

GENETICAL STUDIES AND CHARACTERIZATION IN MARIGOLD

By

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2001A25D

**Dissertation submitted to the Chaudhary Charan Singh
Haryana Agricultural University, Hisar for the partial
fulfilment of the requirement for the degree of :**

DOCTOR OF PHILOSOPHY IN HORTICULTURE



**COLLEGE OF AGRICULTURE
CCS HARYANA AGRICULTURAL UNIVERSITY
HISAR-125 004 (HARYANA)**

2004



Dedicated to :

My Parents

*Who gave me hope
and let me grow.*

My Teachers

*Who gave me cause
to try.*

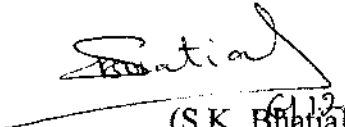
My Friends

*Who gave me hope
to complete it.*

CERTIFICATE I

This is to certify that this dissertation entitled, “**Genetical studies and characterization in marigold**”, submitted for the degree of **Doctor of Philosophy**, in the subject of **Horticulture** of the CCS Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Reena Mathew** under my guidance and supervision and that no part of this dissertation has been submitted for any other degree.

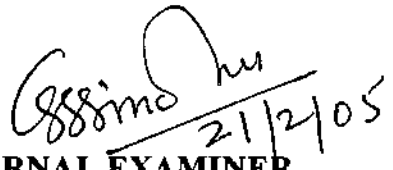
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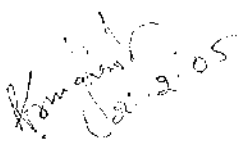

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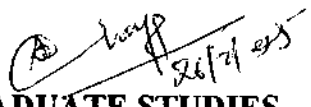
CERTIFICATE II

This is to certify that this thesis entitled, "**Genetical studies and characterization in marigold**", submitted by **Reena Mathew** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfilment of the requirement for the degree of **Doctor of Philosophy**, in the subject of **Horticulture** has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.


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ACKNOWLEDGEMENTS

It's a moment when I feel delighted with heartfelt thanks to all who were instrumental in completion of this crucial milestone of my academic journey. With profound sense of gratitude I express my sincere thanks to my major advisor Dr. S.K. Bhatia, Senior Scientist, Department of Horticulture, CCS HAU, Hisar for his benevolent guidance, constructive advice and utmost cooperation throughout the experiment work.

I am equally beholden to my co-major advisor Dr. B.S. Beniwal, Assistant Scientist, Department of Horticulture for his zealous contribution, mettlesome attitude, constant help and necessary support. I also wish to convey my heartiest appreciation for help extended by Dr. D.P. Deswal, Sr. Scientist, Department of Seed Technology for his unstinted learned counsel, sagacious guidance and constant encouragement throughout the course of investigation.

With utmost reverence, I bestow my gratitude to Dr. B.S. Dahiya, Director of Research CCS HAU for his ungrudging and generous help in finalizing this manuscript.

It gives me immense pleasure to offer my sincere bouquet of gratitude to the members of my advisory committee Dr. A.L. Patel, Professor, Dept. of Plant Physiology, Dr. R.K. Narwal, Professor, Dept. of Agronomy. I am greatly thankful to Dr. M.S. Joon, Professor and Head, Department of Horticulture for providing necessary facilities to carry out this research work.

As the spirit of team work is inevitable for any task to reach its destination I cannot refrain to accord my humble thanks to Dr. Virender Mor and Dr. Amit Jain. The instrument of acknowledgement should have remained unturned if I do not express my heartfelt thanks to my seniors and friends Shiji, Sheena, Susan didi, Kiran didi, Reena didi, Pankaj, Preeti, Neelam, Loveleen, Renuka and Sujata for their willing help whenever required.

I also owe my thanks to Duni Chandji and other staff members of Department of Horticulture.

My indebtedness is beyond expression for Mr. P.T. Mathew & family and Mr. M.G. Cherian & family for their love, cooperation and parental care during my stay at Hisar.

Words of thanks would be insufficient to express gratitude towards my parents Mrs. and Mr. K.P. Mathew, elder brother Thomas (Reji) and relatives for their endless blessings, love and support.

Still there are anonymous well-wishers and friends who directly or indirectly rendered me their valuable help to complete this academic endeavour.

Last but not the least, I thank the Lord God Almighty whose grace alone strengthened, who stood behind me as a strong pillar and provided me patience to complete the task.

*Hisar
Dec., 6th, 2004*

Reena Mathew
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Chapter - I

Introduction

Floriculture is the fast emerging enterprise in the world trade particularly with the globalization of trade in agriculture. The production of flowers and their trade once considered as gardeners profession is now fastly becoming an important commercial venture. The flowers and gardens have been very closely associated with Indian culture since ancient times. The flowers are symbolic of beauty, love and utility from time immemorial. No religious ceremony and social gathering is complete in this country without flowers. Today floriculture has emerged as a lucrative profession with higher potential for returns than most of the field and horticultural crops.

Floriculture as an industry has tremendous potential in India. The different types of climatic conditions prevailing in our country provide the possibility of growing almost all the major cut flower crops of the world.

The global floricultural trade is estimated as \$100 billion. Presently more than ten countries are engaged in floriculture trade. The developed

countries account for more than 90 per cent of the total world trade in floriculture. The economy of some countries like Netherlands, Israel and Columbia is dependant on the floriculture industry. India's share in the global floriculture market is around \$60 million (Anon., 2002).

The estimated area under flower cultivation in India in the year 2001-02 was 106,000 ha. In 1998-99 the export in floriculture was of the order of 96 crores which increased to 123 crores during 2000-01 and then to Rs.190.63 crores in 2001-02. Out of 190.63 crores, 47 crores are from the export of cut flowers. The leading flower growing states in India are Tamil Nadu (1,56,700 MT), Karnataka (1,38,776 MT), Andhra Pradesh (1,21,336 MT), West Bengal (31,276 MT), Maharashtra (30,376 MT) and Uttar Pradesh (Singh, 1997). Tamil Nadu stands first in area and production of flower with 18,718 hectares and annual turn over of Rs. 45 crores (Dhanavel, 2003). The Haryana state has 3250 ha area with production of 40500 tonnes of loose flower and 76.0 million of cut flower (Anon., 2002).

