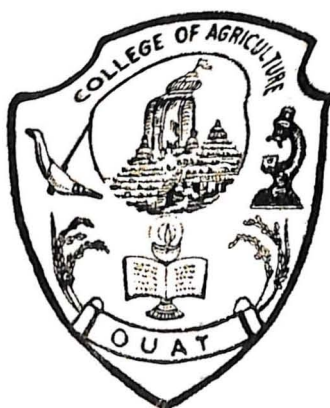


GENETIC VARIABILITY IN SPRAY TYPE CHRYSANTHEMUM (*Chrysanthemum morifolium*)

A
THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
(HORTICULTURE)

By
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*Dedicated to
my parents*

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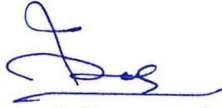
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CERTIFICATE - I

This is to certify that the thesis entitled "**GENETIC VARIABILITY IN SPRAY TYPE CHRYSANTHEMUM (*Chrysanthemum morifolium* Ramat.)**" submitted in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) IN THE SUBJECT OF HORTICULTURE** of the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record bonafied and original research work carried out by Mr. **Saswata Kumar Sahoo** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published any firm.

It is further certified that the help of assistance received during the course of the investigation has been duly acknowledged.

Place : Bhubaneswar,
Date : 03-01-04


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Advisory Committee

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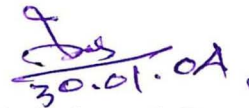
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CERTIFICATE - II

This is to certify that the thesis entitled "**GENETIC VARIABILITY IN SPRAY TYPE CHRYSANTHEMUM (*Chrysanthemum morifolium* Ramat)**" submitted by **Mr. Saswata Kumar Sahoo** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) IN THE SUBJECT OF HORTICULTURE** has been approved by Students Advisory Committee after an oral examination on the same in collaboration with an external examiner.

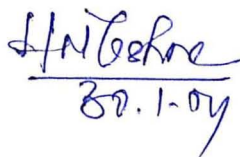
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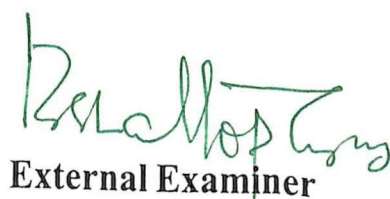

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At the nib but not at the neaptide, I do express my deep sense of gratitude and indebttness to my beloved parents, whose painstaking endeavour, inspiration and blessings have made me to be so today.

Bhubaneswar

Date, the 3rd January 2004

Saswata Kumar Sahoo
(Saswata Kumar Sahoo)

ABSTRACT

Title of the thesis : "Genetic Variability in Spray type
Chrysanthemum (*Chrysanthemum morifolium*)"

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The genetic parameters were estimated in 27 cultivars of spray type chrysanthemum. The differences among the cultivars were statistically significant for all the nine quantitative characters studied. High estimates of genotypic coefficient of variation (G.C.V.), heritability (Broad sense) and genetic advance were observed for number of branches (sprays) 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. Thus, selection based on these characters will be effective in improvement of spray type chrysanthemum. Correlation studies among the traits indicated that number of branches (sprays) per plant, number of flowers per spray and duration of flowering were positively correlated with flower yield (number of flowers per plant). So simultaneous improvement on these traits will be helpful in improving flower yield in spray type chrysanthemum. Path analysis of yield (number of flowers per plant) revealed that number of flowers per spray, number of branches (sprays) per plant and plant height at which first flower bud appeared had maximum direct effect, which indicate their better prospects for future crop improvement. Cultivars evaluated in this experiment represented four different clusters indicating distinct divergence. Selection of the cultivars from such divergent cluster will prove to be effective in heterosis breeding programme.

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CHAPTER - I

INTRODUCTION

INTRODUCTION

The chrysanthemum (chrysos, golden; anthos, flower) is a very popular flower crop of commercial importance. It is believed to be a native of China, Where cultivated more than 2000 years ago. It is migrated to different countries after 8th century the mention in literature is found in China by Kung-Fu-Tzu in 500 BC. In many countries including the US and Japan it is considered as number one while in several other leading flower producing countries. It is next only to rose in value of crop produced. As a result of control over growing conditions by environmental manipulation, fertilization and use of growth regulating chemicals chrysanthemum can now be produced at any time.

Chrysanthemum (*chrysanthemum morifolium* Ramat Syn. *Dendranthema grandiflora* Tzvelev) features among leading flowers of the world. It is commonly called as the “Queen of the East” and is the symbol of royalty in Japan. In Japan chrysanthemum underwent great transformation resulting in a wide range of types varying from perfectly regular blooms to the most irregular forms in USA too. It is the number one source of dollar earner flower while in China and England it is an important flower of commerce. Overall, it occupies second rank among cut flowers and fifth rank among potted flowering plants, around the globe (Attavar and Bhat, 1995). The auction turn over of chrysanthemum in dutch market also highlights its popularity. Flowers of chrysanthemum are highly priced for its varied colour, form, size, shape and use. This diversity is combined with a wide variation in growth habit, vase life and amenability to various growth regulatory practices has made this flower popular among flower crop growers, middle man, Florists and consumers. There is a regular demand for this flower through out the year. In various countries by manipulating the environmental conditions like temperature, the photo period and selecting suitable varieties etc.

Now a days chrysanthemum has earned tremendous popularity as a ornamental flower for the garden either as a potted plant or as bedding plant, as a cut flower for interior decoration or for the greenhouse or conservatory display.

Chrysanthemum has its admirers and enthusiasts all over the world for its use both as a commercial flower crop and as a popular exhibition flower. Its wide popularity is due to its large number of cultivars in respect of growth habit, size, colour and shape of bloom. As a short day plant, it naturally flowers in the autumn and winter. But now a days blooming of chrysanthemum all the year round is possible by the environmental manipulations.

In India, chrysanthemum is being commercially grown for loose flowers in states like Maharashtra, Karnataka, Tamilnadu, West Bengal, Punjab and M.P. It occupies 3rd position among the loose flowers in India which reflect its preference in the Indian floriculture market. Besides these, production of cut flowers and pot plants are also being under taken by specialized nurseries in our country. The all India coordinated floriculture improvement project (A.I. C.R.P.) of Indian council of Agriculture Research (I.C.A.R.) has been included in their co-ordinated trials among five important commercially potent flower crops.

Due to rapid urbanization and population explosion, there is a paucity of space for gardening and growing plants. In metros, cities and flats are coming profusely. This has forced people to grow pot plants of foliage and flowers to decorate their dwellings and surroundings in order to satisfy their gardening desire. Amongst various flowering pot plants available chrysanthemum holds a great promise. The versatile nature of this flower, its early blooming habit along with economy of space, labour and material, simple propagation method and the ease with which the potted plants are not only favoured in internal market but also have tremendous potentiality for export. Each pot sales at a high premium price in Indian market.

At present several spray type of chrysanthemum are available (Kher, 1988, Singh and Dadlani, 1989), Among these varieties the prominent ones are Appu, Apurva Singar, Arun singar, Arun Kumar, Guldasta, Hemant Singar, Pancho, Sharad Singar, Suhag Singar etc. These varieties are no pinch-no-stake in nature which have been exclusively made by breeder for pot culture. These are genetically dwarf, bushy, compact,

round shaped with profuse flowering habit without pinching and staking are the main attraction of these varieties. Therefore, it was worth while to evaluate these varieties along with other spray varieties under Bhubaneswar conditions for raising as pot mums.

There is, however, always a demand for better varieties than existing ones. So keeping in view various attributes like earliness, new colour with other floral characters. The open pollinated seedling of these varieties might yield promising seedlings suitable for pot culture.

Thus the present experiment was conducted with the following objectives:

- 1) To study the magnitude of genetic variation in the collection
- 2) To study the nature and extent of variability and heritability of characters and their expected genetic gain by selection.
- 3) To find out the amount and nature of association different characters with yield through correlation analysis.
- 4) To estimate direct and indirect association among yield components through path coefficient analysis.
- 5) To genotypes for components of productivity and assess genetic divergence among them based on their genetic distance.

CHAPTER - II

**REVIEW OF
LITERATURE**

REVIEW OF LITERATURE

The research results made available on genetic variability in spray type chrysanthemum seems to be rare. This crop has long been neglected although it claims a substantial contribution to our national economy indirectly. However, the systematic scientific sound knowledge of genetic divergence of the crop in addition to selection is essential. The chrysanthemum specific sets of genotypes and under various geographical locations as available have been reviewed in this chapter. It may be pointed out here a few work has done on the genetic variability of chrysanthemum, so works done on other crops relating to genetic variability is also added in this chapter.

2.1 Variability Study :

Any plant breeding programme involves selection of superior genotypes at one stage another and the effectiveness of selection depends upon the existence of genetic variability within or among populations subjected to selection (Tikka *et al*, 1974). Therefore, quantitative assessment of genetic variability would be very helpful in breeding for improvement of quantitative traits. The amount of variation in the available genetic material and the part played by environment on the expression of characters are of prime importance for determining the rate and magnitude of improvement.

Many of the economic important characters in crop plants are quantitative in nature, whose expressions are governed by “poly genes” and greatly influenced by environment. The genetic facts which are inferred from phenotypic observations, are the results of genotype, environment and their interaction. Since environment has got profound influence on quantitative characters. It is difficult to ascertain whether the variability is heritable or non heritable components and this will be tool for the plant breeder the basis of selection. Therefore, total variation or phenotypic variation is classified into four groups like heritable and non-heritable which are as follows.

Heritable or genotypic variation

- i) Additive genetic variance (V_A) which results from the additive or average effect of genes and it is heritable.
- ii) Dominance variance (V_D) which results from intra-allelic interaction and is also heritable.

(a) Non-heritable or Non-genetic variation.

- i) Epistatic variance (V_I) results from interaction of non allelic genes which is called inter-allelic interaction.
- ii) Environmental variance (V_E) results from non-genetic factors such as environmental fluctuations, sampling error and difference in cultural practices.

The progress of breeding is conditioned by magnitudes, nature and inter-relationship among characters in the population at phenotypic and genotypic levels.

Genetic variability only responds to selection as it is inherent variation and generally total genotypic variation is heritable in the absence of dominance and dominance x dominance interaction (Chaudhury and Prasad, 1968).

The genetic and genotypic variations were differentiated by Webber and Moorty (1952). According to them the genetic variance is meant by the effect of additive gene action while genotypic variance includes in addition to genetic variance, the variance largely due to dominance and epistasis.

2.2 Co-efficient of variation:

It is defined as the measure of variation and is independent of unit of measurement which is useful for comparison between different populations. Genetic co-efficient of variation is the genotypic standard deviation expressed as percentage of mean and phenotypic coefficient of variation is expressed as percentage of mean of phenotypic standard deviation. A negligible influence of environment on the character is indicated by a slight difference between phenotypic and genotypic standard deviation as suggested by Chaudhury *et al.* (1973).

2.3 Heritability Studies :

It is calculated as the ratio of genotypic variance to the total phenotypic variance or this is the proportion of the total phenotypic variance that is due to genetic causes. The term heritability is also used in more specific ways on considerations of response to selection, e.g. narrow sense heritability measured as the ratio of additive genetic variance (V_A) to the total phenotypic variance (Wright, 1921) and in broad sense heritability is the ratio of total genotypic variance (V_G) to the observed phenotypic variance (V_P) which are symbolically represented as follows.

$$h^2 \text{ (narrow sense)} = V_A/(V_G+V_E) = V_A/V_P$$

$$h^2 \text{ (broad sense)} = V_G/(V_G+V_E) = V_G/V_P$$

But Liang and walter (1968) defined heritability as the transmission of characters from parent to off spring. This statement was supported by Rangaswamy *et al.* (1973). Heritability is a parameter of great importance for the plant breeder as its magnitude indicates the effectiveness with which selection of genotype can be based on phenotypic performance (Johnson *et al.* 1955). Falconer(1960) reported that the main use of heritability in narrow sense for plant breeder was to estimate expected improvement due to selection or genetic advance.

If heritability is cent percent the phenotypic performance would be a perfect indication of genotypic value, but in such hypothetical situation the heritability value in itself provide no indication to be best individuals. Heritability of 100 percent results when both the genotypic and phenotypic variances were 0.01, 0.1, 1, 10, and 100 etc., but genetic progress would increase with an increase in variance Heritability estimates are increased when used in conjunction with selection differential and genetic advance is completely predicted as the product of heritability ratio and the selection differential (John son *et al.*, 1955)

The heritability of quantitative inherited attributes and their associated genetic and environmental variances and co-variances may be useful for improving the efficiency of selection (Webber and Moorty, 1952). Burton (1952) and Burton and Devane (1953) suggested that genotypic co-efficient of variance and heritability gave the

best picture of the amount of advance to be expected from the selection. Randhawa *et al.*, (1975) suggested that if the heritability of a character is high, the opportunity is really good for selecting a genetically good individual. Low value of heritability indicates high degree of non-heritable variability (Sharma *et al*, 1966).

Robinson (1963) reported that heritability estimates in cultivated plants can be grouped under the following categories.

- i) Low heritability 5% to 10% e.g. yield
- ii) Moderate heritability 10% to 30% e.g. components of yield.
- iii) High heritability 30% to 60% e.g. maturity characters, chemical composition etc.

However, he pointed out the above classification was only approximation and expressed the average heritability estimates over various crop plants, types of populations, procedure of determinations and environments encountered in different location and years.

Heritability estimates differ mostly, depending upon the method used to estimate the parameter (Robinson, 1963), the units for which the variance is considered (Johnson *et al.* 1955) and also the amount of genetic variation in population is evaluated. (Allard, 1960). Frey and Homer (1957) suggested that heritability estimates depend in various non genetic factors such as :

- i) Plant size
- ii) Planting density
- iii) Number of replications
- iv) Climatic and soil fertility conditions affecting the plant growth.

2.4 Genetic advance :

The genetic coefficient of variation along with a heritability estimates would seems to give the best picture of the amount of advance to be expected from

selection (Burton, 1952). The expected genetic advance from selection when expressed as a percent of the mean is the product of

- i) The selection differential measured in terms of phenotypic standard deviation,
- ii) The genetic coefficient of variation and
- iii) The square root of the heritability ratio. It is evident that genotypic coefficient of variation x selection differential provided informations concerning the maximum effect of selection while heritability indicated how closely this maximum being attained when heritability ratio is unit.

The main use of heritability in narrow sense for plant breeder was to estimate expected improvement due to selection or genetic advance (Robinson, 1963). The heritability alone conveys no indication of the amount of genetic progress that will result from selecting the best individual. But when they are used together with the selection differential, the utility is increased (Tikka *et al.*, 1974).

According to Escuro *et al.* (1963) genetic advance indicates the potentiality of selection at a particular level of selection intensity. As suggested by Dayal *et al* (1972), poor genetic advance shows the character is less heritable and high genetic advance shows the character is more variable. (Johnson *et al.*, 1955); suggested that heritability and genetic advance when calculated together are more useful for predicting the resultant effect of selecting the best individual than heritability or genetic advance calculated alone.

Siva Subramaniam and Menon (1973) reported that heritability and genotypic coefficient of variation were not sufficient guide to show the expected progress that could be achieved through selection. Low genetic advance was due to non additive genes and high genetic advance was due to additive genes and utility of heritability estimates was increased when accompanied with high genetic gain (Johnson *et al.*, 1955). Patnaik and Jena (1973) also reported that high heritability with high genetic advance

were the most effective conditions for selection. Further, Swarup and Chougale (1962) stated that heritability estimate and genetic advance determined the heritable portion and the variation.

