number of primary branches per plant. The high heritability indicated that the characters were less influence by environment. High heritability estimate coupled with high genetic advance as per cent of mean was observed flower diameter, number of flowers per plant, flower weight, weight of flowers per plant, and number of ray florets per flower.
- In general, values of correlation coefficient at the genotypic levels were higher than the phenotypic levels. A significant positive correlation both at genotypic and phenotypic levels was recorded between flower yield and yield attributing characters viz., plant height, plant spread in both directions, number of primary branches per plant, number of days taken for flower bud appearance and opening, flower diameter, number of ray florets per flower and flower weight. Therefore, selection for the improvement of one character will lead to simultaneous improvement for the other character. On the other hand, vase life of flowers showed very low, negative and non-significant correlation with yield of flowers.
- The average flower weight recorded the highest direct effect on flower yield per plant followed by duration of flowering, number of flowers per plant and plant height. Negative direct effects on flower yield were observed with plant spread in both directions, number of primary branches per plant, flower diameter. Along with the high direct positive effect, flower weight exhibited a positive indirect effect to flower yield per plant via plant height, plant spread in both directions, and number of primary branches per plant and flower diameter.
- Wide ranges of flower type and colour were observed among nine genotypes of chrysanthemum.

CONCLUSION

On the basis of the findings of the present investigation, it may be concluded that characters viz., flower weight, number of ray florets per flower, weight of flowers per plant, number of flowers per plant, flower diameter exhibited greater variability coupled with high heritability and genetic advance; can be relied upon for effective selection and crop improvement in chrysanthemum.

For crop improvement besides direct selection for yield, indirect selection through average flower weight, duration of flowering, number of flowers per plant and flower diameter could be considered for improvement of weight of flowers per plant (yield).

On an average, Bidhan Madhuri, Arka Chandrika and Bidhan Jayanti were found to be promising genotypes with high yield per plant, better vase life and have desirable appearance with attractive blooms. Thus, Bidhan Madhuri, Arka Chandrika and Bidhan Jayanti were recommended genotypes for the commercial cultivation under the coastal plain zone of Odisha.

REFERENCES

Al-jibouri HA, Miller PA and Robinson HF. 1958. Genotypic and environmental variances in upland cotton cross of inter specific origin, *Agronomy Journal*, **50**: 633-637.

Allard RW. 1960. Principles of Plant breeding. John Wiley and Sons. Inc., New York.

Anderson NO. 2006. Chrysanthemum (*Chrysanthemum grandiflora Tzvelv*.), In: Flower breeding and genetics issues, challenges and opportunities for the 21st century, Springer-Verlag, New York, pp 389– 437.

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

Asil MH, Roein Z and Sabouri A. 2014. Identification of superior chrysanthemum genotypes based on phenological traits and postproduction longevity,*Journal of Science and Technology of Greenhouse Culture*, **5**(18): 27-36.

APEDA. 2017. India Export of Agro Food Products – 2016-17, Agricultural and Processed Food Products Export Development Authority, New Delhi.

Bantu SS. 2013. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cultivars for growth, yield and storage life under open field conditions.*M.Sc thesis*, Dr. Y.S.R. Horticultural University, Anantharajupet, India.

Baskaran V, Jayanthi R, Janakiram T and Abirami K. 2009. Studies on genetic variability, heritability and genetic advance in chrysanthemum, *Journal of Horticultural Science*, **4**(2): 174-176.

Baskaran V, Janakiram T and Jayanthi R. 2004. Correlation and path coefficient analysis studies in chrysanthemum,*Journal of Ornamental Horticulture*, **7**(3&4): 37-44.

Beura S, Maharana T and Jagadev PN. 1995. Genetic variability and character association in dahlia, *Journal of Tropical Agriculture*, **33**: 20-22.

Breese EL and Haywards MD. 1972. The genetic basis of present breeding methods in Forage crops, *Euphytica*, **21**: 324-336.

Burton GW and Devane RW. 1953 Estimating heritability in tall foscue (*Festuca arundinaces*) from replicated clonal material, *Agronomy Journal*, **45**: 478-481.

Carter GD. 1980. Chrysanthemum. In: Introduction to Floriculture, (Ed. R.A. Larson), Academic Press In.

Chattopadhyay TK, Biswas MR, Malla G, Sarangi DK and Jana SC. 1991. Studies on genetic variability, heritability and correlation in chrysanthemum, *Experimental General*, **7** (1-2): 11-14.