Marigold (*Tagetes* species Linn) a member of family *Asteraceae* is one of the most important flower grown commercially. It is native of Central and South America especially Mexico. From Mexico it spread to different parts of the world. It was first introduced into Spain early in the 16th century while in India it was introduced by Portuguese. It is found growing wild in South Africa, Australia, India, Uruguay, Kenya, Brazil, France, etc.

Botanically the marigold inflorescence is capitulum with two types of flowers, the peripheral ray floret and the central disc floret. The disc flowers in the centre are perfect having both anthers and pistil. The surrounding ray flowers with strap like petals are pistillate only and are male sterile.

Marigold requires mild climate (14.5 – 28.6°C) for luxuriant growth and flowering. The seed germinates in all seasons except in extreme cold and hot conditions. In plain areas of the country seeds sown in May-June, Aug.-Oct. or Jan.-Feb. while during March-April in the hills. Marigold is easy to cultivate as it shows wide adaptability to different soils and climatic conditions.

In India, important species found are *Tagetes erecta*, *Tagetes patula*, *Tagetes minuta* and *Tagetes signata* while the two main species of marigold are African (*T. erecta*, 2n=24) and French (*T. patula*, 2n=48). The African marigold is tall and French is dwarf and bushy.

Both the species of marigold are suitable for garden display and grown commercially for use as cut flowers and loose flowers. It is highly suitable as a bedding plant in an herbaceous border and is also ideal for newly planted shrubberies to provide colour and to fill the space. It has attracted the attention of flower growers due to its wide spectrum of attractive colours, shape, size and good keeping quality. In India, it is one of the commonly grown flower and extensively used on religious and social functions.

The plant is very useful as both the leaves and the flowers are equally important from medicinal point of view. The paste and extracts from plant are used as cure for boils, ear ache, eye disease and ulcers. The oil is reported to have bronchodilatory, tranquilizing and anti-inflammatory properties (Chandhoke and Ghatak, 1969). Flower petals are important source of carotenoid pigment, which is used in poultry feed to intensify the colour of the yolk (Kaul *et al.*, 1997). The essential oil present in different species of *Tagetes* can find a use in the perfume industry. The

oil has pronounced odour and acts as repellent to flies, ants and mosquitoes. Marigold has been found highly effective in keeping the population of nematode under control (Gupta *et al.*, 2001).

Looking at the importance and commercial potential, there is urgent need to conserve and characterize the available variability, its evaluation and to identify potential genotypes, which would result in further improvement, and to develop cultivar for specific uses. Thus, effective breeding programme is possible by proper evaluation of the extent of genetic variation available for yield attributes, their heritability, genetic advance as well as the interrelationship between various yield and their contributing characters.

The genetic improvement of any crop depends on the genetic variability present in the available germplasm. This also necessitates the partitioning of the observed phenotypic variability into heritable and non-heritable components of variation. Hence, the present study was undertaken for the systematic and scientific improvement of marigold with the following objectives:

1. To estimate genetic variability, heritability and genetic advance in different genotypes of French and African marigold.
2. To estimate the correlation and path coefficient among yield and its components.
3. To characterize the genotypes based on field and laboratory parameters.
4. To develop schematic diagram/flow chart of genotypes based on field and laboratory parameters.

Chapter - II

Review of Literature

Genetic variation is a prerequisite for any crop improvement. An insight into the magnitude of variability present in a crop species is of utmost importance as it provides the basis for effective selection. Hence literature pertaining to genetic parameters viz. variability, heritability, genetic advance, correlation and path coefficient are reviewed as under. An attempt has been made to include all available literature on marigold, however, there is very limited work carried out on marigold on this aspect which has relevance to the type of study undertaken. Therefore work particularly of *Asteraceae* family and other flower crops has also been included.

2.1 PLANT CHARACTER

2.1.1 Genetic variability

Germplasm evaluation and variability study in eight genotypes of African marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*) species was carried out by Barad (1992). It was observed that genotypes of both the species showed significant difference for characters like plant

height, plant spread and number of branches. Janakiram and Rao (1995) carried out experiment on eight lines of African marigold planted in two different spacing, viz. 30 cm x 40 cm (close spacing) and 30 x 50 cm (wider spacing). The phenotypic coefficient of variation was found to be high in closer spacing than in wider spacing for the characters like plant height, number of main branches, number of lateral branches per plant while plant spread exhibited high phenotypic coefficient of variation in wider spacing.

The lowest coefficient of variation in plant height, 60 days after transplanting was estimated in twelve cultivars each of African and French marigold by Singh and Sen (2000) while Niharika and Mohanty (2002) studied 13 diverse genotypes of marigold in Bhubaneswar during Rabi season and observed high coefficient of variation both at genotypic and phenotypic levels for plant height. Genetic and phenotypic variability was studied by Verma *et al.* (2002) in 33 marigold germplasms. The differences among genotypes were significant for characters like number of branches and plant canopy. The phenotypic coefficient of variation was higher than genotypic coefficient of variation for all characters. The plant canopy showed high PCV and GCV (52.25% and 51.42%).

A performance trial was conducted by Hemlata *et al.* (1992) in Dharwad during *kharif* season, the study comprised 15 genotypes of *chrysanthemum morifolium*. The analysis of variance revealed significant variation between varieties for characters like plant height, number of branches, number of leaves and plant spread.

The experiment on two indigenous and ten exotic cultivars of chrysanthemum revealed significant differences for characters like plant height and number of leaves by Pal and George (2002). Negi *et al.* (1983) conducted variability studies in 19 varieties of china aster and indicated highly significant varietal difference for plant height, number of branches and plant spread.

Performance trial on fifteen dahlia genotypes for nine component traits were tested. The study revealed high coefficient of variation for branches per plant and leaf area (Sashikala *et al.*, 1995). Dhane *et al.* (2002) studied 25 dahlia cultivars and observed that secondary shoot number after pinching had the highest values of genotypic and phenotypic coefficient of variation.