High heritability was not sufficient indication of high genetic gain (Johnson *et al.* 1955). Wherever such an association occurs, the additive genetic effects were probably important (Chaudhary and Acharya, 1969). In case where high heritability is associated with low genetic gain the non additive genes i.e. dominant and epistatic effects are of considerable value (Malik and Das, 1975).

2.5 Correlation Studies (Character association)

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

The nature of association between two components may be positive or negative. When two characters are positively associated then selection for one will indirectly result in selection of the other and when two attributes are negatively correlated selection for one will have average effect on the selection of the other character.

The association between two characters directly evaluated from the phenotypic value is termed as phenotypic correlation which may be due to genetic, environment or both. The utility of correlation studies is enhanced further when phenotypic association is partitioned into genetic and environment correlation. The genetic correlation is the correlation of breeding value and therefore constitutes a more reliable guide in selection than phenotypic correlation. The environment is also a cause of correlation as two characters are influenced by some difference in environmental conditions, pleiotropy and linkage are the genetic causes of association between two characters. However, genetic correlation resulting from linkage are transient and can be modified by recombination. Pleiotropy refers to the property of certain genes influencing

two or more characters. Genetic correlation resulting from pleiotropic action of genes may be positive or negative depending on the pleiotropic effects on the correlated characters and can not be modified by recombination.

The measure of the amount of relationship between two characters was indicated by the term correlation coefficient (r) according to Hays *et al.* (1955) correlation coefficient is the measure of the degree of association between two characters is worked with at the same time.

2.6 PATH COEFFICIENT ANALYSIS OF YIELD COMPONENTS :

Yield is a complex trait resulting from direct and indirect effects of several characters operating either in combination or individually. Selection for a character in one direction may influence another character by a direct or indirect effect via a third variable. The study of correlation gives only the extent of association among various characters taken in pairs. This extent of association does not imply the cause and effect relationship. Therefore, the path coefficient analysis is used to determine the direct and indirect effects of various plant characters on crop yield.

The path coefficient analysis devised by Wright (1921) provides a better knowledge as it reveals direct and indirect causes of associations and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each causal factor. This method was first used by Dewey and Lu (1959) in their analysis of seed yield in created wheat grass. Since then several workers have applied the particular method for analysis of character association in various crops.

2.7 VARIABILITY STUDIES IN CHRYSANTHEMUM & RELATED FLOWER CROPS :

i) Chrysanthemum :

Ponnuswamy, et al. (1985). conducted a trial on variability in chrysanthemum with respect to plant height, spread, number of branches, earliness, number of flowers per plant and flower yield over a period of two years in 27 cultivars.

They found that genotypic variance was generally lower than phenotypic variance ranging from 12.79 to 26234.65 in the first year and from 13.21 to 26241.69 in second year while the figures of phenotypic variance were 26.01 to 52870.08 and 27.07 to 52654.86 for the first and second year respectively.

Gaikwad and Choudhury (1985-1986) studied about the variability of chrysanthemum genotypes and observed that estimates of phenotypic coefficient of variation were higher than the genotypic coefficients of variation, Further, high heritable values along with high genetic advance was observed for the number and weight of flowers per plant, plant height, plant spread, duration of flowering and number of "B" grade flowers indicating high additive genetic variance and hence, these characters could be improved through selection. The number of flowers per plant was significantly and positively correlated with height and spread of plants, number of branches per plant and weight of flowers per plant. The weight of flowers per plant also had a significant and positive correlation with number of branches per plant, duration of flowering and shelf life of flower at room temperature. However, the number and weight of flowers per plant, both had a significant negative association with number of "B" grade flowers. The path analysis which further partitioned the correlation coefficient into various direct and indirect effects through different yield contributing characters showed that the ideal plant type for higher yield should possess higher number flowers, taller plants having more number of branches and bigger flowers. On the basis of yield performances Jaya and Vasantika proved to be the most superior cultivars. Vasantika also had longer lasting quality flowers on plant as well as at room temperature.

Singh and Dadlani (1989) recorded data on vegetative and flowering characters of 15 varieties of *chrysanthemum morifolium* in ratoon crops at the 2nd and 3rd year. They found that "sharadmala" was the earliest to flower and duration of flowering ranged from 30 in 'Flirt' to 50 days in "Decorative" where as flower production varied from <100 in "Kundan" and "Flirt" to >1000 in "Suhag Singar", flower yield in the 3rd year was generally twice than that in 2nd year. The 100 flower weight ranged from 30g in "Suhag Singar" to 200g in "Indira".

Nobie and Ellis (1990) grew successive batches of pot plants in chrysanthemum CV. "Bright Golden Anne" in glass houses in each of three winters. Five rooted cuttings were planted in one pot, "half" pots, given 3 weeks of long days using night-break lighting and then transferred to short days for the remaining of the production period. Samples of pot were given supplementary lighting from high pressure sodium lamps 17.2 w/m² PAR for 11h/day for first two weeks of short day. It was observed that solar radiation or supplementary light did not affect the variability in height of the plants in the pot. The solar radiation integrated during long day period was only weekly correlated with the number of days to flower but was not with number of flowers showing colour per pot or with a variability of flowering of the five plants in pot. There was strong correlation between mean daily solar radiation integrated during the 3rd and 4th weeks of shoot days to flowering the number at flowers showing colour per pot but did not significantly affect variability of flowering.

Genetic variability, correlation and path analysis of flower yield and its components were studied in it genetically diverse stocks of small flowered chrysanthemum by Raghava et al (1992). According to them, number and weight of flowers per plant were recorded to have high genotypic coefficient of variation as compared to other characters studied. Besides these two characters also had high heritability and genetic advance (percent of mean). Flower yield per plant on weight basis showed positive and significant association with plant height, days to flower, flower size and flowers per plant. Path analysis revealed that days to flower and number of flower plant had direct effect on flower yield per plant, while plant height and flower size exerted indirect effect. On flower yield, through the number which was the main component of flower yield and should be given maximum emphasis for such selection procedure.

Arulmozhiyan et al (1993) evaluated 12 chrysanthemum varieties viz. "C.O. -1", "Vasantika", "Sharadmala", "Shanti", "Indira", "Sel-4", "Baggi", "C.O. -2", "Sel-5", "Red Gold", "Basanti", and "Sel-6" in the year 1991-1992. Among the varieties tested

Cv “C.O.-2” recorded the highest flower yield (3036 number , 3268-og/plot) followed by Red Gold (1624 number, 2463.6 g/plot) and (0-1 (1428 number and 2263.6g/plot), while the performance of “Vasanthika” was observed to be very poor (44number and 23.1g/plot). The variety “Sharadmala” and “Shanti” took 79 days for 1st flowering while Co-2 Red Gold, Co-1 took 101, 84, and 90 days respectively. The flower diameter was highest in “Indira” (4.9 cm) followed by “Sel-5”(4.7cm) followed by “Sel-5”(4.7cm) and “CO-1” (4.1cm) and it was the least in Sharadmala which recorded diameter of 2.4cm only.

Sirohi et al (1999) reported that character association and path coefficient analysis were conducted for twelve quantitative traits of 57 genotypes chrysanthemum (*Dendranthema*), in which positive and significant association of yield with flowers per plant, plant spread and number of branches per plant indicated that selection based on this character would be effective for chrysanthemum improvement. The number of flowers per plant had high effect on yield through number of branches per plant.

Sirohi and Behera (2000) taken 57 genotypes of chrysanthemum for variability study and revealed that the phenotype coefficient of variation (PCV) were higher than those of genotypic coefficient of variation for all the character studied, however, GCV and PCV estimates were found for number of flowers per plant, followed by number of branches per plant and disc diameter. High heritability with high genetic advance was observed for number branches per plants disc diameter, number of petals per flower and flower yield. Disc diameter, no of petals per flower and flower yield.

Deka and Paswah (2002) revealed the correlation and direct and indirect effect of nine quantitative characters of flower yield in ten genotypes of chrysanthemum and reported a positive and significant correlation of flower yield with number of branches and number of leaves further size of flowers showed the greatest direct positive effect on flower yield followed by number of flower per plant, number of flower, plant height and duration of flowering. Pal and George (2002) studied on genetic variability and correlations in chrysanthemum and reported that in two indigenous (“Sonar Bangla” and

“Pride of Jamshedpore”) and ten exotic (“Kenrioku Kangiku”, “Bal Combe Perfection”, “Snow Ball”, “Chandrama”, “Okaihama”, “Melody Lane”, “Pink Cloud”, “Silk Brocade Pink”, Ghenzys khan and Gambit chrysanthemum (*Dendranthema morifolium*) cultivars .The cultivars showed significant differences for plant height , number of leaves, individual leaf area, length of leaf, width of leaf, no of lobes per leaf, days to flower bud emergence ,stalk length , stalk diameter ,flower weight and shelf life of flower. Significant variation was observed for plant height ;number of leaves ; individual leaf area ; length ,width and number of lobes of leaf ,days to flower bud emergence ;stalklength and weight ;and shelf life of flowers. High heritability associated with high genetic advance as the percentage of mean indicating the presence of additive gene action. The other traits exhibited high heritability associated with moderate and low genetic advance indicating the presence of non-additive gene action. Most of the correlations were positive. Flower diameter and weight were significantly correlated with plant height, leaf number and area, and stalk length and diameter.

ii) Marigold

Variability studies in marigold conducted at IIHR, Bangalore (Janaki Ram and Rao, 1992) indicated that when marigolds (*Tagetes erecta*) were evaluated for nine important quantitative characters with regard to genotypic and phenotypic variability ,heritability ,genetic advance and correlation coefficients ,highly significant variatal differences and a wide range of phenotypic variability existed for all the characters under study. High genotypic coefficient of variation was observed for number of lateral branches per plant, where as heritability estimate ranged from 48.55 for flower yield per plant , 92.20 for the plant height. Characters like days to flower, plant height, average flower weight number of flower per plant exhibited high values of heritability while number of main branches ,average flower size had medium heritability values . The estimates of genetic advance ranged from 12.12 for days to flower to 61.64 for number of flowers per plant. Average flower weight had high heritability with moderate genotypic advance as percentage of mean. In general, the genetic correlation co-efficient were higher than the phenotypic correlation coefficient. Days taken to flower had positive significant correlation with the eight characters studied, where as it had significant

negative correlation with flower size number of flowers per plant had shown significant positive correlation with days taken to flower plant height, plant spread number of lateral branches per plant.

In a similar trial Janaki Ram and Rao (1993) studied genetic variance and variability in 12 varieties of French marigold planted with two spacings. General mean for all the nine characters studied were observed to be higher in wider spacing except for number of lateral branches and flower size. The genotypic coefficient of variation was higher at close spacing in all the characters except for plant spread number of lateral branches and flower size. All the characters exhibited significant positive correlations with yield in both the spacings.

Bard et al. (1993) studied genetic variability for ten characters in eight genotypes of African marigold according to their heritability estimates and genetic advance expressed as per cent of mean were higher for number of flowers per plant and plant spread. They concluded that heritability in those characters was attributed to additive gene effect.

Rao and Negi (1995) collected 12 exotic varieties of French marigold and evaluated for three years for different quantitative and qualitative characters. They found that majority of the varieties took 50-60 days to flower and their plant height and plant spread were between 20-30 cm Variety "Naughty Marietta" produced maximum number of flowers per plant followed by "Tangerine" and "Harmony", the minimum was in "Spanish Brocade" and "Butter" Scotch flower weight was observed to be maximum in harvest moon while it was the minimum in harmony followed by "Dainty marietta" flower size was the biggest in "Queen Sophia" where as it was the smallest in "Lemon drop" in "Naughty Marietta" and "Tangerine" flower yield per plant was more than the rest of the cultivars considering both qualitative and quantitative traits all the 12 varieties viz., "Butter Scotch", "Carmen", "Dainty Marietta", "Fiesta", "Harmony", "Harvest Moon", "Lemon drop", "Merry June Flame", "Naughty Marietta", "Queen Sophia", "Spanish Brocade" and "Tangerine" were found to be suitable for potting bedding and

could be used for landscaping. Except “Dainty Marietta” and “Naughty Marietta” other varieties were found to be suitable for worshipping and floral decoration.

In another study the same authors (Rao and Negi, 1995) evaluated seven African marigold (*Tagetes erecta*) varieties such as “Double Lemon”, “Double Orange”, “Golden Age”, “Gold Smith”, “Hawaii”, “Mr Moon Light” and “Spun Gold” for three years collected from exotic sources. They observed that among the varieties flower colour varied from yellow to orange. “Mr Moon light” and “Golden Age” were earliest to flower. “Spun Gold” and “Mr Moon Light” had less plant height and plant spread whereas “Goldsmith” was the tallest. Number of flowers per plant was least in “Spun Gold” while it was highest in “Double Lemon” followed by “Golden Age”. Further it was noticed that flower size and weight were maximum in “Hawaii” and minimizing “Mr Moon Light” flower yield per plant was found to be highest in Hawaii mainly due to maximum flower size and weight where as flower yield was least in case of “Spun Gold” because of lesser number of flowers. “Mr Moon light” and “Spun Gold” were suitable for wedding and cutting purpose because of their compactness and dwarfness and remaining varieties could be grown for loose flower purposes. Among varieties tested “Golden Age” and “Mr Moon light” had odourless foliage were and found to be promising.

iii) China aster

A total of 38 genotypes of China aster were evaluated by (Rao and Negi, 1992) in randomized block design with three replications at the IIHR, Bangalore. Studies on variability, heritability and genetic advance were conducted on 12 biometric characters. It was observed that the difference between phenotypic and genotypic coefficient of variation was medium for number of laterals per plant and narrow for remaining characters. Further heritability estimates (Broad sense) for the characters were found to be medium to high. High heritability as well as high genetic gain was observed for flower weight and number of ray florets, whereas medium heritability along with high genetic gain was observed for number of laterals per plant indicating additive gene effect. High heritability accompanied by low genetic gain was exhibited by number of main branches per plant. These associations showed predominance of non additive gene action thus it was

concluded that selection based on flower weight, number of laterals per plant could be very effective for further improvement of the crop.

Ashwath and Parthasarathy (1993) concluded variability and correlation studies in nine traits indicated that plant height, stem diameter and number of florets showed high frequency of genotypic correlation suggesting their use as selection indices the estimates of heritability and coheritability showed that all character were controlled by additive gene effects.

Janaki Ram and Rao. (1995) compared two promising clones of China aster IIHR-26 and IIHR – 35, developed at IIHR, Bangalore with the standard local variety namely local violet and local white in a replicated trail for three years during 1991-94. They noted that the number of main branches, number of flowers total yield per plant were much higher in IIHR – 26, and IIHR- 35. Considering their quantitative and qualitative characteristics both the promising lines were found to be good for cut flower and loose flower purpose.

2.8 Genetic divergence :

Selection of genetically divergent varieties is important in the exploitation of heterosis and in the development of transgressive segregants for an efficient breeding programme. The information regarding the nature and magnitude of genetic distance among the genotypes will help the breeder in choosing the suitable diverse combinations.

P.S. Sirohi and T.K. Behera (2000) reported that 52 genotypes of several dimorphism in number of flowers per plant followed by number of branches per plant and disk diameter. High heritability with high genetic advance was observed for number of branches per plant, disc diameter, number of petals per flower and yield of flower.

Barigidad et al. (1992), Chaugule (1985) conformed the above results indicating more divergence between genotypes.

Gondhali et al (1997) also conformed by taking 9 cultivars of spray type chrysanthemum and studied on the basis D^2 values.