Chaudhary, R. 1997. Development and evaluation of chrysanthemum (Dendranthema grandiflora Tzevlev) hybrids for pot culture. *M.Sc thesis*, Punjab Agricultural University. Ludhiana,India.

Chauhan P, Dhiman SR, Gupta YC, Kashyap B, Gupta RK and Dogra RK. 2017. Evaluation and variability studies in carnation genotypes,*Journal of Ornamental Horticulture*, **20** (1&2): 54-60.

Choudhary D, Srivastava DP, Ghosh AK and Seetharaman. 1973. Genetic variability and correlation for yield components in rice,*Indian Journal of Agricultural Sciences*, **43**(5): 181-184.

Choudhary M, Beniwal BS and Kumari A. 2017. Genetic diversity in marigold genotypes,*Journal of Crop and Weed*,**13**(3): 61-68.

Cochran GW and Cox GM. 1950. Experimental Designs, John Wilet and Sons, New York, pp 45-47.

Deka KK and Paswan L. 2001. Growth performance of some standard chrysanthemum (*Dendranthema grandiflora* Tzelev.) cultivars under the agroclimatic conditions of Jorhat, *Research on Crops*, **2**(3): 364-367.

Deka KK and Paswan L. 2002. Correlation and Path analysis studies in chrysanthemum, *Annals of Biology*, **8**(1): 31-34.

Dewey DR and Lu KH. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production, *Agronomy Journal*, **51**:515-521.

Dowrick GJ. 1952. The chromosomes of chrysanthemum In. Heredity, **6**: 365-376.

Fisher, R.A. and Yates, F. 1963. Statistical tables for biological agricultural and medical research. Oliver and Boyd. London, pp 279-283.

Gantajt SS and Pal P. 2009. Correlation studies in spray chrysanthemum (*Chrysanthemum morifolium* Ramat.) under polyhouse and open field, *Environment and Ecology*, **27**(3): 1070-1072.

Ghimiray TS, Sarkar I and Roy A. 2005. Variability studies in chrysanthemum grown over two environments, *Research on Crops*, **6**(3): 514-516.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research (2^{nd} edition), A Wiley – Interscience Publication John Wiley & Sons, pp. 680.

Hanson CH, Robinson HF and Comstock RE. 1956. Biometrical studies of yield in segregating populations of Korean Lespedeza, *Agronomy Journal*, **48**: 268-272.

Hegde L and Mathad GV. 2009. Genetic variability for dye content in African marigold (*Tagetes erecta* L.), *Biomed Central*, **4**(3): 203-210.

Johnson HW, Robinson HF and Comstock RE. 1955. Estimated of genetic and environmental variability in Soyabean, *Agronomy Journal*, **47**:314-318.

Jung JD. 1984. Genetic analysis in *Chrysanthemum morifolium* flowering time and flower number at low and optimum temperature, *Euphytica*, **33**: 455-463.

Kameswari PL, Pratap M, Hameedunnisabegum and Anuradha G. 2015. Studies on genetic variability and character association for yield and its attributes in chrysanthemum (*Dendranthema grandiflora* Tzvelev), *Agricultural Science Digest*, **35** (1): 25-30.

Karuppaiah P and Kumar PS. 2010. Correlation and path analysis in african marigold (*Tagetes erecta* L.), *Electronic Journal of Plant Breeding*, **1**(2): 217-220.

Kavitha R and Anburani A. 2010. Genetic variability in African marigold (*Tagetes ereta* L.), *The Asian Journal of Horticulture*, **5**(2): 344-346.

Kavitha R and Anburani A. 2010. Screening of genotypes through correlation and path co-efficient analysis in African marigold (*Tagetes ereta* L.), *The Asian Journal of Horticulture*, **5**(2): 458-460.

Kishore N and Raghava SS. 2001. Variability studies in African marigold, *Ornamental Horticulture*, **4**(2): 124-125.

Kumar M, Kumar S, Singh MK, Malik S and Kumar A. 2012. Studies on correlation and path analysis in chrysanthemum (*Dendranthema grandiflora* Tzvelev), *International Journal of Plant Research*,**25** (2): 62-65.

Kumar S, Malik S, Kumar M and Singh O. 2015. Variability, heritability and genetic advance in chrysanthemum (*Dendranthema grandiflora* Tzvelev), *Progressive Horticulture*, **47**(2): 271-274.