Parameter related to growth and yield including fourteen traits in gerbera were studied by Anuradha *et al.* (1999) which revealed a wide range of variability for these characters. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters including plant height and number of leaves.

Lakshmanaiah (1980) conducted trial on 144 diverse germplasm collections of sunflower and revealed highly significant varietal differences for all the character including plant height and number of leaves. The genotypic coefficient of variation was high for leaf number. Similar results were also observed by Chaudhary and Anand (1987) in 30 exotic collections of sunflower and also by Moghali *et al.* (1994) in 196 germplasm accessions of sunflower.

Analysis of variance revealed significant genotypic difference for all the thirteen characters studied by Patil *et al.* (1996) in 225 genotypes of sunflower. Plant height was less affected by environment showing close correspondence between GCV and PCV. Similarly, plant height showed high range of variation in fifty-one inbreds and three control genotypes of sunflower (Sujatha, 2002).

High phenotypic and genotypic coefficient of variation (21.06% and 20.58%) for plant height was observed by Rao *et al.* (2003) in 82 genotypes of sunflower. A wide range of variability for plant height and low for leaf number was observed in 30 cultivars of gladiolus by Lal *et al.* (1985). The value for genetic coefficient of variation was the lowest (125.53%) for leaf number among all the characters studied. Bichoo *et al.* (2002) indicated wide range of phenotypic variability among 41 cultivars of gladiolus.

2.1.2 Heritability and genetic advance

High heritability for plant spread and plant height was observed on evaluation of eight genotypes of African and French marigold by Barad (1992) while genetic advance in percentage of mean was moderate for plant height and number of branches.

A trial on eleven lines of African marigold by Janakiram and Rao (1994) found high heritability for plant height (92.20%) and plant spread (88.81%). Moderate values of genetic advance as percentage of mean was shown in plant height and plant spread while low values was exhibited by number of main branches (18.60%). Another experiment on eight varieties

of African marigold by Janakiram and Rao (1995) revealed high heritability for characters like plant height, plant spread, number of main branches per plant and number of lateral branches per plant. High genetic advance was also observed in all characters except number of main branches per plant.

The study on the estimates of 12 cultivars each of African and French marigold by Singh and Sen (2000) revealed high heritability for plant spread (99.5%), plant height (95.9%) and number of branches (94.6%). High genetic advance as per cent of mean was observed in plant spread (77.8%) and low in number of branches (34.9%). It was stated that improvement in characters with high heritability and high genetic advance could be brought by practising phenotypic selection.

Niharika and Mohanty (2002) in an investigation on 13 genotypes of marigold revealed high values of heritability for plant height (80.8%), plant spread (74.6%) and leaf area (71.1%) while low values were observed for number of branches (26.5%). Another study on 33 marigold germplasms revealed high heritability (96.8%) and high genetic advance (104.23%) for plant canopy (Verma *et al.*, 2002).

An experiment conducted on fifteen genotypes of chrysanthemum revealed estimates of broad sense heritability and genetic advance for number of branches, number of leaves and leaf area due to additive gene effects (Hemlata *et al.*, 1992) whereas, Raghava *et al.* (1992) studied 17 genetically diverse stock of small flowered chrysanthemum and found high estimates of heritability (90.24%) and low (39.59%) of genetic advance

for plant height indicating variation in this character to be non-additive in nature.

High heritability was observed by Manjunath Rao (1982) for plant height and plant spread in china aster whereas high heritability associated with high genetic advance recorded for branches per plant and leaf area in 15 genotypes of dahlia by Sashikala *et al.* (1995). Mishra *et al.* (1997) studied 20 varieties of dahlia and found high heritability with high genetic advance for plant height showing additive gene effects whereas, number of leaflets per flower and petiole length exhibited high heritability and low genetic advance showing non-additive gene effect. Dhane *et al.* (2002) in 25 dahlia cultivars, found high heritability for all characters except secondary shoot number after pinching.

In 48 accessions of gerbera, Kannan and Ramdas (1990) observed high heritability (97.3%) and low genetic advance as per cent of mean (29.6%) for number of leaves per plant. Anuradha and Gowda (1999) revealed low heritability and genetic advance as per cent mean for number of leaves (29.1% and 27.6%) in gerbera.

In 73 varieties of sunflower, Srivastava and Mishra (1976) observed high heritability for girth of stem (75.7%) and comparatively low heritability for plant height (66.4%) while estimates of genetic advance was low for plant height (23.7%) and stem girth (24.2%) while Lakshmanaiah (1980) observed high broad sense estimate for plant height. Muhammed *et al.* (1992) in a trial on 14 sunflower hybrids observed high heritability and low genetic advance estimates for plant height which reflected dominant and epistatic nature of inheritance.

Moghali *et al.* (1994) studied 196 accessions of sunflower during *kharif* and observed moderate heritability (67.01%) and genetic advance (30.6%) for plant height while moderate values of heritability (50.9%) and low genetic advance (19.3%) for stem girth. Patil *et al.* (1996) in 225 sunflower genotypes revealed high heritability and genetic advance for plant height. Similar estimates were also observed by Sujatha (2002) in 51 inbreds and three control genotypes of sunflower and by Rao *et al.* (2003) in 82 genotype of sunflower.

Moderate estimates of heritability (63.6%) and low genetic advance as per cent of mean (9.53%) was observed by Negi *et al.* (1982) in 39 varieties of gladiolus. Lal *et al.* (1985) in 30 cultivars of gladiolus observed high heritability for plant height (79.1%) and leaf number (83.1%) while moderate values of genetic advance. Mishra *et al.* (1988) studied 60 varieties of gladiolus observed high heritability for number of shoots per plant (68.2%), and low estimates of heritability for number of leaves per shoot (37.81%) and plant height (4.38%). Genetic advance as per cent of mean was lowest for number of leaves per shoot (0.47%). Pant and Lal (1991) reported high heritability for plant height (94.2%), number of leaves (84.5%) and leaf size (87.1%) while lowest genetic advance (1.89%) for number of leaves in 40 varieties of gladiolus. Deshraj *et al.* (1998) estimated high broad sense heritability for plant height in gladiolus whereas Bichoo *et al.* (2002) observed high heritability combined with genetic advance for plant height indicating the apparent contribution of additive gene effects in the expression of traits.