Niharika Pattnaik and C.R. Mohanty (2002) also reported that 13 genotypes of African marigold shown coefficient of variation both at genotypic and phenotypic levels was maximum for yield of flowers. Other characters with high GCV (44.01) and PCV (52.0) were number of flowers per plant, weight of individual flower and the highest of the plant. This would help the breeder in selection of appropriate breeding methods.

Wolff et al (1993) were studied using a recently developed technique to enumerate random amplified polymorphic DNAs (RAPD). Variation between cultivars was high and the cultivars used could be distinguished from each other by using only two different primers. A family of cultivars, derived from one original cultivar by vegetative propagation, had identical fragment patterns. Because of the high level of polymorphism and clonal stability. RAPD fragments are useful for cultivar identification. Genetic variability among related *Dendranthema* species was too high to study genetic or distances either among cultivars within chrysanthemum or among species related to chrysanthemum.

The degree of association of yield with its components and other inter-relationship are of great importance for making effective selection (Sikka and Jain, 1958). Because some correlation may restrict desirable combination of characters while others may aid in the process of selection. If high correlation exists between lowly heritable characters like yield and highly heritable character, then selection will be done basing on the later for improvement. If negative correlation will exist between components of yield, then selection will exist between components of yield, then selection is to be done for intermediate combination for improvement in yield.

CHAPTER - III

**MATERIAL AND
METHODS**

MATERIALS AND METHODS

The present investigation was undertaken in form of experiment in pots for investigation on the topic of “Genetic variability studies in spray type Chrysanthemum (*Chrysanthemum morifolium*. Ramat Syn *Dendranthema grandiflora* Tzevlev). In the experimental garden of Horticultural Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during September to February 2002 – 2003. The materials and techniques adopted during the course of investigation are described in this chapter.

3.1 GEOGRAPHICAL LOCATION OF THE EXPERIMENTAL SITE

The Horticultural Research Station which is under College of Agriculture, O.U.A.T, Bhubaneswar, Orissa is situated about 5 km away from Bhubaneswar and located at the latitude of 20° 15'N and longitude of 85° 52'E. It is about 60km away from the Bay of Bengal, at an altitude of 25.5m above mean sea level. It is situated on the foot hills of Khandagiri.

3.2 CLIMATE

The temple city of Bhubaneswar enjoys rainy season from June to September having mild winter for 4 months after which the Summer season begins. The climate of Bhubaneswar comes under the subtropical climate. The mean annual precipitation is mm 1646.43 mm from June 2002-2003, out of which 1216.04 mm is received from June to September and the rest 430.39 mm between October and May. The average maximum temperature ranges from 35°C to 39°C during May and June. While the minimum temperature ranges from 13°C to 15°C during December and January. The details of the weather condition during the period of investigation from September 2002 to February 2003 has been presented in the Table –1.

Figure - 1

PLAN OF LAYOUT

Treatment	Replication I	Replication II	Replication III
T ₁	CV-3 (A-3)	CV-1 (A-1)	CV-2 (A-2)
T ₂	CV-6 (A-9)	CV-4 (A-7)	CV-5 (A-8)
T ₃	CV-9 (A-13)	CV-7 (A-10)	CV-8 (A-11)
T ₄	CV-12 (A-16)	CV-10 (A-14)	CV-11 (A-15)
T ₅	CV-15 (A-19)	CV-13 (A-17)	CV-14 (A-18)
T ₆	CV-18 (A-24)	CV-16 (A-20)	CV-17 (A-23)
T ₇	CV-21 (A-27)	CV-19 (A-25)	CV-20 (A-26)
T ₈	CV-24 (A-30)	CV-22 (A-28)	CV-23 (A-29)
T ₉	CV-27 (Yellow gold)	CV-25 (A-31)	CV-26 (Ravi kiran)
T ₁₀	CV-1 (A-1)	CV-2 (A-2)	CV-3 (A-3)
T ₁₁	CV-4 (A-7)	CV-5 (A-8)	CV-6 (A-9)
T ₁₂	CV-7 (A-10)	CV-8 (A-11)	CV-9 (A-13)
T ₁₃	CV-10 (A-14)	CV-11 (A-15)	CV-12 (A-16)
T ₁₄	CV-13 (A-17)	CV-14 (A-18)	CV-15 (A-19)
T ₁₅	CV-16 (A-20)	CV-17 (A-23)	CV-18 (A-24)
T ₁₆	CV-19 (A-25)	CV-20 (A-26)	CV-21 (A-27)
T ₁₇	CV-22 (A-28)	CV-23 (A-29)	CV-24 (A-30)
T ₁₈	CV-25 (A-31)	CV-26 (Ravi kiran)	CV-27 (Yellow gold)
T ₁₉	CV-2 (A-2)	CV-3 (A-3)	CV-1 (A-1)
T ₂₀	CV-5 (A-8)	CV-6 (A-9)	CV-4 (A-7)
T ₂₁	CV-8 (A-11)	CV-9 (A-13)	CV-7 (A-10)
T ₂₂	CV-11 (A-15)	CV-12 (A-16)	CV-10 (A-14)
T ₂₃	CV-14 (A-18)	CV-15 (A-19)	CV-13 (A-17)
T ₂₄	CV-17 (A-23)	CV-18 (A-24)	CV-16 (A-20)
T ₂₅	CV-20 (A-26)	CV-21 (A-27)	CV-19 (A-25)
T ₂₆	CV-23 (A-29)	CV-22 (A-28)	CV-24 (A-30)
T ₂₇	CV-26 (Ravi kiran)	CV-27 (Yellow gold)	CV-25 (A-31)

DESIGN RANDOMISED BLOCK

Plot size : Diameter = 30 cm

Height = 1 feet

Treatments = 27 CVs

T = Treatment

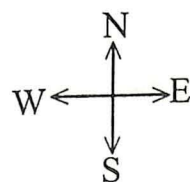


Table 1. Meteorological data collected during the experimental period.

Month	Year	Temperature			R.H. %			Rainfall	No. of rainy days	BSH
		Max	Min	Avg	FN	AN	Avg			
Sept.	2002	31.7	24.6	28.1	96	79	88	181.7	16	4.6
Oct.	2002	32.3	22.9	27.6	95	63	79	48	7.7	1.2
Nov.	2002	30.1	17.3	23.7	90	50	70	27.2	3	7.6
Dec.	2002	30.1	14.2	22.2	93	37	65	-	-	8.6
Jan.	2003	27.9	14.1	21	85	43	64	-	-	8.0
Feb.	2003	30.8	19.4	25.1	94	53	74	9.6	3	7.9

3.3 CROPPING HISTROY OF THE SOIL TAKEN FROM THE FIELD FOR EXPERIMENT

The soil taken for experiment was brought from a virgin land, No crop was grown during last 3 years excepting the present crop spray type of chrysanthemum taken of during 2002-2003.

3.4 SOIL CHARACTERISTICS OF THE EXPERIMENTAL SITE

A composite soil sample was collected from soil taken for pot mixture of the experimental purpose, having red laterite soil, before mixing with sand and FYM . The soil sample, after proper processing was analysed to study the mechanical and chemical compositions. Results of such analysis were presented in Table

3.5 VARIETAL DESCRIPTION

Spray type of Chrysanthemum (*Chrysanthemum morifolium* Ramat.) accessions were selected for this experiment with 'Ravikiran' and 'Yellow gold' as two named varieties (check) for growing.

Different shades of yellow, cream, pink, mauves, brown, purple with soft flesh.

3.6 COLLECTION OF PLANTING MATERIALS

Chrysanthemum is an annual plant. It is propagated by seed , by suckers and rooted tip meristematic stem cutting. For the present investigation, the rooted stem cuttings of cultivars were collected from the Regional Plant Resource Centre Bhubaneswar and were grown in the Horticultural Research Station,OUAT,Bhubaneswar

PLATE I



CV-1 (A-1)

PLATE II



CV-2 (A-2)

PLATE III



CV-3 (A-3)

PLATE IV



CV-4 (A-7)

PLATE V



CV-5 (A-8)

PLATE VI



CV-6 (A-9)

PLATE VII



CV-7 (A-10)

PLATE VIII



CV-8 (A-11)

PLATE IX



CV-9 (A-13)

PLATE X



CV-10 (A-14)

PLATE XI



CV-11 (A-15)

PLATE XII



CV-12 (A-16)

PLATE XIII



CV-13 (A-17)

PLATE XIV



CV-14 (A-18)

PLATE XV



CV-15 (A-19)

PLATE XVI



CV-16 (A-20)

PLATE XVII



CV-17 (A-23)

PLATE XVIII



CV-18 (A-24)

PLATE XIX



CV-19 (A-25)

PLATE XX



CV-20 (A-26)

3.8.3 Preparation of planting materials

The planting materials treated with 0.2% blitox-50 solution for 20 minutes, spread over the potted mixture for two to three hours and were allowed to dry up before planting.

3.8.4 After care of the experimental plots of pots.

- i) **Irrigation** : A light irrigation was given after planting in the evening hours, later the pots were irrigated at 7 to 10 days interval depending upon the weather and moisture condition of the soil as and when required.
- ii) **Weeding** : Hoeing and hand weedings were done as and when necessary to keep the pots weed free.
- iii) **Plant protection** : The experimental plots were mostly free from pest and diseases. However, the prophylactic measures were taken at fortnightly interval.

3.9 HARVESTING

Flowers were harvested when the florets are fully open showing colour.

Treatment

CV1 (A-1)	CV15 (A-19)
CV2 (A-2)	CV16 (A-20)
CV3 (A-3)	CV17 (A-23)
CV4 (A-7)	CV18 (A-24)
CV5 (A-8)	CV19 (A-25)
CV6 (A-9)	CV20 (A-26)
CV7 (A-10)	CV21 (A-27)
CV8 (A-11)	CV22 (A-28)
CV9 (A-13)	CV23 (A-29)
CV10 (A-14)	CV24 (A-30)
CV11 (A-15)	CV25 (A-31)
CV12 (A-16)	CV26 (Ravikiran)
CV13 (A-17)	CV27 (Yellow Gold)
CV14 (A-18)	

PLATE XXI



CV-21 (A-27)

PLATE XXII



CV-22 (A-28)

PLATE XXIII



CV-23 (A-29)

PLATE XXIV



CV-24 (A-30)

PLATE XXV



CV-25 (A-31)

PLATE XXVI



CV-26 (Ravikiran)

PLATE XXVII



CV-27 (Yellow gold)

Biometric Observation

Sampling technique: From each treatment comprise five pots and replicated thrice. The average of five plants were chosen for twenty seven chysanthemum varieties and all the plants were levelled by wax coated Tags. All the observations are taken from the leveled potted plants. Experimental main observation were taken in fortnightly interval and nine such characters were recorded. The details of the biometric observation taken during the period of observation as follows.

Growth Characteristics

- i) **Plant height at first flower bud appearance :** The height of the plant was measured from the base of the plant to the top and average value were recorded.
- ii) **Number of primary branches (sprays) per plant :** The total number of branches emerging from main stem was counted and mean value was recorded.
- iii) **Length of Spray :** Length of spray from secondary branch upto top were measured and the mean value recorded.
- iv) **Days taken to first flower bud appearance :** The total no. of days were counted from the date of planting to the date of bud appearance were estimated in each case.

Yield parameters

- i) **Number of flowers per spray :** The number of flowers were counted per spray and the average were recorded.
- ii) **Number of flowers per plant :** Number of flowers are counted per plant and the average were recorded.
- iii) **Diameter of the flowers :** The diameter of the flower was measured by the vernier callipers
- iv) **Weight of flowers :** After taking selected flowers harvested and the fresh weight of the flowers taken. 10 no. g. flower of each plant were taken for the weight of the flower and data was recorded.

Statistical Analysis :

The data for each character in observational plants were summed up and mean values for each character were estimated and subjected to stastical analysis (Gompz and Gomez, 1983).

Analysis of variances :

The analysis of variance for each of the character's stated was done to find out varietal differences the analysis was carried out separately for each trait following the procedures of randomized block design analysis (Gomez and Gomez, 1983, Panse and Sukhatme, 1954). Analysis of variance was done on the basis of the following model

$Y_{ij} = m + g_i + r_j + e_{ij}$

Where Y_{ij} = Phenotypic observation in the i th genotype and J_{th} replication.

m = General mean

g_i = Effect of the i th genotype/treatment

r_j = Effect of the j th replication

e_{ij} = Random error associated with i th genotype in j th replication.

Table 2. Analysis of variance and expected mean sum of square.

Source	df	MSS	Expected mean sum of square
Replication	($r-1$)	M_R	$\sigma_e^2 + g\sigma_r^2$
Genotype	($g-1$)	M_G	$\sigma_e^2 + r\sigma_g^2$
Error	($r-1$) ($g-1$)	M_E	σ_e^2

Mean, range, standard error and critical difference

mean values of each character were worked out by dividing the total corresponding number of observation while the highest and lowest values for each character were taken as the range. The S.E. and C.D. were calculated by using the following formula.

Standard Error of mean = $\sqrt{\frac{EMS}{r}}$

$$\text{Critical difference (C.D)} = \sqrt{\frac{EMS}{r}} \times t \quad \text{Value at error degrees of freedom at 5\% and 1\% levels of significance}$$

where

r = number of replication

EMS = Error mean sum of square

Coefficient of variation :

For comparing the variability of two or more than two characters, coefficient of variation were calculated by using the following formula.

$$C.V. = \frac{SD}{\bar{X}} \times 100 = \sqrt{\frac{EMS}{\bar{X}}}$$

Where S.D. is the standard deviation which is square root of mean square due to error (EMS) and $\bar{x}$ the experimental mean from the structure of the analysis of variance.

$$\text{Error variance} = \sigma_e^2 = ME$$

$$\text{Genotypic variance} = \sigma_g^2 = \frac{M_G - M_E}{r}$$

$$\text{Phenotypic variance} = \sigma_p^2 = \frac{M_G}{r} = \sigma_g^2 + \sigma_e^2$$

The genotypic coefficient of variance (GCV) and phenotypic coefficients of variance (PCV) were calculated by the formula by Burton (1952)

$$GCV = \frac{\text{Genotypic standard deviation}}{\text{Grand mean}} \times 100$$

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

Heritability (Broad sense)

Degree of correspondence between phenotypic value and breeding value is measured by the heretability estimate. Heritability (h^2) estimate was worked out by using the formulae suggested by Lush (1949) and Burton and Devance. (1953). This was expressed in percentage according to weber and moorthy (1952). Heritability in broad sense was calculated by using the formula.

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

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

Expected Genetic advance :

Genetic advance was estimated as per the formula suggested by Johnsen. Robinson and Comstock (1955)

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

Where

K = selection differential in standard units (Which is 2.06 for 5% selection intensity)

h = Square root of heritability coefficient.

σ_p = Phenotypic standard deviation

G_A expressed as percentage of mean as calculated genetic gain

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

$\bar{X}$ = the general mean of character,

Estimation of correlation coefficients :

Simple correlation coefficients were completed at genotypic and phenotypic levels between pairs of characters using the following formula :

$$\text{Genotypic correlation (rg)} = \frac{\sigma_g(XY)}{\sigma_g(X) \times \sigma_g(Y)}$$

$$\text{Phenotypic correlation (rp)} = \frac{\sigma_p(XY)}{\sigma_p(X) \times \sigma_p(Y)}$$

Where

$\sigma_g(XY)$ = Genotypic covariance between the two traits X and Y,

$\sigma_p(XY)$ = Phenotypic covariance between the two traits X and Y,

$\sigma_g(X)$ and $\sigma_g(Y)$ = Stands for genotypic standard deviation of X and Y respectively

$\sigma_p(x)$ & $\sigma_p(y)$ = standard for phenotypic deviation for x and y respectively.