Kumar H, Ravi and Paul VS. 2003. Genetic variability and character association studies in China aster (*Callistephus chinensis*) genotypes, *Journal of Ornamental Horticulture,* **6**(3):222-228.

Kumari A, Patel KS, Choudhary M and Patel HC. 2013. Correlation studies in gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.), *Annals of Agri-Bio Research,* **18**(2): 206-209.

Kumari P, Kumar R, Rao TM, Dhananjaya MV and Bhargav V. 2017. Genetic variability, character association and path coefficient analysis in china aster [*Callistephus chinensis* (L.) Nees], *HortFlora Research Spectrum*,**6**(4): 278-282.

Mather K and Jinks JL. 1971. Biometrical Genetics, Chapman and Hall, London, pp 382.

Mishra HN, Das JN and Palai SK. 2006. Genetic variability studies in spray type chrysanthemum, *Orissa Journal of Horticulture*, **34**(1): 8-12.

Misra S, Mandal T, Vanlalruati and Das SK. 2013. Correlation and path coefficient analysis for yield contributing parameters in spray chrysanthemum, *Journal of Horticulture Letters*, **3**(1): 14-16.

Nazeer MA and Khoshoo RN. 1982. Cytogenetical Evaluation of Garden Chrysanthemum, *Current Science*, **51**(12): 583-585.

NHB. 2017. Final Estimate of area and production of horticultutral crops – All India 2016-17, National Horticultural Board, Gourgoan, Haryana

Pal P and George SV. 2002. Genetic variability and correlation studies in chrysanthemum, *Horticultural Journal*, **15**(2): 75-81.

Pandita PN and Bhan MK. 1989. Genotypic and phenotypic correlations in pyrethrum, *Pesticides*, **23**(2): 28-29.

Panse VG and Sukhatme PV. 1967. Statistical methods for agricultural workers. ICAR, New DelhI. pp 381.

Panse VG and Sukhatme PV. 1985. Statistical methods for agricultural workers. Indian council of Agricultural Research, New Delhi.

Panwar S, Singh KP, Janakiram T and Namita. 2013. Genetic variability, heritability and genetic advance in african marigold (*Tagetes erecta* L.) genotypes, *Progressive Horticulture*, **45**(1): 135-140.

Peddi L, Pratap M and Reddy SA. 2009. Variability studies in yellow coloured chrysanthemum (*Dendranthema grandiflora* L.), Crop Research, **37**(1/3): 154-157.

Pleog AVD and Hauvelink E. 2006. The influence of temperature on growth and development of chrysanthemum cultivars: a review, *Journal of Horticultural Science and Biotechnology*, **81**(2): 174-178.

Ponnuswami V, Chezhiyan N, Md. Abdul Khader, J.B.M. and Thamburaj S. 1985. Genetic variability in chrysanthemum, *South Indian Horticure*, **33**: 211-213.

Poornima G, Kumar DP and Seetharam GK. 2006. Evaluation of China Aster (*Callestephus chinensis* (L.) Ness) genotypes under hill zone of Karnataka, *Journalof Ornamental Horticulture*, **9**(3): 208-211.

Prakash A, Kumar M, Sirohi U, Singh MK, Kumar SMV, Rana A and Maurya OP. 2017. Assessment of genetic variability, heritability and genetic advance in chrysanthemum (*Dendranthema grandiflora* Tzvelev.), *HortFlora Research Spectrum*, **6**(3): 212-214.

Raghava SPS, Negi SS and Nancharaiah D. 1992. Genetic variability, correlation and path analysis in chrysanthemum, *Indian Journal of Horticulture*, **49**(2): 200-204.

Raman KR, Ahmad SH and Shanmugam A.1969. A note on time of planting chrysanthemum, *South India Horticulture*, **17**(44): 88-90.

Rani M, Sheoran OP, Sheoran RK and Chander S. 2017. Genetic variability, character association and path analysis for agronomic traits in sunflower (*Helianthus annuus* L.), *Annals of Agri- Bio Research*, **22**(1): 31-35.

Reena M, Beniwal BS, Bhatia SK and Deswal DP. 2005. Variability and correlation studies in African marigold (*Tagetes erecta* L.), *Research on Crops*, **6**(2): 322-327.