2.1.3 Correlation and path coefficient analysis

Correlation analysis for 13 characters related to growth and flowering in 10 diverse genotypes of African and French marigold was studied by Bhanu Pratap *et al.* (1999). The study revealed that plant height had a positive and significant correlation at the genotypic and phenotypic levels with spread of plant and number of lateral branches. The spread of plant was also positively and significantly correlated with size and yield of flower per plant. In French marigold, plant height showed significant correlation with number of lateral branches and days to bud visibility while the spread of plant showed a positive correlation with number of flowers per plant.

In seventeen small flowered chrysanthemum, Raghava *et al.* (1992) reported that plant height had positive and significant association with flower size, flowers per plant and flower yield per plant. This showed that taller plants will produce more and larger number of flowers.

Sirohi and Behera (1999) studied character association of 12 quantitative traits in 57 genotypes of chrysanthemum. Plant spread and number of branches per plant showed positive and significant phenotypic correlation with yield and indicated that selection based on these characters would be effective for chrysanthemum improvement. Path coefficient analysis in gerbera revealed that leaf area and girth of stalk had high direct effect. The significant positive correlation of leaf area with flower number per clump could thus be attributed to the high positive direct effect of the character. The non-significant association of plant height and number of

leaves with number of flowers per clump was largely due to their negative direct effect on the dependant variable (Mahanta *et al.*, 1988).

Correlation studies were conducted by Lal *et al.* (1985) in gladiolus for six quantitative characters. Plant height was directly correlated with spike length while leaf number showed a positive correlation with spike weight. Mishra and Saini (1990) studied 20 characters in sixty varieties of gladioli and revealed that plant height was positively correlated with number of leaves per shoot and durability of spike. Number of leaves per shoot had positively significant correlation with days to first flowering and number of florets per spike. Anuradha *et al.* (2002) studied path coefficient analysis in 25 gladiolus genotypes and found that plant height showed highest direct effect on spike length while leaf area, number of leaves showed a negative direct effect on spike length.

Wahi and Bhattacharjee (1986) conducted experiment on 45 genotypes of gladiolus and studied 11 characters, number of shoots, number of leaves and length of leaves showed positive significant correlation with number of bulbs at both genotypic and phenotypic levels. The estimates of genotypic levels were much higher in magnitude than corresponding estimates at phenotypic level. It indicated that there was strong inherent association between the various characters studied the phenotypic expression of the correlation was lessened under the influence of environment.

2.2 FLORAL CHARACTER

2.2.1 Genetic variability

High to moderate genetic coefficient of variation was seen by Barad (1992) in eight genotypes of African and French marigold. Janakiram and Rao (1994) observed highly significant varietal differences and a wide range of phenotypic variability for number of flowers per plant, flower weight and total flower yield per plant in eleven varieties of African marigold.

Niharika and Mohanty (2002) studied 13 genotypes of African marigold and revealed relatively higher phenotypic and genotypic coefficients of variation for characters like yield of flowers per plant (52.0% and 44.0%), number of flowers per plant (39.76% and 29.76%) and weight of individual flower (29.77% and 27.27%). The phenotypic coefficients of variation were higher than genotypic coefficients of variation which indicated greater interaction of genotype and environment.

Singh and Sen (2002) studied 12 cultivars each of French and African marigold. Highest coefficient of variation was obtained for flower yield and lowest for duration of flowering in French marigold while in African marigold it was high for flower dry weight.

The experiment conducted on variability of studies in 10 African marigold genotypes by Sreekala *et al.* (2002) revealed higher phenotypic and genotypic variance for all characters except flower diameter. Verma (2002) conducted variability studies in 33 marigold germplasms. The difference among genotypes was significant for characters like flower

diameter and fresh flower weight. The flower weight obtained high PCV and GCV (56.38% and 51.42%).

High phenotypic and genotypic coefficients of variation for number of flowers per plant were observed by Chaugule (1985) in chrysanthemum; whereas, Ponnuswamy *et al.* (1985) exhibited high degree of both genotypic and phenotypic variation for days to buttoning and duration of flowering in 27 chrysanthemum varieties. Singh (1987) revealed highly significant clonal variation for flower yield ranging from 151.1 – 259.0 g per plant in 500 clones of *Chrysanthemum cinerariaefolium*.

Raghava *et al.* (1992) evaluated 17 genetically diverse stalk of small flowered chrysanthemum. The genotypic coefficient of variation was high for flower yield per plant (76.69%), number of flower per plant (71.67%) and flower size (24.56%). Similarly, Sirohi and Behera (1999) in 57 genotypes of chrysanthemum observed high GCV and PCV estimates for flower per plant and disc diameter. While, Pal *et al.* (2002) observed significant variation for days to flower bud emergence and flower weight in chrysanthemum. Negi *et al.* (1983) in china aster observed high genotypic coefficient of variation for flower weight and stalk length.

Sashikala *et al.* (1995) in 15 dahlia varieties found high genotypic coefficient of variation for total number of flower per plant. Srinivas and Gowda (1995) exhibited high phenotypic and genotypic coefficients of variability for number of disc florets and diameter of disc florets. Mousamee *et al.* (2001) found high coefficient of variation both at genotypic and phenotypic levels for flower number in 18 dahlia genotypes.

While Syamal *et al.* (2002) in 11 dahlia cultivars observed high to moderate genotypic coefficient of variation for number of flowers, flower diameter and days to flowering. GCV was highest for flower diameter (26.6%) while estimate for PCV was highest for flower duration.

Dhane *et al.* (2002) studied 25 dahlia cultivars and found highest variability for disc floret number per flower. Flower fresh weight exhibited high values of genotypic and phenotypic coefficient of variation. The GCV was the highest for flower fresh weight and the lowest for days to bud appearance.