To test the significance of correlation coefficients at phenotypic level, the estimated values were compared with the table value (Fisher and Yates, 1967) at (n-2) degree of freedom at the 5% and 1% level of significance.

Path coefficient analysis :

The path coefficient analysis a type of cause and effect relationship among the various correlated characters, path coefficients were standardized by partial regression coefficients which individually provide a measured direct effect of the causal factors on the effect variable. They permit partitioning of correlations between causal factor and the effect of variables into components of direct and indirect effects and thus give a better picture of the association of the causal factors with the effect variable.

In the present investigation, number of flowers/plant was taken as the effect with other characters like plant length, main branches plant, Number of spray per plants, number of leaves per plant related to yield as the causal factors. The path coefficients were obtained by solving the following simultaneous equations which give the basic relationship and path coefficients in system of correlated causes (Dewey and Lu, 1959)

$$m.y = m_1 p_1 y + m_2 p_2 y + \dots + m_x p_x y$$

Where

R = Correlation coefficient between x th and y th characters.

P = indirect effect of a character in yield.

Analysis of genetic divergence and grouping of varieties : Using Mahalanobis' D^2 statistics as described by Rao, (1952). The genetic divergence with regard to characters was estimated. All possible D^2 were calculated among 27 varieties by using formula $n(n-1)/2$ were computed. The relative contribution of individual characters to divergence was assessed by ranking of component D^2 as well as by percentage contribution to total D^2 overall combination.

The types were grouped into clusters on the basis of D^2 values following Tocher's methods described by Rao(1952). The criterion of grouping was that any two cultivars belonging to the same cluster should have a smaller D^2 than those between cultivars belonging to different clusters Canonical analysis was also done following Rao, (1952) and Z_1 and Z_2 values corresponding to the first two Canonical vectors plotted as a supplement to grouping by Tocher's method.

CHAPTER - IV
EXPERIMENTAL
RESULTS

EXPERIMENTAL FINDINGS

During the course of the present investigation in the project, "Genetic variability studies in spray type Chrysanthemum (*Chrysanthemum morifolium* Ramat.), observations on flower yield and its component traits were recorded. The mean values of the characters studied, were statistically analysed to study the variability, heritability and genetic gain for selection and their association with yield as well as among themselves. The direct and indirect effect of these characters on yield and their nature and extent of genetic divergence among different cultivars were also studied. The salient findings as revealed from the investigation are presented below.

Analysis of variance

The variances (mean square values) between cultivars for nine characters such as days taken to first flower bud appearance, plant height at first flower bud appearance, number of flowers per spray, number of flowers per plant, number of branches (sprays) per plant, length of the spray, diameter of flower, average flower weight and duration of flowering were presented in table 3.

The data showed that there were significant ($p = 0.01$) differences among the cultivars for all the nine characters studied. The coefficient of error variation ranged from 0.06% (days taken to first flower bud appearance) to 0.70% (number of branches per plant). In general C.V. value being less than 20 per cent for the characters studied, reflected a good deal of experimental precision in evaluating the cultivars.

Mean performance and coefficient of variation.

The mean performance, standard error of variation (S.E), critical difference (C.D.) and coefficient of variation (C.V) values are presented in Table 4.

Table 3. Form of Analysis of variance among cultivars for nine characters in spray type chrysanthemum

Sources of variation	D.F.	Days taken to first flower bud appearance (day)	Plant height at first flower bud appearance (cm)	Number of flower/spray	Number of flowers/ Plant	Number of branches/ plant	Length of spray (cm)	Diameter of flower (cm)	Av flower weigh (g)	Duration of flowering (day)
1	2	3	4	5	6	7	8	9	10	11
Rep.	2	1.148	0.173	0.055	9.902	0.210	0.315	1.110	0.076	1.333
Var.	26	82.692**	198.251**	19.929**	709.162**	84.222**	96.781**	3.123**	5.156**	94.154**
Error	52	1.533	0.203	0.053	11.048	0.268	0.336	0.1736	0.065	1.949
C.V.	-	0.06	0.17	0.30	0.28	0.70	0.20	0.16	0.50	0.13

* Significance of p = 0.05

** Significant of p = 0.01

Table 4. Mean performance of 27 cultivars of spraytype cheysanthemum for nine characters

Character	Days taken to first flower bud appearance	Plant at height at first flower bud appearance	Number of flower/spray	Number of flower/plant	Number of stem branches/plant	Length of spray (cm)	Diameter of flower (cm)	Avg. flower weight (g)	Duration of flowering (days)
Treatment									
Cv-1 (A-1)	72.00	35.60	5.20	50.80	10.70	16.90	7.85	1.96	40.00
Cv-2 (A-2)	76.00	51.70	8.10	49.40	7.70	28.90	5.88	2.84	38.00
Cv-3 (A-3)	69.00	48.30	6.80	42.53	7.30	25.80	6.91	5.92	33.00
Cv-4 (A-7)	72.00	55.30	8.80	57.20	6.70	36.60	6.31	6.62	32.00
Cv-5 (A-8)	79.00	45.00	6.70	46.60	5.90	25.80	6.73	2.49	38.00
Cv-6 (A-9)	76.00	43.50	8.30	56.80	7.30	27.60	6.68	1.76	36.00
Cv-7 (A-10)	79.00	45.70	7.80	49.60	4.90	22.80	6.95	1.92	35.00
Cv-8 (A-11)	74.00	48.50	12.60	73.40	3.50	25.90	5.64	1.65	49.00
Cv-9 (A-13)	88.00	67.10	5.60	29.30	4.70	41.80	7.85	6.65	38.00
Cv-10 (A-14)	68.00	49.60	8.20	37.40	4.40	24.00	7.90	3.61	37.00
Cv-11 (A-15)	73.00	34.73	16.47	57.80	4.60	25.10	5.61	1.78	58.00
Cv-12(A-16)	72.00	48.70	7.60	64.40	7.20	34.90	6.74	1.91	40.00
Cv-13 (A-17)	78.00	43.80	6.40	34.30	4.80	32.80	6.48	1.75	39.00
Cv-14 (A-18)	73.00	44.70	7.20	46.60	5.90	26.90	6.76	2.81	38.00
Cv-15 (A-19)	68.00	34.10	6.20	43.50	5.70	27.20	6.31	2.93	40.00
Cv-16 (A-20)	72.00	31.20	12.20	55.73	3.50	23.35	5.13	2.16	47.00
Cv-17 (A-23)	78.00	44.66	11.2	55.20	5.60	26.80	4.41	1.67	42.00
Cv-18 (A-24)	81.00	55.20	7.80	39.40	3.30	25.27	5.72	2.32	44.00
Cv-19 (A-25)	79.00	37.70	9.60	65.20	6.50	30.23	7.98	1.83	42.00
Cv-20 (A-26)	63.00	35.40	12.20	84.46	3.50	21.84	5.46	2.31	50.00
Cv-21 (A-27)	74.00	51.30	8.70	73.66	5.90	24.90	4.48	1.35	43.00
Cv-22 (A-28)	78.00	37.70	7.80	79.80	9.50	25.70	5.95	1.29	44.00
Cv-23 (A-29)	74.00	46.90	6.60	73.80	30.30	22.90	5.98	1.64	41.00
Cv-24 (A-30)	80.00	47.00	10.20	75.20	8.70	23.85	5.11	1.36	48.00
Cv-25 (A-31)	84.00	52.10	6.10	30.33	7.90	25.85	5.08	3.89	40.00
Cv-26	77.00	54.10	6.88	41.80	13.10	38.50	7.64	3.59	40.00
(Ravikiran)									
Cv-27	74.00	52.58	6.68	45.10	13.90	37.20	6.20	3.32	44.00
(Yellow Gold)									
s.e.d (±)	1.01	0.36	0.18	2.71	0.42	0.47	0.34	0.20	1.14
C.D. 5%	1.71	0.62	0.31	4.61	0.71	0.80	0.58	0.35	1.93
C.D. 1%	2.12	0.77	0.39	0.69	0.88	0.99	0.71	0.43	2.69
C.V.	0.06	0.17	0.30	0.28	0.70	0.20	0.16	0.50	0.13

Days taken to first flower bud appearance

The first flower bud appeared at the minimum days in CV-20 (63.00 days) followed by CV-15 and CV-10 (68.00 days in each), CV-3 (69.00 days) and CV-1, CV-4 and CV-12 (72.00 days each). On the contrary maximum days (88.00) taken for appearance of first flower bud in CV-9 followed by CV-25 (84.00 days), CV-18 (81.00 days) and CV-24 (80.00 days) in descending order. However, CV-23, CV-8, CV-6 and CV-2 have shown medium value for this character.

Plant height at first flower bud appearance

The cultivars showed considerable variation for the height at which 1st flower bud appended. The CV-16 was the shortest type (31.20 cm) followed by CV-15 (34.10 cm), CV-11 (34.73 cm), CV-20 (35.40 cm) and CV-1 (35.60 cm). Tall flowering types were CV-9 (67.10 cm) followed by CV-4 (55.30 cm), CV-18 (55.20 cm) and CV-26 (54.10 cm). However, CV-3 (48.30 cm), CV-8 (48.50 cm), CV-12 (48.70 cm) and CV-10 (49.60 cm) were of medium type for this trait.

Number of flowers per spray

Highest number of flowers per spray was observed in CV-11 (16.47) followed by CV-8 (12.6), while CV-1 recorded the lowest value (5.20). The cultivars like CV-17 was of medium type (11.2). The cultivars like CV-16 and CV-20 (12.20 in each), CV-8 (12.60 cm) produced fairly high number of flowers per spray.

Number of flowers per plant

Number of flowers per plant showed a wide variation ranging from 29.30 (CV-9) to 84.40 (CV-20). The cultivars like CV-22 (79.80), CV-24 (75.20), CV-23 (73.80), CV-8 (73.70) and CV-21 (73.66) also produced fairly high number of flowers per plant.

Number of branches per plant

A significant variation was recorded with regard to number of branches (sprays) per plant varying from 3.30 (CV-18) to 13.90 (CV-27). The cultivars like, CV--23 (13.30), CV-26 (13.10) and CV-1 (10.70) exhibited good number of sprays per plant.

Length of the spray

Maximum spray length was observed in CV-9 (71.80 cm) followed by CV-26 (38.50 cm), and CV--27 (37.20 cm). Lowest spray length was observed in CV--1 (16.90 cm) followed by CV--20 (21.84 cm) CV-7 (22.80cm) and CV--23 (22.90 cm) in ascending order.

Diameter of the flower

Diameter of flower ranged from 4.41 cm to 7.98 cm. The cultivar CV-19 produced the biggest size of flowers (7.98 cm diameter), while CV-17 produced smallest size of flowers (4.41 cm diameter). Other cultivars showing fairly good size of flowers were CV--10 (7.90 cm), CV--1, CV-9 (both 7.85 cm) and CV-26 (7.64 cm) in order of preference.

Average flower weight

Considerable variation was found in weight of flowers. The average weight of flowers ranged from 1.29 g (CV-22) to 6.65g (CV-9). The cultivars showing medium value for this character were CV-25 (3.89 g), CV-7 (3.62 g), CV-10 (3.61g) and CV-26 (3.59 g).

Duration of flowering

Duration of flowering varied from 32.0 days (CV-4) to 58.0 days. (CV-11). Flowering was also observed for a considerable high duration in CV-20 (50

days) followed by CV-8 (49 days), CV-24 (48 days) and CV-16 (47 days) in descending order.

Estimation of genetic parameters

Estimation of genetic parameters of variability for the nine characters were presented in table 5 and figure-2. The mean performance of the cultivars for growth characters such as plant height at which first flower bud appeared and number of branches (sprays) per plant were 46.00 cm and 7.51 cm respectively. Other characters indirectly affecting flower yield such as days taken to first flower bud appearance and duration of flowering showed mean value 75.22 and 41.33 days respectively with greater variability. Among the direct yield contributing characters such as number of flowers per spray, number of flowers per plant, spray length, diameter of flower, average weight of flower showed mean values 8.43, 54.04, 27.75 cm, 6.28 cm and 2.60 g respectively. The cultivar CV-20 (A-26) having moderate growth habit moderate spray length, high number of flowers per spray, medium flower size with high duration of flowering was the highest yielder among the cultivars evaluated.

The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) in most of the characters studied. The PCV was highest for number of branches (sprays) per plant (70.47 per cent) followed by average flower weight (50.25 per cent). Moderate values ranging from 20.67 to 30.54 per cent were observed for length of spray, number of flowers per plant and number of flowers per spray. Rest characters showed lower value for this parameter being lowest 6.98 per cent for days taken to first flower bud appearance.

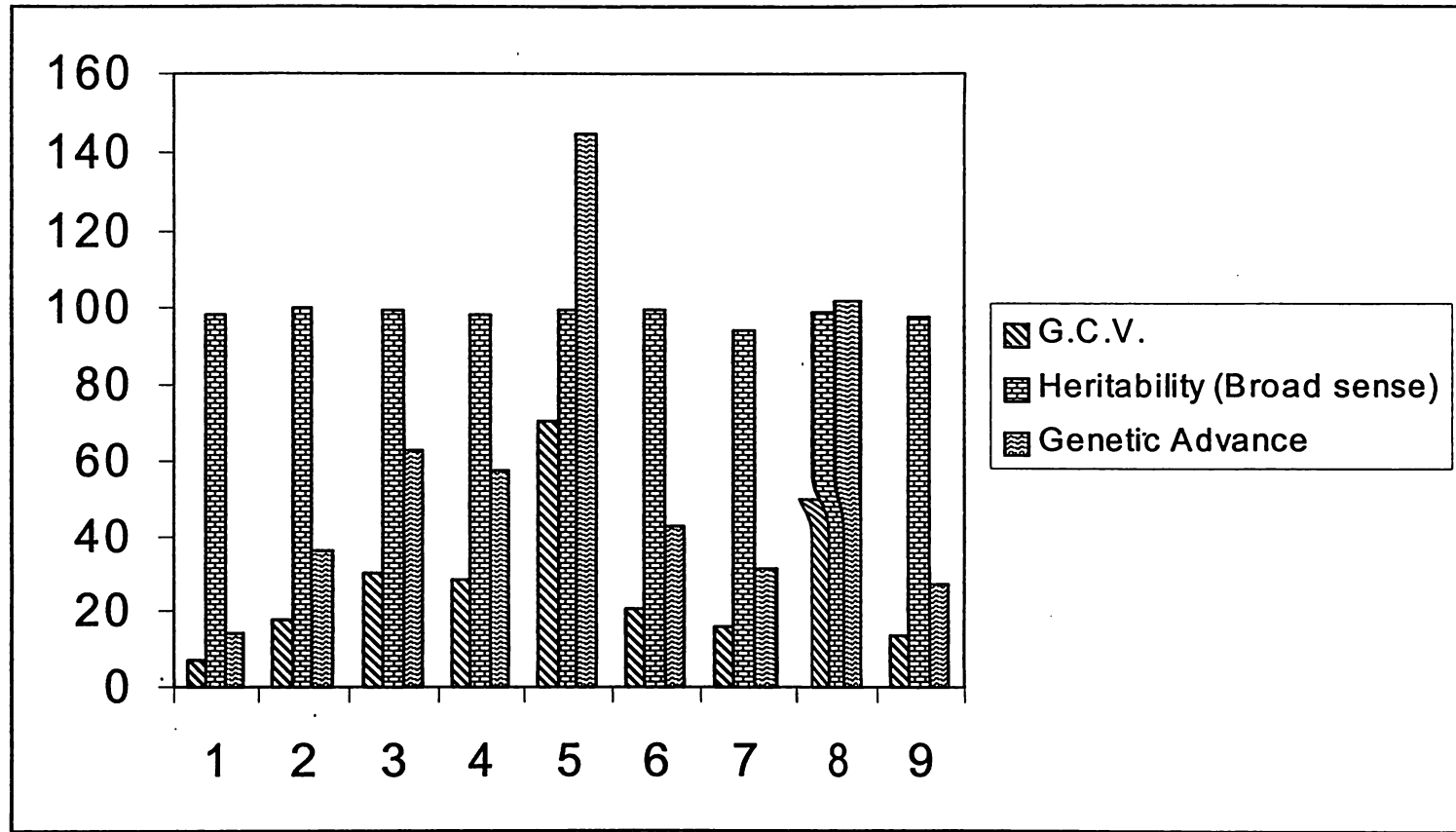
The genotypic coefficient of variation (GCV) showed parallelism trend for the traits as in PCV. Highest GCV was recorded for number of branches (sprays)

Table 5. Range, general mean, phonotypic (PCV) and Genotypic, Co-effiient of variation, heritability (h^2) and expected genetic advance (GA) for nine characters in spray type chrysanthemum.