Robinson HF. 1966. Quantitative genetics in relation to breeding on centennial of Mendelium, *Indian Journal of Genetics and Plant breeding*, **26**: 171-187.

Sahoo SK. 2003. Genetic Variability in Spray type chrysanthemum (*Chrysanthemum morifolium*). *M.Sc. Thesis*, Department of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, pp 39.

Sahu M and Sharma G. 2014. Genetic variability, correlation and path analysis for yield and its attributing traits in small flowered chrysanthemum, *Journal of Ornamental Horticulture*, **17**(1&2): 32-37.

Senapati AK, Prajapati P and Singh A. 2013. Genetic variability and heritability studies in *Gerbera jamesonii* Bolus. *African Journal of Agricultural Science*, **8**(41): 5090-5092.

Sheshaiah and Shankergoud I. 2015. Genetic variability and correlation studies in sunflower (*Helianthus annuus* L.), *Electronic Journal of Plant Breeding*, **6**(2): 644- 650.

Singh AK, Singh AK and Singh OP. 2009. Correlation and path coefficient analysis in African marigold (*Tagetes erecta* L.), *Advances in Plant Sciences*, **22**(1): 239-241.

Singh D and Kumar S, 2008. Studies on genetic variability, heritability, genetic advance and correlation in marigold, *Journal of Ornamental Horticulture*, **11**(1): 27-31.

Singh S, Kumar R and Poonam. 2008. Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzevlev) open pollinated seedlings for vegetative and floral characters, *Journal of Ornamental Horticulture*, **11**(4): 271-274.

Singh VP and Mishra KK. 2010. Variability and character analysis in bael germplasm, *Indian Journal of Horticulture*, **67**: 70-74.

Sirohi PS and Behera TK. 1999. Correlation and path analysis studies in chrysanthemum, *Journal of Ornamental Horticulture (New Series)*, **2**(2): 80-83.

Sirohi PS and Behera TK. 2000. Genetic variability in chrysanthemum, *Journal of Ornamental Horticulture (New Series)*, **3**(1): 34-36.

Sivasubramanian V and Madhavamenon P. 1973. Path analysis for yield and yield components of rice, *Madras Agricultural Journal*, **60**: 1217-1221.

Swaroop K, Prasad KV and Raju DVS. 2008. Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzvelve.) germplasm in winter season under Delhi conditions, *Journal of Ornamental Horticulture*, **11**(1): 58-61.

Talukdar MC, Mahanta S, Sharma B and Das S. 2003. Extent of genetic variation for growth and floral characters in chrysanthemum cultivars under Assam condition, *Journal of Ornamental Horticulture New Series*, **6**(3): 207-211.

Telem RS, Sadhukhan R, Sarkar HK, Akoijam R, Haribhushan A and Wani SH. 2017. Genetic studies for flower yield and component traits in *Chrysanthemum morifolium* Ramat, *Journal of Applied and Natural Science*, **9** (1): 211-214.

Weber C and Moorty, 1952. Heritable and non-heritable relationships and variability of oil content and agronomic characters in the F2 generation of soyabean crosses, *Agronomy Journal*, **44**: 202-209

Wilfert GJ and Harbaugh BK. 1980. Mini pot garden chrysanthemum Cultivar characteristics and consumer preference, *Proceedings of the Florida State Horticultural Society*, **92**:317-19.

Wright S. 1921. Correlation and Conisation, *Journal of Agricultural Research*, **20**: 557-585.

APPENDIX - I

Meteorological data collected during the experimental period (July 2017 to February 2018)

Year	Month	T_{max}(^{0}C)	T_{min} (^{0}C)	Rainfall (mm)	RH1 (%)	RH2 (%)	Wind velocity (km/hr)	BSH (h)	Evaporation (mm)
2017	Jul	31.9	25.9	445.9	92	78	3.7	2.0	3.3
2017	Aug	32.9	25.8	377.0	91	76	2.9	4.9	3.4
2017	Sep	33.6	25.7	245.2	92	70	2.4	4.7	3.4
2017	Oct	32.2	24.3	204.5	93	69	2.5	6.0	3.3
2017	Nov	29.6	18.7	55.2	89	56	3.0	7.1	3.3
2017	Dec	28.2	14.4	36.3	91.8	47.6	1.9	7.0	3.4
2018	Jan	28.0	12.0	0.0	92	35	1.8	7.3	3.7
2018	Feb	33.7	15.9	0.0	91	29	2.5	8.4	4.2