Mahanta *et al.* (1998) revealed high genetic variability for days to full flowering in ten cultivars of gerbera. Aswath *et al.* (1998) conducted experiment on 23 varieties of gerbera and observed high genotypic and phenotypic coefficient of variability for floret diameter and flower number per plant while days to flower opening and days to wilt showed low PCV and GCV estimates.

An experiment conducted on thirty exotic collections of sunflower over three seasons by Chaudhary and Anand (1987) revealed maximum range of variation in head diameter in spring while days to heading, days to flowering exhibited highest range of variation in Rabi.

The coefficient of variation was lowest (11.88%) for floret size in a study carried out by Negi *et al.* (1982) in gladiolus. Number of spikes also exhibited lowest values of genotypic as well as phenotypic variances. Lal *et al.* (1985) expressed a wide range of variability for characters like days to flower, spike length and spike weight in 30 cultivars of gladiolus.

Anuradha and Gowda (1990) studied 25 genotypes and revealed narrow differences between phenotypic and genotypic coefficient of variation for floret length, days to spike emergence and spike length indicating less environmental interference on the expression of these traits. Similarly, in 40 varieties of gladiolus, Pant and Lal (1991) found wide range of variation for days to flower, spike length and spike weight. Soorianathasundaram *et al.* (1991) studied 15 cultivars of gladiolus which exhibited highest phenotypic and genotypic coefficient of variation for spike weight. The GCV/PCV ratio indicates that environmental influence is less conspicuous for spike weight.

2.2.2 Heritability and genetic advance

High broad sense heritability was observed by Janakiram and Rao (1994) in 11 varieties of African marigold for number of flowers per plant (64.62%) and flower weight (70.04%) while medium values of heritability was observed in flower yield per plant (48.55%) and flower size (70.04%). Genetic advance was high for number of flowers per plant (61.64%) while for other characters moderate values of genetic advance was exhibited. During the year 1995, they studied eight lines of African marigold and reported high heritability for flower weight at close spacing while heritability values were higher for flower size, number of flowers per plant and total yield per plant in case of wider spacing. The values of genetic advance were higher for all the characters at closer spacing when compared to wider spacing except for number of flowers per plant.

Singh and Sen (2000) studied 12 cultivars each of African and French marigold and observed high heritability and high genetic advance for flower yield per plot in both species indicating heritability and genetic advance to be useful criteria for selecting the best individual. Sreekala *et al.* (2002) in 10 genotypes of African marigold revealed high value of heritability for flower diameter (92.20%) indicating selection can be good method for genetic improvement of this character. A high value of heritability in broad sense was also recorded for flower yield per plant. Verma *et al.* (2002), in an experiment on 33 marigold germplasms obtained high heritability (91.18%) and genetic advance as per cent mean (105.92%) for flower weight.

Chaugule *et al.* (1985) found high heritability for number of flower per plant and fresh weight of flowers per plant in chrysanthemum. Singh *et al.* (1987) studied 37 clones of *Chrysanthemum cinerariaefolium* and revealed high broad sense heritability for flower per plant, flower diameter and 100 flower weight while in 500 selected clones of *Chrysanthemum cinerariaefolium*, high heritability coupled with high expected genetic advance was reported by Singh *et al.* (1987) in number of flowers per plant indicating most of the variation in this character to be additive in nature.

The study conducted on 15 genotypes of chrysanthemum by Hemlata *et al.* (1992) revealed high heritability and genetic advance for number of flowers per plant disc diameter, number of petals per flower and dry weight of flower. High heritability was also exhibited by yield per plant, flower

diameter, days to bud initiation, days to first flower opening, days to 50% flowering and duration of flowering.

Raghava *et al.* (1992) evaluated 17 genetically diverse stalk of small flowered chrysanthemum and reported high heritability and genetic advance as per cent of mean for number of flowers per plant (96.37% and 208.96%) and flower yield per plant (98.27% and 284.56%) while high heritability (97.89%) and low genetic advance (3.17%) was observed for flower size. Sirohi and Behera (1999) in 57 genotypes of chrysanthemum, recorded high heritability with high genetic advance for disc diameter, number of petals per flower and flower yield.

In china aster, Manjunath Rao (1982) reported high heritability values for flower yield and duration of flowering. Sashikala *et al.* (1995) in 15 dahlia varieties, observed high heritability associated with high genetic advance in total flowers per plant, whereas, Srinivas *et al.* (1995) reported high heritability and genetic advance for number of disc floret and number of ray florets in dahlia. Syamal *et al.* (2002) studied 12 dahlia cultivars and revealed high heritability and genetic advance for number of flowers, flower diameter and days to flower.

Dhane *et al.* (2002) studied 25 dahlia cultivars and found high heritability for flower diameter, days to freshness of flower from bud break to complete withering, flower fresh weight and flower number per plant. The genetic advance was highest for flower fresh weight. Therefore, characters like flower fresh weight, flower diameter, days to freshness of flower from bud break to complete withering and flower number per plant offer a greater scope for improvement through selection from the

population as these attributes exhibited high to moderate genetic advance with high heritability and variability estimates.

In 48 accessions of gerbera, Kannan *et al.* (1990) found highest estimates of heritability and genetic advance for flowers per plant. Similarly, high heritability combined with high genetic advance was observed (Anuradha *et al.*, 1999) for weight of ray florets (94.4%), disc diameter and fresh weight of inflorescence in gerbera.

Srivastava and Mishra (1976) studied 76 varieties of sunflower and revealed low estimate of heritability for diameter of head yield per plant exhibited high heritability (97.89%) and high genetic advance (40.45%). Period of flowering had high heritability (81.80%) and moderate genetic advance (13.72%). High heritability with high genetic advance was said due to additive gene effects. Lakshmanaiah (1980) observed high broad sense heritability for days to flowering in 196 diverse germplasm of sunflower. Similarly, heritability was high for days to heading, days to flowering over three seasons, *kharif*, *rabi* and *spring* in 30 exotic collections of sunflower, as studied by Chaudhary and Anand (1987).