Sl. No.	Character	Range	G.M.	GCV	PCV	Heritability (h^2) (Broad sense)	GA	GA*
1	Days taken to first flower bud appearance (Day)	62.0-89.0	75.22	6.91	6.98	98.15	10.61	14.11
2	Plant height at first flower bud appearance (cm)	30.7-67.4	46.00	17.66	17.67	99.90	16.71	36.36
3	Number of flower / spray	5.1-16.6	8.43	30.54	30.54	99.73	5.29	62.75
4	Number of flowers/plant	29.0-84.7	54.04	28.22	28.45	98.44	31.17	57.69
5	Number of branches/plant	2.8-30.8	7.519	70.36	70.47	99.68	10.88	144.75
6	Length of spray (cm)	16.2-42.4	27.75	20.64	20.67	99.66	11.78	42.44
7	Diameter of flower (cm)	4.0-8.4	6.28	15.76	16.23	94.37	1.98	31.55
8	Av. flower weight (g)	1.15-4.39	2.60	49.94	50.25	98.75	2.66	102.22
9	Duration of flowering (day)	31.0-59.0	41.33	13.41	13.55	97.93	11.30	27.34

* Percent of population mean.

Fig. 2. Genotypic coefficient of variation, heritability and genetic advance of quantitative characters in spray type Chrysanthemum



- | | |
|---|---|
| 1. Days taken to first flower bud appearance (days) | 2. Plant height at first flower bud appearance (days) |
| 3. Number of flower(spray) | 4. Number of flowers per plant |
| 5. Number of branches per plant | 6. Length of spray (cm) |
| 7. Diameter of flower (cm) | 8. Average flower weight (g) |
| 9. Duration of flowering (days) | |

per plant (70.36 per cent) and lowest (6.91 per cent) for days taken to first flower bud appearance.

In general the PCV and GCV were high (more than 50 per cent) for number of branches (sprays) per plant, moderate ($>20\%$ $<50\%$) for number of flowers per spray, number of flowers per plant and spray length. Others characters like diameter of flower, duration of flowering plant height at first flower bud appearance and days taken to first flower bud appearance showed lower value for both the parameters.

Heritability

Heritability (broad sense) estimate ranged from 94.37 per cent for flower diameter to 99.90 per cent for plant height at which first flower bud appear. In general high heritability was estimated for all the characters.

Genetic advance

The genetic advance varied from 1.98 (diameter of flower) to 31.17 (for number of flowers per plant). Other characters showing high genetic advance (more than 10.0 per cent) were days taken to first flower bud appearance (10.61), number of branches (sprays) per plant (10.88), duration of flowering (11.30), length of spray (11.78) and plant height at which first flower bud appearance (16.71). Rest of the characters showed low genetic advance (less than 10 per cent).

The predicted genetic advance expressed as per cent of population mean ranged from 14.11 for days taken to first flower bud appearance to 144.75 for number of branches (sprays) per plant. Average flower weight also exhibited high predicted genetic gain (102.22 per cent). Moderately high (above 40 per cent) predicted genetic advance were observed for spray length and number of flower

Table 6. Phenotypic (r_p) correlation between all pairs of nine characters in spray type chrysanthemum

Character	Plant height at first flower bud appearance	Number of flowers / spray	Number of flowers/ plant	Number of branches/ Plant	Length of spray (cm)	Diameter of flower (cm)	Avg. flower weight (g)	Duration of flowering (days)
Days taken to first flower bud appearance (Day)	0.501**	-0.266	-0.338	0.007	0.332	0.024	0.124	-0.11
Plant height at first flower bud appearance (cm)		-0.408*	-0.402*	0.0693	0.612**	0.139	0.565**	-0.415*
Number of flower / spray			0.507**	-0.342	-0.253	-0.479*	-0.397*	0.748**
Number of flowers/plant				0.191	-0.353	-0.400*	-0.637**	0.475*
Number of branches/plant					0.006	0.061	-0.082	-0.095
Length of spray (cm)						0.298	0.485*	-0.271
Diameter of flower (cm)							0.415*	-0.488**
Av. flower weight (g)								-0.452*

* Significance of $p = 0.05$

** Significant of $p = 0.01$

Table 7. Genotypic (r_p) correlation between all pairs of nine characters in spray type chrysanthemum

Character	Plant height at first flower bud appearance	Number of flowers / spray	Number of flowers/ plant	Number of branches/ plant	Length of spray (cm)	Diameter of flower (cm)	Avg. flower weight (g)	Duration of flowering (days)
Days taken to first flower bud appearance (Day)	0.506**	-0.271	-0.346	0.009	0.335	0.029	0.128	-0.113
Plant height at first flower bud appearance (cm)		-0.409*	-0.407*	0.094	0.613**	0.144	0.569**	-0.420*
Number of flower / spray			0.512**	-0.343	-0.253	-0.493*	-0.400	0.757**
Number of flowers/plant				0.193	-0.357	-0.419*	-0.646**	0.485*
Number of branches/plant					0.005	0.060	-0.084	-0.095
Length of spray (cm)						0.308	0.489**	-0.275
Diameter of flower (cm)							0.430*	-0.500**
Average flower weight (g)								-0.462*

* Significance of $p = 0.05$

** Significant of $p = 0.01$

per spray in order of merit. Rest of the characters showed low predicted genetic gain (more than 25 per cent and less than 40 per cent).

High heritability associated with high predicted genetic gain was observed for number of branches (sprays) per plant followed by average flower weight, number of flower per spray and number of flowers per plant in descending order.

Character Association

Estimates of phenotypic and genotypic correlation coefficients for all pairs of nine characters are presented in Table 6 and 7 respectively. The correlation coefficient ranged from -0.637 to 0.748 and -0.646 to 0.757 between number of flowers per plant and average flower weight and number of flowers per spray and duration of flowering at phenotypic and genotypic level respectively. In general genotypic correlation were of higher magnitude than phenotypic correlation in all the pairs of characters.

Phenotypic correlations

Number of flowers per plant was significantly and positively correlated (0.475) with duration of flowering. It was significantly negatively correlated with average flower weight. Number of flowers per spray was significantly and positively correlated with number of flowers per plant (0.507) and duration of flowering (0.748) but significantly and negatively correlated with diameter of flower (-0.479) and average flower weight (-0.397). Days taken to first flower bud appearance was positively and significantly correlated with plant height at which the first flower bud appeared (0.501) but with having insignificant correlation with rest of the characters having positive value with length of spray (0.333), average flower weight (0.124), flower diameter (0.024) and number of branches (sprays) per plant

(0.007). With the rest of the character it was negatively associated. Plant height at first flower bud appearance was significantly and positively correlated with length of the spray (0.612) and average flower weight (0.565) but it is significantly and negatively associated with number of flowers per spray (-0.408) and duration of flowering (-0.415). With rest of the characters plant height at first flower bud appearance was having insignificant correlation with positive value. Number of branches (sprays) per plant was insignificantly correlated, with most of the characters Positive association was observed with spray length (0.06) and flower diameter (0.061), whereas it was negatively associated with average flower weight (-0.082) and duration of flowering (-0.095). Spray length was significantly and positively associated with average flower weight (0.789). It was positively correlated with flower diameter and negatively associated with duration of flowering having insignificant values (0.298) and (-0.271) respectively. Flower diameter was significantly and positively correlated with average flower weight (0.715), whereas it was significantly and negatively correlated with duration of flowering (-0.788). Average flower weight was negatively and significantly correlated with duration of flowering (-0.452).

Genotypic correlation

The genotypic correlation between all pairs of nine characters showed a parallel trend with phenotypic correlation. Number of flowers per plant was significantly and positively correlated with duration of flowering (0.485), whereas it is significantly and negatively correlated with flower diameter (-0.419) and average flower weight (-0.646). With rest of the character it was insignificantly correlated. Number of flowers per spray was significantly and positively correlated with number of flowers per plant and duration of flowering having values (0.512) and (0.757) respectively, while it was significantly and negatively correlated with

Table 8. Estimates of direct and indirect effects of component characters on yield at the phenotypic level in spray type chrysanthemum cultivars

Character	Days to first flower bud appearance (day)	Plant height at first flower bud appearance	Number of flowers / spray	Number of branches/ plant	Length of spray (cm)	Diameter of flower (cm)	Avg. flower weight (g)	Duration of flowering (days)	Number of flowers/plant
Days taken to first flower bud appearance (Day)	<u>-0.247</u>	0.071	-0.095	0.001	-0.004	-0.001	-0.060	-0.002	-0.338
Plant height at first flower bud appearance (cm)	-0.124	<u>0.142</u>	-0.146	0.024	-0.008	-0.005	-0.277	-0.007	-0.040
Number of flower / spray	0.065	-0.058	<u>0.358</u>	-0.091	0.003	0.020	0.194	0.013	0.507
Number of branches/plant	-0.001	0.013	-0.122	<u>0.266</u>	-0.000	-0.002	0.040	-0.001	0.191
Length of spray (cm)	-0.082	0.087	-0.090	0.001	<u>-0.013</u>	-0.012	-0.237	-0.004	-0.353
Diameter of flower (cm)	-0.005	0.019	-0.171	0.016	-0.004	<u>-0.042</u>	-0.203	-0.008	0.400
Av. flower weight (g)	-0.030	0.080	-0.142	-0.021	-0.006	-0.017	<u>-0.490</u>	-0.008	-0.637
Duration of flowering (day)	-0.027	-0.059	0.268	-0.025	0.003	0.020	0.221	<u>0.018</u>	0.475

Fig. Underline denote direct effects

Residual effect = 0.631

flower diameter (-0.493). With rest of the characters, number of flowers per spray was negatively and insignificantly correlated. Days taken to first flower bud appearance was positively and significantly correlated with plant height at first flower bud appearance (0.506), while it was insignificantly correlated with the rest of the characters. Plant height at which first flower bud appeared was positively and significantly correlated with spray length (0.613) and average flower weight (0.569) while it was significantly and negatively correlated with number of flowers per spray (-0.409), number of flowers per plant (-0.407) and duration of flowering (-0.420). With other characters this trait was positively correlated having insignificant values. Length of the spray was positively correlated with flower diameter (0.308) and average flower weight (0.489) having significant value in later, while it was insignificantly and negatively correlated with the duration of flowering. Diameter of flower was significantly and positively associated with flower weight (0.430) and significantly and negatively correlated with duration of flowering (-0.500). Average flower weight was significantly and negatively correlated with duration of flowering (-0.462).

Path coefficient analysis

In order to determine the cause of effect relationship on flower yield per plant, path coefficient analysis was carried out taking nine quantitative traits in spray type chrysanthemum. The correlation of number of flowers per plant (yield) were partitioned into components of direct and indirect effects, that would reflect on the nature of the association and relative importance of components in determining the flower yield. The phenotypic and genotypic correlation coefficient were used in path analysis and results are presented (phenotypic and genotypic path) in table 8 and 9.

Table 9. Estimates of direct/indirect effect of component characters on flower yield at the genotypic level in spray type chrysanthemum cultivars

Character	Days to first flower bud appearance (day)	Plant height at first flower bud appearance	Number of flowers / spray	Number of branches/ plant	Length of spray (cm)	Diameter of flower (cm)	Avg. flower weight (g)	Duration of flowering (days)	Number of flowers/plant
Days taken to first flower bud appearance (Day)	<u>-0.255</u>	0.074	-0.096	-0.002	-0.003	-0.001	-0.063	-0.001	-0.346
Plant height at first flower bud appearance (cm)	-0.129	<u>0.146</u>	-0.145	0.025	-0.005	-0.006	-0.284	-0.007	-0.407
Number of flower / spray	-0.069	-0.059	<u>0.355</u>	-0.091	0.002	0.023	0.199	0.012	0.512
Number of branches/plant	-0.002	0.013	-0.122	<u>0.266</u>	0.000	-0.002	0.042	-0.001	0.193
Length of spray (cm)	-0.085	0.089	-0.090	0.001	<u>-0.009</u>	-0.014	-0.244	-0.004	-0.357
Diameter of flower (cm)	-0.007	0.021	-0.175	0.016	-0.002	<u>-0.047</u>	-0.214	0.008	-0.419
Av. flower weight (g)	-0.032	0.083	-0.142	-0.022	-0.004	-0.020	<u>-0.499</u>	-0.007	-0.646
Duration of flowering (day)	0.028	-0.061	0.269	-0.025	0.002	0.023	0.230	<u>0.016</u>	0.485

Fig. Underline denote direct effects

Residual effect = 0.631

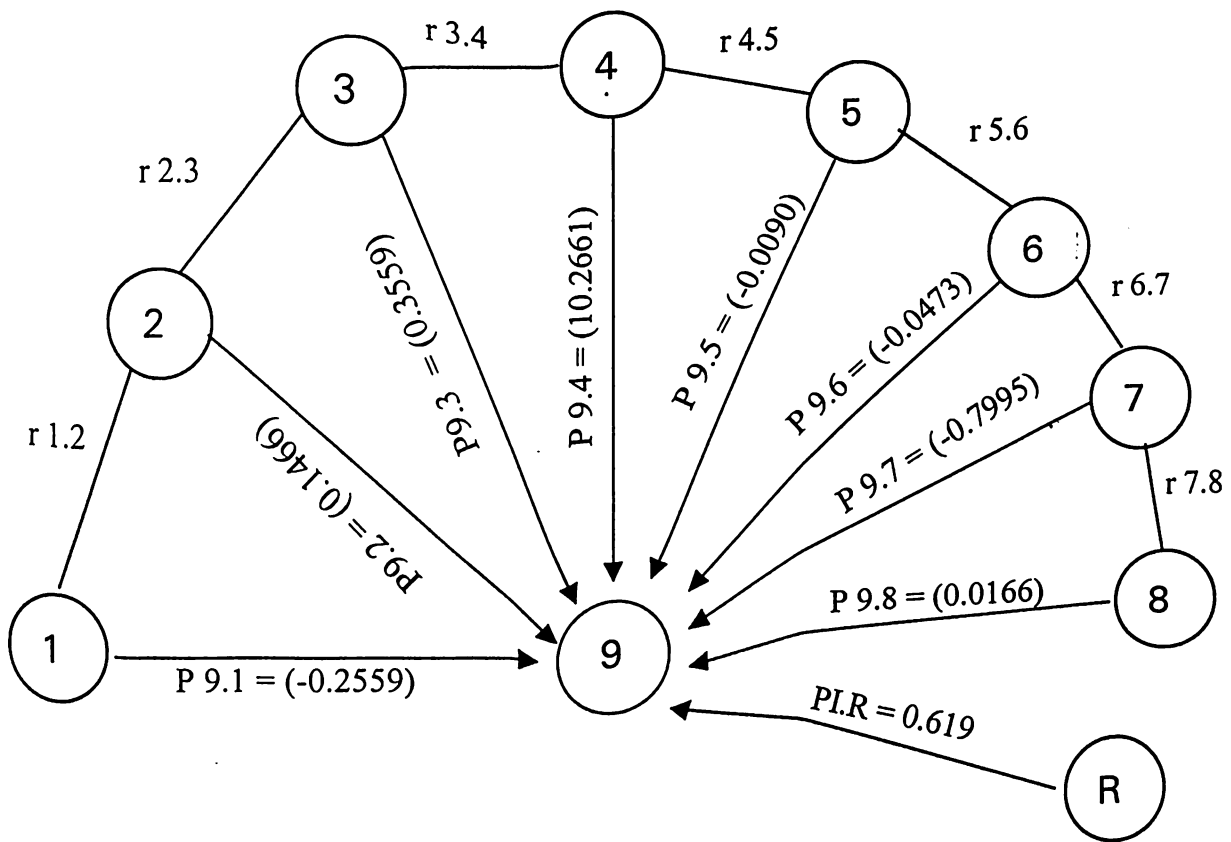


Fig. 3. Path diagram of factors influencing yield in spray type Chrysanthemum.

Characters

1. Days taken to first flower bud appearance (days)
2. Plant height at first flower bud appearance (days)
3. Number of flower(spray)
4. Number of branches per plant
5. Length of spray (cm)
6. Diameter of flower (cm)
7. Average flower weight (g)
8. Duration of flowering (days)
9. Number of flowers per plant.

Phenotypic path analysis :

Phenotypic path analysis table -8 indicted highest positive direct effect of number of flowers per spray (0.358) followed by number of branches (sprays) per plant (0.266) and plant height at which the first flower bud appeared (0.142). Positive direct effect of low magnitude (0.018) was observed for duration of flowering. Rest of the characters showed negative direct effect being highest (-0.490) in average flower weight. In the phenotypic level the positive direct effect were mainly nullified by direct negative effect of average flower weight and days taken to first flower bud appearance.

Number of flowers per spray have the highest indirect positive effect via average flower weight (0.194), days taken to first flower bud appearance (0.065) and duration of flowering (0.013). Similarly number of branches (spray) per plant showed direct positive effect via average flower weight (0.040) and plant height at first flower bud appearance (0.01) indirectly.

Therefore from the phenotypic path, existence of high direct effect of number of flowers per spray was visualized which was also significantly and positively correlated with numbers of flowers per plant suggesting profound influence of this character affecting the flower yield in spray type chrysanthemum.

Genotypic path analysis

The results of path analysis at genotypic level table -9 and figure -3 indicated that number of flowers per spray had the highest positive direct effect (0.355) for flower yield (number of flowers per plant) followed by numbers of branches (sprays) per plant (0.266) and plant height at which first flower bud appeared (0.146). Duration of flowering also indicated positive direct effect of lower magnitude

(0.016) as its effect was cancelled by high indirect effect via number of flowers per spray (0.269) and average flower weight (0.230). High negative direct effects were noticed by average flower weight (-0.499) followed by days to taken first flower bud appearance (-0.285).

The indirect effects of number of flowers per spray via average flower weight, flower diameter and duration of flowering were in positive direction, thus producing high positive direct effect for this character.

Average flower weight exhibited highest negative direct effect (0.499). The indirect effects of average flower weight via number of flowers per spray (-0.142), days taken for first flower bud appearance (-0.03) and flower diameter (-0.02) were in negative direction. The number of branches per plant showed high and positive direct effect (0.266). The positive direct effect were being mainly contributed as the positive indirect effect via average flower weight (0.072) and plant height at first flower bud appearance (0.013). Plant height at which first flower bud appeared showed direct positive effect (0.146) which was mainly through the indirect positive effect via number of branches (sprays) per plant (0.025). Duration of flowering showed lowest positive direct effect (0.016) due to high negative indirect effect via plant height at first flower bud appearance (-0.061) and number of branches (sprays) per plant (-0.025).

Negative direct effect of high magnitude as observed for average flower weight (-0.499) and days taken for first flower bud appearance were mainly due to high negative indirect effect via number of flowers per spray, number of branches (sprays) per plant, length of the spray and flower diameter.

Table 10. Estimates of genetic divergence between 351 pairs in 27 cultivars of spray type of chrysanthemum

Cultivars	CV1 (A-1)	CV2 (A-2)	CV3(A-3)	CV4 (A-7)	CV5 (A-8)	CV6 (A-9)	CV7(A- 10)	CV8 (A-11)	CV9 (A-13)	CV10 (A-14)	CV11 (A-15)	CV12 (A-16)	CV13 (A-17)	CV14 (A-18)	CV15 (A-19)	CV16 (A-20)	CV17 (A-23)	CV18 (A-24)	CV19 (A-25)	CV20 (A-26)	CV21 (A-27)	CV22 (A-28)	CV23 (A-29)	CV24 (A-30)	CV25 (A-31)	CV26 (Ravi kiran)	CV27 (Yellow gold)
CV1(A-1)	-	2317.7	1797.6	4384.0	991.1	1155.0	996.9	3951.2	9009.1	1903.8	3951.2	2544.8	1703.4	1156.7	793.6	2087.8	1863.1	2724.2	1468.2	2362.1	1974.4	628.6	3054.7	1485.1	2232.4	3899.6	3326.1
CV2(A-2)		-	314.4	423.7	392.9	463.7	411.7	932.2	2811.5	221.6	4013.0	318.7	579.9	352.6	1929.7	3399.4	632.6	191.3	1478.8	3182.0	224.8	1521.0	3079.7	568.0	399.3	435.5	335.6
CV3(A-3)			-	953.6	354.4	60.41	411.2	1501.0	3315.3	197.6	4410.7	776.4	719.9	324.3	1528.0	3284.2	1002.0	539.0	1610.4	3187.6	667.1	1570.7	3430.4	1002.0	430.0	965.9	853.3
CV4(A-7)				-	1361.7	1242.4	1422.3	1281.1	2013.0	792.2	4759.3	440.8	1138.3	1131.8	3100.0	4560.1	1259.2	750.4	2259.1	4158.7	864.4	2839.1	4855.6	1532.0	1291.7	396.4	481.5
CV5(A-8)					-	161.7	51.7	1187.2	4403.5	320.4	3495.2	568.6	237.8	55.7	784.7	2274.3	585.6	596.0	798.4	2382.4	476.4	676.5	3312.2	556.3	574.4	1260.7	1046.3
CV6(A-9)						-	149.3	670.3	5165.6	420.9	2403.2	368.0	266.9	81.1	629.4	1541.3	210.3	921.1	359.6	1558.3	382.4	399.1	3376.7	326.6	1111.8	1386.9	1119.3
CV7(A-10)							-	979.4	4746.1	269.9	3194.6	663.1	390.0	92.3	884.8	2098.4	460.6	591.3	800.1	2145.4	386.4	679.6	3335.4	436.5	685.0	1481.4	1258.5
CV8(A-11)								-	5753.1	861.8	1417.0	716.7	1245.1	886.9	1850.1	1625.7	215.9	1336.3	857.2	1191.6	513.3	1262.4	4695.2	443.3	2243.2	2018.9	1741.0
CV9(A-13)									-	3582.4	11890.6	3585.6	4207.8	4496.9	8026.7	11377.4	5616.2	2392.9	7234.1	11094.4	4209.1	7890.8	8139.2	5572.9	2541.6	1668.6	2222.2
CV10(A-14)										-	3522.4	527.3	563.4	219.3	1453.6	2757.1	613.7	344.4	1285.5	2565.7	377.3	1441.8	3901.3	712.3	652.6	1039.0	922.5
CV11(A-15)											-	3210.1	3357.1	2987.8	2418.7	550.3	1558.3	4950.4	1351.3	508.4	3191.4	2075.0	7636.3	2260.7	5973.3	5792.0	5243.2
CV12(A-16)												-	335.2	380.4	1452.8	2686.4	533.0	757.9	891.4	2442.0	409.8	1218.6	4514.1	717.0	1219.3	661.7	524.4
CV13(A-17)													-	185.9	746.5	2249.6	666.1	885.2	658.2	2465.8	784.2	931.9	4207.8	969.7	1054.6	1161.1	1013.7
CV14(A-18)														-	660.4	1942.2	402.9	662.1	615.7	1956.8	399.5	643.1	3578.6	507.1	786.4	1218.8	993.3
CV15(A-19)															-	911.1	1083.4	2559.8	433.2	1236.1	1724.5	440.3	5085.1	1447.1	2536.7	3258.2	2813.0
CV16(A-20)																-	1261.2	4265.4	659.3	228.4	2688.2	1001.1	6789.9	1839.4	4784.6	5349.4	4765.4
CV17(A-23)																	-	1107.4	444.3	1173.7	396.0	670.4	3878.0	243.5	1593.3	1707.4	1411.6
CV18(A-24)																		-	2174.6	4047.4	438.4	2172.3	4810.4	938.0	2519.2	714.0	675.0
CV19(A-25)																			-	833.7	122.4	332.5	4810.4	813.8	2519.2	2572.7	2236.9
CV20(A-26)																				-	2260.5	1076.5	6471.3	1628.4	4822.5	5146.2	4517.4
CV21(A-27)																					-	1064.2	3003.1	216.8	871.1	1095.3	822.4
CV22(A-28)																						-	3270.2	580.4	2187.3	2802.4	2287.9
CV23(A-29)																							-	2527.2	2845.7	3424.3	2860.1
CV24(A-30)																								-	1249.2	1599.9	1227.9
CV25(A-31)																									-	787.2	719.2
CV26 (Ravi kiran)																										-	61.7
CV27 (Yellow gold)																											-

From the path analysis it was visualized that number of flowers per spray, number of branches (sprays) per plant and plant height at which first flower bud appeared showed high direct effect on number of flowers per plant (flower yield). High indirect effect through these component characters were also observed clearly suggesting importance of these component traits contributing to flower yield in spray type chrysanthemum.

D² Analysis

The D² estimate corresponding to 351 possible pairs of combinations among 27 cultivars were computed and presented in table 10. The tabulated values of χ^2 at 5% level of significance was lower than calculated values of D² which clearly indicate that all the D² values were significant. Thus it will be worth while to classify the population into different genetic groups on the basis of aggregate effect of characters studied.

The D² values ranged from 51.7 between CV-5 and CV-7 to 11890.6 between CV-9 and CV-11, indicating that some cultivars are quite close to each other genetically, while others are strongly diversified. The genetic closeness between CV-5 (A-8) and CV-7 (A-10) possessing lowest D² value (51.7) was apparently due to their similarities in characters like days to first flower appearance, plant height at which first flower bud appeared, number of flowers per spray, number of flowers per plant, flower diameter and duration of flowering (Table 4). Maximum divergence as observed between CV-9 (A-13) and CV-11 (A-15) having value 11890.6 due to the wide dissimilarities with respect to characters like days taken to first flower bud appearance, plant length at which first flower bud appeared, number of flowers per spray, spray length, flower diameter and duration of flowering. The D² values were also higher between CV-9 and CV-16 (11377.4) and CV-9 and CV-20 (11094.4), while lower value was observed between CV-5 and CV-14 (55.7) and CV-3 and CV-6 (60.41).

Table No 11. Clustering pattern of 27 spray type chrysanthemum cultivars.

Cluster No.	Number of cultivar included in cluster	Code of the cultivar	Accession number
I	22	CV1	A-1
		CV2	A-2
		CV3	A-3
		CV4	A-7
		CV5	A-8
		CV6	A-9
		CV7	A-10
		CV8	A-11
		CV10	A-14
		CV12	A-16
		CV13	A-17
		CV24	A-18
		CV15	A-19
		CV17	A-23
		CV18	A-24
		CV19	A-25
		CV21	A-27
		CV22	A-28
		CV24	A-30
		CV25	A-31
		CV26	Ravi kiran
		CV27	Yellow gold
II	3	CV11	A-15
		CV16	A-20
		CV20	A-26
III	1	CV9	A-13
IV	1	CV23	A-29

Table 12. Intra (Diagonal) and inter cluster average (D^2) and corresponding D values (intra parenthesis) among four groups of spray type chrysanthemum

Cluster	I	II	III	IV
I	1007.10 (31.73)	2878.20 (53.65)	3665.90 (60.55)	4566.60 (67.58)
II		495.05 (20.71)	6965.90 (83.46)	11454.10 (107.02)
III			0.00 (0.00)	8139.20 (90.21)
49 IV				0.00 (0.00)

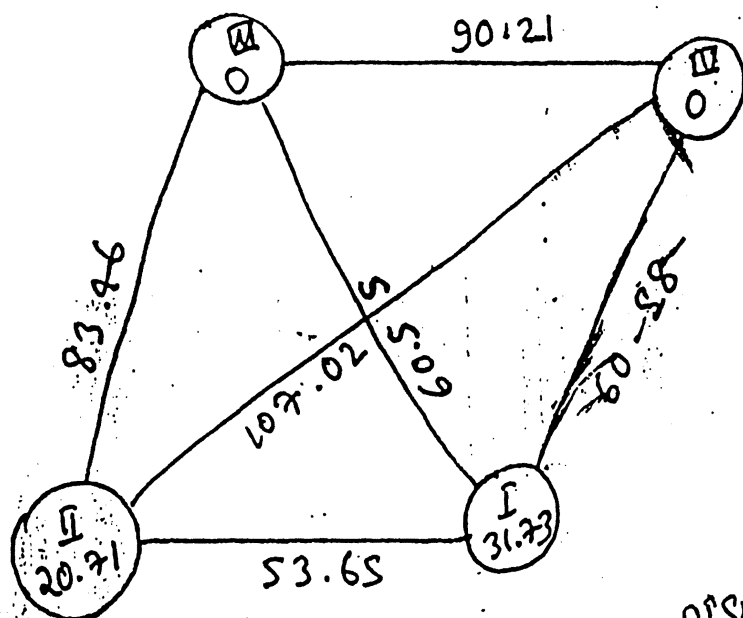


FIGURE 4 RELATIVE DISPOSITION OF CLUSTERS
SHOWING GENETIC DISTANCE (D) BETWEEN AND WITHIN
THEM IN SPRAY TYPE CHRYSANTHEMUM

Table 13. Cluster means for nine characters for groups of spray type chrysanthemum cultivars

Clusters Characters		I(22)@	II (3) @	III (1) @	IV (1) @
50	Days taken first flower bud appearance (Day)	75.22	69.33*	74.00	88.00**
	Plant height at first flower bud appearance (cm)	47.47	33.77*	46.90	67.10**
	Number of flowers/spray	7.94	13.60**	6.60 *	5.60*
	Number of flowers/plant	52.64	66.00	73.80**	29.30*
	Number of branches/plant	7.10	3.86*	30.30**	4.70
	Length of spray (cm)	27.92	23.43	22.90*	41.80**
	Diameter of flower (cm)	6.35	5.40*	5.98	7.85**
	Avg. flower weight (g)	2.53	2.09	1.64*	6.65**
	Duration of flowering (Days)	40.09	51.66**	41.00	38.00*

@ = Number of cultivars in the cluster

* & ** denote minimum and maximum figures respectively.