Alavarez *et al.* (1992) evaluated 37 open pollinated population of sunflower and observed the highest broad sense heritability for days to maturity. Hemlata *et al.* (1992) in 15 genotypes of sunflower reported high estimates of broad sense heritability and genetic advance for number of flowers per plant due to additive gene effects. Muhammed *et al.* (1992) in sunflower observed high heritability and low genetic advance estimate for capitulum diameter which reflects dominant and epistatic nature of inheritance.

High estimates of heritability and genetic advance was recorded for flower yield per plant and number of flowers per plant in crossandra by Lalitha and Kumar (1993) while Reddy *et al.* (2002) reported high heritability and genetic advance for spikes per plant, flower yield per plant and days to first flowering. Wahi and Bhattacharjee (1986) studied 45 genotypes of *Hippeastrum hybridum* and observed high heritabilities in flower diameter and duration of flowering.

Soorianathasundram *et al.* (1991) in seventy five cultivars of gladiolus, observed high heritability and high genetic advance for number of florets per spike (87.90% and 35.47%) and floret size (79.51% and 34.70%) showing the involvement of additive gene action governing these traits. The study on 39 varieties of gladiolus by Negi *et al.* (1982) reveals high heritability estimates for floret size, number of floret per spike and days taken to flower. Floret size and days taken to flower exhibited low genetic advance as per cent of mean. Lal *et al.* (1985) in 30 cultivars of gladiolus, recorded high heritability coupled with high genetic advance for number of floret per spike, spike length and spike weight. High heritability with low genetic advance was exhibited in days to flowering showing non additive gene effects.

Anuradha and Gowda (1990) studied twenty five genotypes of gladiolus and reported high heritability and genetic advance for days to spike emergence, days to opening of first flower and number of florets per spike while low heritability and moderate genetic advance as per cent of mean in durability of spike similar results were observed by Pant and

Lal (1991) in 40 varieties of gladiolus. Singh *et al.* (2000) studied 11 genotypes of gladiolus and showed high heritability for number of spikes per plant coupled with high genetic advance as per cent of mean indicating influence of gene action.

2.2.3 Correlation and path analysis

Correlation studies in 11 varieties of African marigold by Janakiram and Rao (1994) revealed that days to flower had a positive significant correlation with plant height, plant spread, number of main branches, number of flowers per plant, flower weight and total flower yield per plant, number of flowers per plant had a significant and positive association with plant spread. The positive significant association between characters was attributed due to a pleotropic effect of a single gene or to the location of two independent genes controlling these traits in close proximity. The same workers during 1995 took eight varieties of African marigold and found that except the flower size and flower weight all other characters were found to be positively correlated with yield under closer spacing.

Shanmugam (1972) studied interrelationship between yield and certain growth and floral attributes in two chrysanthemum varieties. It was observed that number of days taken for first flowering was negatively correlated with yield indicating that less the number of days taken for first flowering, the greater the yield. Yield was positively correlated with duration of flowering indicating the value of sustained optimal growth and productively over a longer time.

Correlation and path analysis studies in 37 clones of chrysanthemum by Singh *et al.* (1987) revealed that flower yield was significantly correlated with diameter of flower and number of flowers per plant. Path coefficient analysis showed that flowers per plant, flower diameter and 100 flower weight had a positive direct effect on pyrethrin content while flower yield had a negative direct effect on pyrethrin content.

Singh *et al.* (1987) worked on 500 selected clones of chrysanthemum and reported that number of flowers per plant was positively and significantly correlated with flower yield. Raghava *et al.* (1992) evaluated 17 genetically diverse stalk of small flowered chrysanthemum and revealed positive and significant correlation of days to flower with flower per plant and flower yield per plant. Association between flower size and flower yield was positive and significant. However, size had negative and significant correlation with flowers per plant. Number of flowers per plant was positively correlated with flower yield per plant. Genotypic correlation coefficients were higher than phenotypic correlation coefficients. This indicates that there was inherent association between various characters studied. Path analysis studies revealed that flowers per plant and days to flower showed strong direct positive effect on flower yield per plant. Flower size had weak direct effect on flower yield.

Sirohi and Behera (1999) studied character association and path coefficient in 57 genotypes of chrysanthemum. Positive and significant phenotypic association of yield was observed with number of flowers per plant. The number of flowers had a high effect on yield through number of branches per plant.

Character association studies conducted by Sashikala (1995) on dahlia revealed a significant positive association of yield with duration of flowering and internodal length and negative association with days to flowering. Mahanta *et al.* (1998) conducted path coefficient analysis studies in gerbera and found that leaf area and days to flower bud opening had high direct effect. The significant positive correlation of leaf area with flower number per clump could thus be attributed to the high positive direct effect of the character. Path analysis studies in crossandra by Lalitha and Kumar (1993) indicated that the number of flowers per plant and spikes per plant were major factors contributing to flower yield. Correlation studies conducted by Wahi and Bhattacharjee (1986) in 45 genotypes of *Hippeastrum hybridum* revealed that the number of flowers per stalk showed a significant correlation with number of shoots and leaves.

Mishra and Saini (1990) found positively significant correlation of number of floret per spike with number of florets remain open, durability of spike and number of capsules per shoot in gladiolus. Path coefficient analysis indicated direct effect of number of florets per spike with number of florets remain open, number of capsules per shoot and durability of whole spike. A poor or negative direct effect was seen with number of seeds per capsule, spike length, number of shoots per corm, days to flowering and flower diameter. De and Mishra (1994) conducted correlation and path coefficient studies on 25 varieties of gladioli. Positively significant correlation of number of floret per spike were obtained with plant height, rachis length and number of capsules per spike

while seed number exhibited negatively significant association. Path coefficient analysis revealed poor positive direct effect for days to initial flowering and last floret opening on number of florets per spike. Anuradha and Gowda (2002) studied 25 gladiolus genotypes and found that floret length and number of florets per spike showed direct effect on spike length while leaf area, number of leaves, floret character showed negative direct effect towards spike length.