Clustering pattern following Tocher's method, the 27 cultivars were grouped into four clusters (Table 11). The cluster - I, composed of maximum number of 22 cultivars (CV-1, CV-2, CV-3, CV-4, CV-5, CV-6, CV-7, CV-8, CV-10, CV-12, CV-13, CV-14, CV-15, CV-17, CV-18, CV-19, CV-21, CV-22, CV-24, CV-25, CV-26 and CV-27) while cluster - II consisted of three cultivars (CV-11, CV-16 and CV-20). The remaining two clusters cluster - III and cluster - IV consisted of only one cultivar each. There was a fair correspondence between genetic diversity and morphological diversity in various clusters.

Intra and inter cluster distance

The twenty seven cultivars were grouped into four clusters and the population included in them were given in table 12. The inter and intra cluster distances are given in table -12 and the cluster diagram is presented in figure 4. The highest inter cluster distance was between groups II and IV. ($D = 107.02$), while it was lowest between I and II ($D = 53.65$). The intra cluster distance was maximum in cluster I ($D = 31.73$) and minimum in cluster II ($D = 20.71$). This range is fairly reasonable in the context of multidimensional space occupied by cluster each representing one diagram. Thus it is apparent that the entries included in cluster II were having close resemblance to character expression as compared to those entries in cluster I. The diagrammatic representation of cluster IV (Figure.4) revealed that cluster IV was most diversified from the rest three clusters. Further cluster III were also more diversified from cluster I and II. Cluster I and II were closest to each other.

Characteristics features of the clusters

Cluster means of nine quantitative characters in spray type chrysanthemum is presented in table 13. Cluster-I consisting of maximum number of 22 cultivars exhibited moderate to high mean values for most of the characters studied.

Table 14. Relative contribution of different characters of genetic divergence in spray type chrysanthemum

Characters	Average D ²	Percentage of total D ²	Rank total
Days taken to first flower bud appearance (Day)	35.97	1.88	2288
Plant height at first flower bud appearance (cm)	643.18	33.77	962 I
Number of flower / spray	311.45	16.35	1405 II
Number of flowers/plant	157.87	8.29	1528
Number of stem branches/plant	299.96	15.75	1661
Length of spray (cm)	254.16	13.34	1508 III
Diameter of flower (cm)	38.33	2.01	2399
Average flower weight (g)	98.48	5.17	1981
Duration of flowering (day)	64.89	3.40	2063
Total	1904.29	100.00	15795

Cluster-II consisting of three cultivars showed highest figures with respect to duration of flowering (51.66 days) and number of flowers per spray (13.60), while lowest value was recorded for days taken to first flower bud appearance (69.3 days), plant height at first flower bud appearance (33.77 cm), number of sprays per plant (3.86) and flower diameter (5.40 cm) among all the clusters compared.

Cluster-III which is monogenic, consisting CV-9 (A-13) exhibited highest values for number of flowers per plant, number of sprays per plant while it showed lowest value for spray length (22.9 cm) and average flower weight (1.64 g) among different clusters compared for various quantitative characters.

Cluster IV consisting of single cultivar, CV-23 (A-29) exhibited highest figure for days taken to first flower bud appearance (88.00 days), plant height at first flower bud appearance (67.10 cm), spray length (41.80 cm), flower diameter (7.85 cm) and average flower weight (6.65 g), while lowest figure were observed for number of flowers per spray (5.60), number of flower per plant (29.30) and duration of flowering (38.0 days) among different clusters.

Relative contribution of characters to divergence :

Analysis of relative contribution of characters to divergence is presented in table - 14. Rank total over the paired combinations were also used as an additional criterion for assessing the relative contribution of characters. On the basis of average D^2 values for individual character over 351 paired combinations it was noticed that plant height at which first flower bud appeared contributed the maximum (33.7%) followed by number of flowers per spray (16.35%), number of branches (sprays) per plant (15.75%), and spray length (13.34%). Rank totals indicated the

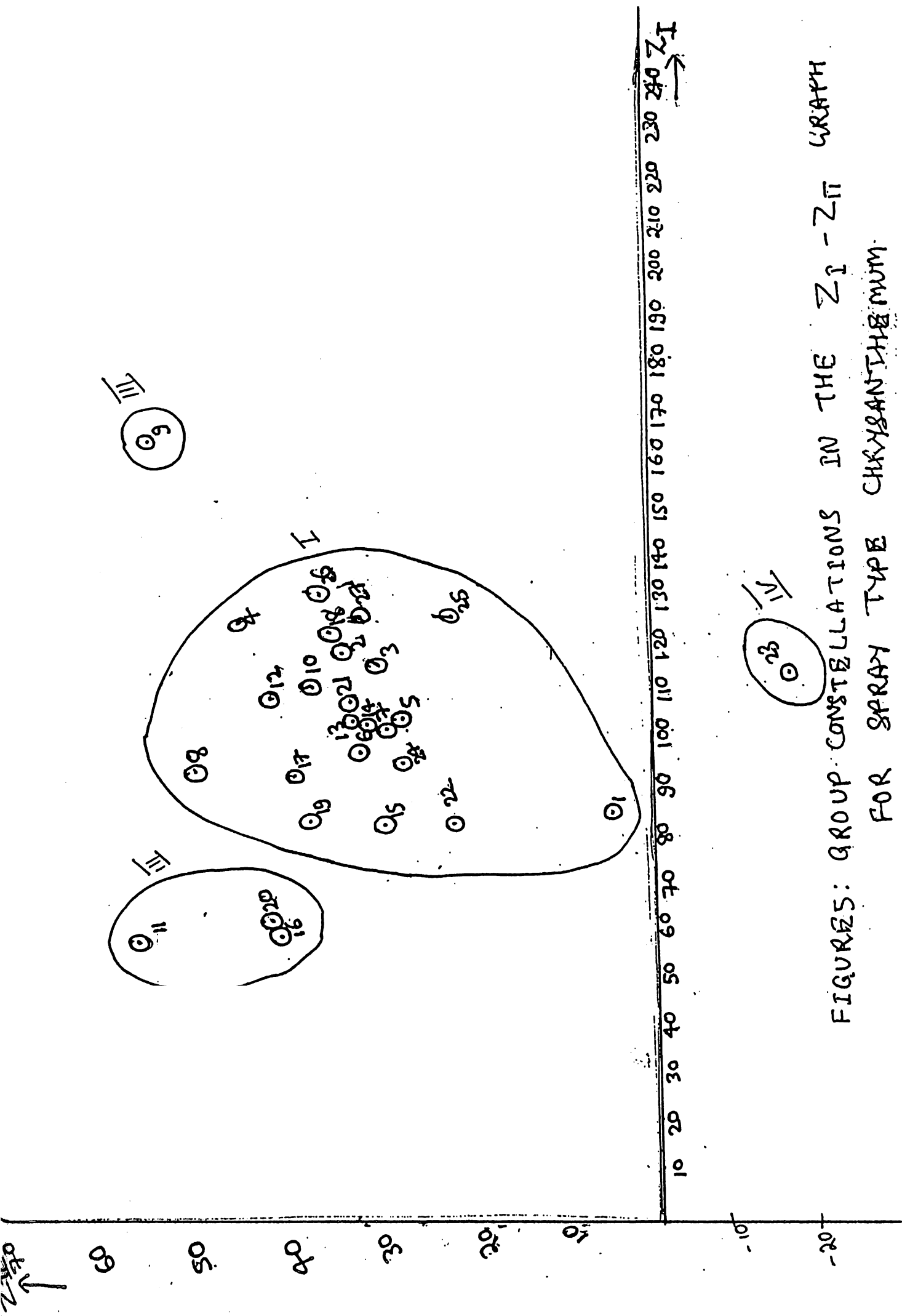
Table 15. Estimate of coefficient of the first two canonical vectors (Z_1 , Z_2) for nine characters in 27 spray type chrysanthemum cultivars .

Characters	Coefficients of first canonical two vectors	
	Z_1	Z_2
Days taken to first flower bud appearance (Day)	0.9380	0.0004
Plant height at first flower bud appearance (cm)	.7186	0.2192
Number of flower / spray	-0.3730	0.4021
Number of flowers/plant	-0.3375	-0.0525
Number of branches/plant	-0.3051	-0.5354
Length of spray (cm)	0.1762	0.6789
Diameter of flower (cm)	0.0375	0.1964
Average flower weight (g)	0.2423	0.0279
Duration of flowering (day)	-0.1936	-0.0223

Variations accounted for in percent $\lambda_1 = 59.20$, $\lambda_2 = 20.20$

Table 16. Mean value of first two canonical varieties (Z_I & Z_{II}) in spray type chrysanthemum cultivars.

Cultivars	Z_I	Z_{II}
Cv-1 (A-1)	83.381	4.399
Cv-2 (A-2)	116.457	33.592
Cv-3 (A-3)	113.786	29.559
Cv-4 (A-7)	124.349	49.495
Cv-5 (A-8)	103.875	27.088
Cv-6 (A-9)	96.656	31.545
Cv-7 (A-10)	101.490	27.677
Cv-8 (A-11)	92.718	46.917
Cv-9 (A-13)	165.054	50.428
Cv-10 (A-14)	109.438	36.183
Cv-11 (A-15)	58.353	50.897
Cv-12(A-16)	108.466	41.892
Cv-13 (A-17)	103.813	37.403
Cv-14 (A-18)	101.585	31.694
Cv-15 (A-19)	80.221	29.190
Cv-16 (A-20)	59.205	39.697
Cv-17 (A-23)	92.716	38.840
Cv-18 (A-24)	122.141	34.319
Cv-19 (A-25)	81.678	37.834
Cv-20 (A-26)	61.378	41.273
Cv-21 (A-27)	106.580	32.108
Cv-22 (A-28)	81.830	21.532
Cv-23 (A-29)	112.642	-16.214
Cv-24 (A-30)	96.664	27.166
Cv-25 (A-31)	125.166	21.746
Cv-26 (Ravikiran)	130.792	35.506
Cv-27 (Yellow Gold)	125.885	31.792



contribution of characters in the following order plant height at first flower bud appearance > number of flowers per spray > spray length > number of flowers per plant > number of sprays per plant.

In both the analysis (average D^2 and rank total) the contribution of plant height at which first flower bud appeared was found to be highest followed by number of flowers per spray towards genetic divergence. In case of number of sprays per plant and spray length discrepancy arose slightly for contribution towards divergence in both the analysis.

Canonical analysis

From the canonical analysis it was found that the two canonical roots ($Z_1 = 59.20\%$ and $Z_2 = 20.20\%$) accounted for 79.40% of total variability thus qualifying for graphic representation. The values of first two canonical vectors Z_1 and Z_2 (Table 15) were used as coordinates in plotting a two dimensional dispersion matrix of genotypic constellation as in figure 5. The grouping obtained by D^2 analysis by following the Tocher's method was super imposed on the constellation made by canonical analysis. On examination it was found that the scattered points of $Z_1 - Z_2$ graph were in good agreement with the magnitude of divergence measured by D^2 statistics, thus very well corroborating the clustering by Tocher's method.

The relative importance of the characters contributing towards divergence as reflected in the coefficient of the two canonical vectors is presented in table 15. From Z_1 contributing highest total variability, it was observed that the important characters responsible for genetic divergence were days taken to first flower bud appearance (0.938) followed by plant height at flower bud appearance (0.718), number of flowers per spray (-0.373), number of flowers per plant (-0.337) and

number of branches (spray) per plant (-0.305) ignoring the signs. In the second axis of differentiation (Z_2) length of the spray (0.678) followed by number of spray per plant (-1.538), number of flowers per spray (0.402) and plant height at flower bud appearance (0.219) contributed towards divergence in order ignoring the signs. Thus, the results of component analysis further corroborated the character contribution of plant height at first flower bud appearance, number of flowers per spray, number of sprays per plant has significant contribution towards divergence assessed by D^2 and rank total.

CHAPTER - V

DISCUSSION

DISCUSSION

The improvement programme in any crop requires a thorough knowledge about the nature and extent of genetic variability present in the cultivar collection is important in planning for successful breeding programmes involving selection and hybridization. The progress of selection in a population depends on the nature and magnitude of variability. Besides information and degree of transformation of different character, their interrelationship and direct and indirect effects on yield is of immense importance.

Considering the importance of the above factors for improvement in chrysanthemum, the present investigation on genetic variability of spray type chrysanthemum was conducted during, rabi season of the year 2002-2003 at the horticultural research station, Orissa University of Agriculture and Technology, Bhubaneswar to select the superior genotypes, to improve the productivity and their adaptability under Orissa conditions. Experimental results of the above studies have been discussed as follows :

Pattern of variation in plant attributes

The nature and magnitude of variability for nine different quantitative characters in spray type chrysanthemum can be clearly visualized on examination of ANOVA (Table 3). The values indicate highly significant differences for all the characters under study, thereby suggesting existence of great amount of variation among the cultivars. The large amount of variation observed in the collection of cultivars revealed that considerable improvement can be made in this crop. Similar to the findings of present investigation, wide variation for the character studied was also reported by Ponnuswamy *et al.* (1985) and Deka and Paswah (2002) in chrysonthemum.

It may be generalized from the statistics of range and general means value of the characters that there is a great deal of variability for each character under study. Further, the magnitude and wide spectrum of variation observed in each character indicate a better possibility of selecting cultivars for specific goals.

The cultivars CV-20 (A-26), CV-22 (A-28) and CV -23 (A-29) having moderate growth habit, moderate spray length, higher number of sprays per plant, high number of flower per spray and high duration of flowering, were the high yielders. Considering the various direct attributes of flower yield, such as spray length, number of sprays per plant, number of flowers per spray and size of flowers contributed maximum. These characters instead of being competitive produced compatible association, which may be explained due to their further association, with other yield attributing characters such as days taken to first flower bud appearance, plant height of which first flower bud appeared and average flower weight.

Two aspects are most important for understanding the breeding principle i.e. (i) selection can not create variability but act only that which is already existence and (ii) selection can act effectively on heritable differences (Allard, 1960). Thus the first and foremost necessity for selection is to ascertain whether genetic variability for this character is present at significant level or not. Further the phenotypic mean values are the basis of comparison may fall far short of requirement and may even be misleading as the phenotypic effects, sometimes influenced by the environment, thereby may not necessarily represent the genotypic values. The estimates of phenotypic and genotypic coefficients of variation (Burton and De vane, 1953) afford a sound basis to assess the variability component, so as to know the relative amount of heritable and non heritable variation for each of these characters.

In comparing the phenotypic coefficient with genotypic coefficient of variation, it may be seen that the former values are greater than the later, in respect of all the characters studied. This is in agreement with the findings of Gaikwad and Chaudhury (1985-86), Sirohi and Behera, (2000) and Raghava et al. (1992) in chrysanthemum. Janaki Ram and Rao, (1992), Patnaik and Mohanty (2002) in marigold, Rao and Negi (1992) in China aster reported the similar trend in agreement with the present findings. Further the difference between the P.C.V. and G.C.V. with regards to values for various characters are quite less suggesting a negligible influence of environment on such characters (Chaudhury *et al.*, 1973).