Studies on 37 jasmine genotypes were conducted by More (1980) and reported positive and significant correlation coefficients for total yield with number of flowers and total flower bud length. Weight of 100 flowers had significant positive association with bud diameter. Path analysis showed that number of flowers had maximum direct effect on yield followed by flower bud length.

Srivastava and Devaiah (1988) studied 16 genotypes of *Jasminum auriculatum*. The weight of 100 flowers was significantly associated with flower diameter, petal width, petal length, floral bud length and width. They further showed that 100 bud weight and flower diameter had a marked direct effect on yield in a positive direction. All the other characters affected yield indirectly through these two characters indicating that bud weight and flower diameter could be taken as selection index.

Path analysis studies in pin and thrum types of open pollinated progeny in *Jasminum auriculatum* carried out by Karmakar and Srivastava (1986) revealed that the number of flowers per plant had the maximum direct effect on flower yield in pin type plants, whereas in thrum type

ones the 100 bud weight and number of flowers per plant both determined the yield. Dadlani *et al.* (1996) studied 45 collections of jasmine and found significant correlation of yield with flower number and bud length. Path and coefficient analysis showed high direct effects for flower number, bud length and bud diameter on yield.

Kannan *et al.* (1998) studied correlation and path analysis in tuberose and found that diameter of flower, flowers per spike exhibited significant positive association with yield. It indicated that flower per spike and flower longevity had direct effect on flower yield while diameter of flower had negative direct effects.

2.3 SEED CHARACTERS

2.3.1 Genetic variability

Variability for five seed characters was studied by Kennedy (1997) in twenty diverse genotypes of marigold. It was observed that phenotypic coefficient of variations (PCV) were higher than genotypic coefficient of variations (GCV). Maximum GCV (23.95%) and PCV (23.96%) was shown by vigour index followed by 1000 seed weight, germination percentage and seedling dry weight. Low estimate of coefficient of variability in seedling length (9.39%) indicated less scope for genetic improvement.

In a study on 73 varieties of sunflower, by Srivastava and Mishra (1976) 100 seed weight ranged from 2.77-13.74 g with significant difference among varieties. The phenotypic and genotypic variance was lowest for 100 seed weight (3.94 and 3.69). However, the genotypic coefficient of variation as observed by Lakshmanaiah (1980) in 144 germplasms of sunflower was high for seed yield.

Chaudhary and Anand (1987) reported maximum range of variation for fresh and dry matter weight of seedling, seedling height and seed yield during spring in 35 exotic collection of sunflower while 1000 seed weight indicated highest degree of variation during kharif. Muhammed *et al.* (1992) in fourteen sunflower hybrids reported high genotypic and phenotypic variance for achene yield.

An experiment on evaluation of 196 germplasm accessions of sunflower was conducted by Moghali *et al.* (1994) during *kharif*. The phenotypic and genotypic coefficient of variation were high for 100 seed weight (41.7% and 40.7%), seed yield (35.8% and 26.4%) and number of filled seeds per plant. Kshirsagar *et al.* (1995) in 14 sunflower cultivars revealed that variation was greatest for seed yield per plant followed by 100 seed weight.

Variability study on 225 sunflower genotypes by Patil *et al.* (1996) revealed maximum range of variation for number of seeds per head (141-1632) and seed yield (3-75 g). The wider difference between GCV and PCV show the effect of environment on characters like seed yield and seeds per head. In 51 inbreds and three control genotypes of sunflower, Sujatha *et al.* (2002) found high magnitude of variation for 100 seed weight, seed density and seed test weight.

Rao *et al.* (2003) studied variability in 82 genotypes of sunflower and reported high phenotypic and genotypic coefficient of variation for number of filled seeds per head (48.13% and 48.78%), seed yield (45.72% and 45.52%) and test weight (20.28% and 20.10%).

High genotypic coefficient of variation (38.5%) was observed for number of seeds per capsule by Mishra and Saini (1988) in 60 varieties of gladiolus. Similarly, Anuradha and Gowda (1990) studied 25 genotypes of gladiolus and found highest values of phenotypic and genotypic coefficient of variation for number of seeds per capsule.

2.3.2 Heritability and genetic advance

High heritability and high genetic advance was observed for vigour index (99.98% and 49.33%) and germination percentage (99.90% and 32.92%) while studying twenty genotypes of marigold (Kennedy, 1997) indicating improvement in this character by practicing selection. The high heritability coupled with low genetic advance was noticed for 1000 seed weight (85.11% and 1.49%) and seedling length (92.79% and 17.96%) indicating the preponderance of dominant gene action and it could be improved through hybridization.

Srivastava and Mishra (1976) studied 73 varieties of sunflower and observed high heritability (93.70%) and low genetic advance (3.55%) for test weight (100 seed weight) which suggests heritability of this character due to non-additive gene effects. Lakshmanaiah (1980) observed low heritability for seed yield while studying 144 germplasms of sunflower. Chaudhary and Anand (1987) in 35 exotic collection of sunflower, reported high heritability for seed yield (70.1%) in kharif while genetic advance was consistently high for seed yield in *kharif*, *rabi* and *spring*.

A trial on 32 selected genotypes of sunflower in *rabi* conducted by Alam *et al.* (1987) revealed high heritability and genetic advance for seed

per plant. Alavarez *et al.* (1992) in 37 open pollinated population of sunflower in three environment, suggested highest broad sense heritability for seed length. The estimates of genetic advance was high for seed number and seed yield while Muhammed *et al.* (1992) in 14 sunflower hybrids, showed high heritability and genetic advance in achene yield.

Moghali *et al.* (1994) conducted experiment on 196 accessions of sunflower and recorded high heritability and high genetic advance for seed yield (68.6% and 50.5%), 100 seed weight (72% and 31.6%) and number of filled seeds (64.9% and 33.9%). Kshirsagar *et al.* (1995) in 14 sunflower cultivars, reported high heritability for 100 seed weight and moderate values of heritability for yield while Patil *et al.* (1996) in 225 genotypes of sunflower, observed low heritability (34.37%) and genetic advance (5.32%) for filled seed suggesting this character cannot be effectively improved by selection.