The phenotypic coefficient of variation exhibiting parallelism effect with the genotypic coefficient of variation suggested that phenotypes truly represent to the genotype. Further, the existence of large genetic variability in a character, indicates that its major portion attributed through its additive components and additive interaction instead of dominance and epistatic components and usually favours an effective selection. In the present investigation, presence of high genotypic coefficient of variation for number of sprays per plant, average flower weight, number of flowers per spray and number of flowers per plant may be considered for selection. Raghava *et al.* (1992) reported highest G.C.V. for number and weight of flowers in chrysanthemum similar to present finding. The rest of the characters showing low genotypic coefficient of variation offers little scope for selection.

The heritability is of interest to a plant breeder primarily as a measure of selection for a particular character in various types of progeny and as an index of transmissibility. Poehlman and Borthakur (1972) have the view that the characters not influenced by environment will have high heritability. Randhawa *et al.* (1975) was of opinion that higher the heritability value of a character, less will be the

environmental influence, thereby indicating an opportunity for selecting a genetically good individual. In the present study depiction of high heritability value were obtained in most of the characters, suggesting that these characters might be highly heritable and less influenced by the environment. It may be worth while for selecting the cultivars on the basis of such character. The results obtained here are in agreement with the findings of the Gaikwad and Chaudhury (1985-86) for number of flowers per plant, weight of flowers, duration of flowering, Raghava *et al.* (1992) for flower weight and number of flowers per plant, Sirohi and Behera (2000) for sprays per plant and flower yield, Deka and Paswah (2002) for most of the characters in chrysanthemum, Janaki Ram and Rao, (1992-93) and Bard *et al.* (1993) in marigold; Rao and Negi (1992) and Janaki Ram and Rao (1995) in China aster.

It is true that information concerning heritability of quantitative characters, genetic and environmental variance when considered together will be useful for improving the efficiency of selection (Weber and Moorthy (1952). Considering the heritability estimates with genotypic coefficient of variation it is noticed that high values are obtained for both the parameters, in case of number of sprays per plant, number of flowers per spray, average weight of flowers. So selection maybe quite effective based on these characters. High genotypic coefficient of variation and heritability has been reported for number and weight of flowers in chrysanthemum by Raghava *et al.* (1992) which is in accordance with the present findings. On the contrary, deviations noticed from the findings of the previous workers, in the present investigation is due to difference in genetic stock and environmental variation.

Inspite of importance of heritability estimates in relation, the scope is limited due to its broadsense estimation as well as they are prone to change with

the change in environment and material. Further, the heritability by itself may not be solely an useful index of genetic potentiality of the characters. Escuro *et al* (1963) stated that genetic advance indicate the potentiality of selection at a particular level of selection intensity. Thus, heritability estimate along with genetic advance are more valuable than heritability alone in predicting the response to selection (Johnson *et al.*, 1955; Robinson, 1963). High heritability does not necessarily mean that the character will show high genetic advance. In case of existence of high association, additive genes comes into prominence because no genetic advance is due to non-additive genes. The selection based on a character showing high genetic gain may be desirable, in case of directional selection, when the main aim of the selection is to change the mean value of the character to have better standards. In the present study the results revealed , high heritability coupled with high genetic advance for characters such as number of branches (Sprays) per plant, average flower weight, number of flowers per spray and number of flowers per plant may be ascribed due to effect of additive genes (Panse and Sukhatme, 1954; Liang and Walter, 1968) and become favourable for selection. Our findings are in conformity with the works of Gaikwad and Chaudhury (1985-86), Raghava *et al.* (1992) Sirohi and Behera (2000); Deka and Paswah (2002) in chrysanthemum and Janaki Ram and Rao (1992-93) is marigold, Rao and Negi, (1992) and Janaki Ram and Rao (1995) in china aster. Whatever deviation has been observed in present investigation from that of the previous workers may be ascribed due to difference in genetic material tested under different environmental conditions.

Considering the three important genetic parameters such as genotypic coefficient of variation, heritability estimate and the predicted genetic gain at a glance together character such as number of sprays per plant, average flower weight, number of flowers per spray and number of flowers per plant showed the highest level to the above three parameters suggesting additive gene action for expression

of these characters. Thus selection based on these characters will be effective in selection of spray type chrysanthemum.

In spray type chrysanthemum, flower yield is most economic character, which is ultimate effect of interaction quantitative character that are susceptible to environmental variation. Thus, selection based on flower yield alone, may not be sound preposition for effective selection. Among various component characters which directly and positively correlate with flower yield often act as an useful indicator in selection. Thus, in planning successful and effective breeding programme the sound knowledge such association among flower yield and its component traits is of prime importance. Robinson (1966) was of opinion that correlation studies are useful in choosing superior genotypes from their phenotypic expression. Thus, after obtaining information and variation in genetic parameter, in the present set of cultivars, attempts have been made to study the interrelationship of these quantitative traits, through correlation studies, both at phenotypic and genotypic level.

An examination of results (Table 6 and 7) indicated that the genotypic correction coefficient were of higher magnitude than phenotypic correlation coefficient in all pairs of characters, suggesting that there was a strong inherent association between the various characters studied. Further, as the genotypic correlation coefficient was parallel to the phenotypic correlation coefficient, it maybe assumed that there were not much influence of environment in determining the association of these yield attributing character with flower yield and probably is due to strong genetical make up of the plant.

According to Wigan and Mather (1992) and Sprague, (1966), a strong positive association of characters with yield may be attributed to linkage and

pleiotropy. In the present investigation , significant positive correlation both at genotypic and phenotypic level were observed for numbers of flowers per plant with number of flowers per spray and duration of flowering. These associations suggest that selection for these component traits will be effective in improving flower yield in spray type chrysanthemum. Results of similar trend were reported by Sirohi *et al.* (1999) Deka and Paswah (2002) in chrysanthemum.

Days to first flower bud appearance was significant positively correlated with plant height at which first flower bud appeared. Plant height at which first flower bud appeared was significantly and negatively correlated with number of flowers per spray, they positively and insignificantly related with spray length and average flower weight suggesting that dwarf spray type chrysanthemums are having longer spray with heavier flowers and less number of flowers per spray. Number of flower per spray was significantly and positively correlated with number of flowers per plant and duration of flowering but significantly and negative correlated with flower size (diameter of flower), suggesting that cultivars having long flowering duration will have more number of flower per spray with smaller size flowers. Spray length and diameter of flower was significantly and positively correlated with average flower weight but negatively correlated with duration of flowering. Average flower weight was negatively correlated with duration of flowering. The findings suggest that spray type chrysanthemums producing bigger size flowers will have higher flower weight and in cultivars having greater duration of flowering will produce flowers having less weight.

From the above discussion on correlation it can be concluded that numbers of sprays per plant, number of flowers per spray, duration of flowering and number of flowers per plant are important components contributing towards flowers yield

in spray type chrysanthemum. Simultaneous improvement on these traits will be helpful in improving flower yield in chrysanthemum.

Direct and indirect effects of characters on flower yield (Path coefficient analysis)

Correlation coefficient which measures the association between any two characters may not give the true comprehensive picture of rather complex situation. The association between any two characters which are measured do not exist by themselves alone, but are part of complicated pathway in which other traits are also interwoven. The indirect association become complex and important due to number of variables in the correlation study. Further, the mutual relationship among different characters which maybe positive or negative may makes the situation complicated. In such situation, path coefficient analysis devised by Wright (1921) provides better knowledge as it relates direct and indirect causes of association and permits a critical observation of these specific forces acting to produce a given correlation and measure the relative importance of causal factors. The cause and effect relationship with value of correlation and path coefficients for the components of flower yield (number of flowers per plant) at genotypic level is presented in Figure.3 and their direct and indirect effects at genotypic level (Table 9).

Genotypic path coefficient analysis revealed that number of flowers per spray had maximum direct effect followed by number of branches per plant and plant height at which first flower bud approved. Further, average flower weight and days taken to first flower bud appearance, had maximum negative direct effect on yield (number of flowers per plant). Other characters showed low positive or negative effect as there effects are cancelled by their respective indirect effect either positive or negative. via; number of flowers per spray, number of sprays per

plant and plant height at which first flower bud appeared. The findings are in agreement with the previous reports of Gaikwad and Chaudhury (1985-86) in *Chrysanthemum*.

The indirect effect of number of flowers per spray, via average flower weight, flower diameter and duration of flowering were in positive direction. Thus, producing high positive direct effect with character. Sirohi *et al.* (1999) also reported similar to the present finding. Negative direct effects of high magnitude as observed for average flower weight and days taken for first flower bud appearance were mainly due to high negative indirect effect via number of flowers per spray, number of branches (sprays) per plant, length of the spray and flower diameter.

On the basis of foregoing discussion it may be inferred that number of flowers per spray, number of branches (sprays) per plant and plant height at which first flower bud appeared, had highest direct effect on flower yield (number of flowers per plant). High indirect effect through these traits were also observed. This clearly indicates that above three characters are important yield contributing components in spray type chrysanthemum.

Genetic divergence

The multi variate analysis based on Mahalanobis D^2 statistics is being employed as a powerful tool for measuring genetic divergence among the test genotypes (Peter and Rai, 1976; Singh and Singh, 1976; Nair and Gupta, 1976). Further published reports of Murthy and Arunachalam (1966); Anand and Moorthy (1968); Ramanujam *et al.* (1974) have emphasized the merits of D^2 statistics and canonical analysis for genetic grouping of germplasm. In the present investigation the grouping by two multivariate techniques (Table 12 and figure.5).

Being a numerical estimate, the multivariate technique has an added advantage over other criteria of permitting precise comparison among all possible pair of population in any given group. Since the estimates are obtained from study of potential parents themselves, the required information is available before deciding parent for future recombination breeding, thus, can be used with advantage.

It is established phenomenon that hybrids derived from divergent parents are found to be promising probably because of complementary interaction of divergent genes in the parents. In the present study CV-23 (A-29) and CV-9 (A-13) are the two most genetically divergent cultivar and hybridization involving these two could be result oriented. Some promising result may also be obtained between CV-23 (A-29) and CV-11 (A-15), CV-9 (A-13) and CV-11 (A-15), CV-9 (A-13) and CV-16 (A-20), CV-23 (A-29) and CV-8 (A-11). The genotypes are expected to produce heterotic hybrid and wide variation in the segregating generation favouring selection of superior progeny. Present findings are in agreement with the findings of Gondhali *et al.* (1997); Sirohi and Behera (2002).

It was observed that the important characters responsible for genetic divergence were days taken to first flower bud appearance, plant height at which flower bud appeared, number of flowers per spray, number of branches (spray) per plant, contributed predominantly to divergence in spray type chrysanthemum. Therefore, selection of parent differing in these traits may be useful for utilization of parents for heterosis breeding programme in spray type chrysanthemum.

CHAPTER - VI

**SUMMARY AND
CONCLUSION**

SUMMARY AND CONCLUSION

This study was carried out in spray type chrysanthemum (*Chrysanthemum morifolium* Ramat) to assess the comparative performance, genetic variability, character association through direct and indirect effect and genetic divergence by Mahalonobis's D^2 statistics to formulate a suitable breeding programme for improvement in the crop. 27 cultivars collected from Regional Plant Resource Centre, Bhubaneswar (which are originally collected from different places by the centre) were subjected to evaluation. Observations were recorded on nine quantitative characters viz. days to first flower bud appearance, plant height at first flower bud appearance, number of flowers per spray, number of flowers per plant, number of branches (sprays) per plant, length of spray, diameter of flower and duration of flowering. The results of this investigation are summarised below.

1. Analysis of variance indicated that 27 cultivars of spray type chrysanthemum under investigation differed significantly among themselves for all the nine quantitative characters studied. Further, wide range of variation was noticed for all the characters as revealed through statistics of mean, range and coefficient of variation suggesting considerable improvement can be made in this crop.
2. Closeness of phenotypic coefficient of variations and genotypic coefficient of variations for all the characters indicated that the phenotype represent true to the genotype. A wide range of genetic diversity was recorded for number of branches (sprays) per plant, whereas number of flowers per spray, number of flowers per plant and spray length showed moderate genetic variability as visualised from phenotypic and genotypic coefficient of variation. The rest of the characters exhibited lower value for these characters.

3. High heritability estimates were obtained for all the characters under study suggesting that these characters might be highly heritable, less influenced by environment. It may be worth while selecting the cultivars on the basis of such character.
4. Highest genetic advance in percentage of mean was observed for number of flowers per plant followed by plant height at which first flower bud appeared, length of spray, duration of flowering and number of branches (sprays) per plant. Rest of the characters showed very low value for this parameter.
5. Considering the three genetic parameters such as genotypic coefficient of variation, heritability estimate and predicted genetic gain all together at a glance phenotypic selection will be effective for number of branches (sprays) per plant, average flower weight, number of flowers per sprays due to additive gene effect and less influence of environment.
6. The genotypic correlation coefficient were of higher magnitude than phenotypic correlation coefficient in all pairs of characters studied indicating a strong inherent association between various characters. Further, genotypic correlation coefficient showing parallelism to the phenotypic correlation coefficient suggested that flower yield in chrysanthemum is due to strong genetical make up of the cultivars. Number of flowers per plant was significantly and positively correlated with number of flowers per spray and duration of flowering. Days to first flower bud appearance was significantly and positively correlated with plant height at which first flower bud appeared. Number of flowers per spray was significantly and positively correlated with number of flowers per plant and duration of flowering. Spray length and diameter of flower was significantly and positively correlated with flower weight but negatively correlated with duration of

flowering. So in general numbers of sprays per plant, number of flowers per plant, duration of flowering and the average flower weight are important components contributing towards flower yield (number of flowers per plant) in spray type chrysanthemum. Simultaneous improved on this trait will be helpful in improving flower yield in spray type chrysanthemum.

7. Path coefficient analysis of various quantitative characters revealed that number of flowers per spray, number of branches (sprays) per plant and plant height at which first flower bud appeared had maximum direct effect on flower yield (number of flowers per plant) in spray type chrysanthemum. High indirect effect through these traits were observed.

8. By using D^2 statistics and Tocher's method, the 27 cultivars were grouped in four clusters. The cluster III and IV are monogenic, cluster II consisted three cultivars while cluster I consisted maximum number of (22) cultivars.

9. The cluster II and IV are most divergent cluster. The characters like days taken to first flower bud appearance, plant height at which first flower bud appeared, number of flowers per spray, number of branches (spray) per plant contributed more towards the genetic divergence in spray type chrysanthemum. The grouping by Tocher's method showed large correspondence with the di-dimensional dispersion of the cultivars by the first two canonical variates.

10. The cultivar CV-23 (A-29) and CV-9 (A-13) are the two most genetically divergent cultivars.

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Conclusion

From the results of present study it may be concluded that besides direct selection from flower yield (number of flowers per plant) indirect selection through number of flowers per spray, number of branches (sprays) per plant and the plant height at which first flower bud appeared should be considered for further improvement of flower yield in spray type chrysanthemum. Other characters like average flower weight, duration of flowering and number of flowers per plant have also considerable influence on flower yield in spray type chrysanthemum. The cultivars such as CV-23 (A-26), CV-22 (A-28) and CV-23 (A-29) are important in order of merit.

The most genetical divergent cultivars were CV-23 (A-29) and CV-9 (A-13). Other promising divergent cultivars were CV-23 (A-29) and CV-11 (A-15), CV-9 (A-13) and CV-11 (A-15); CV-9 (A-13) and CV-16 (A-20), CV-23 (A-29) and CV-8 (A-11). It is expected that the hybridization between these divergent cultivars may produce highly heterotic hybrids and thus, would produce wide spectrum variation in the segregating generation.

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