Forty-five sunflower genotypes grown under four environments were studied for heritability estimates by Gill (1997). High estimates of heritability and genetic advance was observed for 100 seed weight while seed yield per plant and number of seeds per head exhibited moderate values for these parameters. Sujatha *et al.* (2002) analysed 51 inbreds and three control genotypes of sunflower. High heritability coupled with high genetic advance was recorded for per cent seed set and seed yield per plant. High heritability with low genetic advance was recorded for 100 seed weight suggesting these characters cannot be effectively improved by selection. Rao *et al.* (2003) in a study on 82 genotypes of sunflower

revealed high heritability estimates for number of filled seeds per head, seed yield and test weight.

Experiment on 60 varieties of gladiolus by Mishra and Saini (1988) revealed high heritability (79.02%) for number of seeds per capsule with moderate levels of genetic advance (15.34%). Seed germination recorded high heritability and genetic advance in 18 genotypes of crossandra (Reddy *et al.*, 2002).

2.3.3 Correlation and path coefficient

Correlation studies (Lakshmanaiah, 1980) on 145 germplasm of sunflower revealed that seed yield was positively and significantly associated with capitulum diameter, seed number per capitulum and seed filling. Path coefficient analysis revealed that the capitulum diameter had the greatest positive direct effect on seed yield.

Marinkovic (1992) studied path coefficient analysis of some yield components of sunflower. The highest direct positive effect on seed yield per plant was exhibited by 1000 seed weight while head diameter, volume weight and kernel content had a negative direct effect.

Character association studies by Rao *et al.* (2003) on 82 genotypes of sunflower indicated the presence of significant positive association of seed yield with number of filled seeds per head, test weight and head diameter. Path coefficient analysis showed that the number of filled seed/head, test weight and head diameter had maximum direct effect on seed yield.

Path coefficient analysis studies by Hondelmann and Strauss (1990) in *Euphorbia lathyris* revealed that the flower per primary inflorescence

and flower per secondary inflorescence had the greatest direct effect on seed yield.

2.4 CHARACTERIZATION

Characterization and identification of cultivars is crucial to variety release programme and in the coming times in WTO regime for the registration of the genotypes/cultivars. Practically a variety must be distinct, uniform and stable in the characters that are adopted for use in varietal characterization and identification. The marigold is tremendously diverse with respect to growth habit and morphology. The ability to distinguish and identify varieties of cultivated species is fundamental to the operation of germplasm improvement programme. Characterization based on the qualitative characters is useful in their identification, because of reliability of qualitative attributes over environments. Therefore, an attempt has been made to review the work related to characterization. In literature research few reports are available on the floriculture crops, therefore, on the similar aspects, the work on field crops has also been reviewed.

2.4.1 Plant morphology

Characterization on 196 accessions of sunflower was done by Moghali and Virupakshapa (1994). The morphological parameters studied are leaf shape, leaf margin, leaf colour, petiole length, branching pattern, disc colour and vein angle. The morphological characters such as stem pigmentation, stem hairiness and pod colour have been studied for varietal identification under field condition by Ram *et al.* (1998) in blackgram.

Dahiya *et al.* (1993) studied the morphological characters like foliage colour, leaflet size and shape, flower colour and pod characteristics etc. for chickpea varieties under field condition for varietal characterization. Szabo *et al.* (1983) characterized 40 soybean cultivars by flower colour, pubescence, petiole colour and colour of dry pods. Morphological parameters served the purpose for certification of soybean varieties through the stem pigmentation, flower colour and pod shape and size (Kahre *et al.*, 1998). Prakash and Singhal (1997) studied seven grain and vegetable cultivars for various cultivar on the basis of morphological characters and reported possibility to identify the individual cultivars on the basis of morphological characters.

Twenty-seven genotypes of desi cotton were characterized by Prakash (1998) through characters like plant height, stem colour, leaf size and shape, petal colour etc. the flow chart was prepared to identify cultivars from each other. Varietal identification of 24 genotypes of cotton was carried out by Singh (1995). Flow chart was prepared for identifying each genotype on the basis of observations recorded for plant type, stem, leaf, flower characters etc. Kumar *et al.* (1994) showed different morphological characters in fourteen *Gossypium* cultivars viz. plant type, stem characters, leaf characters, flower traits, seed and seedling characters and made several groups under these characters and differentiated each and every cultivar on the basis of morphological characters.

2.4.2 Seed morphology

The sunflower hybrids and their parental lines were characterized on the basis of seed colour, seed shape and size (Jagdish *et al.*, 1994;

Sahoo, 1996). Seed size, seed shape, seed colour and seedling pigmentation were found to be useful characters to identify chickpea varieties (Dahiya *et al.*, 1993). Kumar *et al.* (1997) reported that characters like seed size, seed shape, seed coat colour and test weight were important seed morphological characters for the varietal identification of rapeseed and mustard cultivars. Agarwal (1984) suggested that stem colour, leaf colour, margin serrations, pigmentations, flower colour, plant height, silique colour and silique shape can successfully be used for identification of cultivars of rapeseed and mustard.

One hundred sixteen soybean varieties were studied by Morris and Payne (1977) against colour of tests, 1000-seed weight and dimensions of seed which proved useful in distinguishing among varieties. Seed colour, seed shape and test weight proved useful in identifying 13 soybean lines (Villalobos and Fournier, 1978).

Chapter -III

Material and Methods

The present investigation entitled '**Genetical studies and characterization in marigold**' carried out in the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the winter season of both the years i.e. 2002-03 and 2003-04.

3.1 GEOGRAPHIC LOCATION AND CLIMATE OF THE EXPERIMENTAL SITE

Hisar is situated at 29°10' north latitude and 75°46' east longitude with an elevation of 215.2 meters above mean sea level. The tract is characterized by semi-arid climate with hot and dry summers and cold winters. The meteorological data during the crop season of both the years are presented in the Appendix III.

Soil

The soil of the experimental site was loam to sandy loam, low in available nitrogen but high in available potash and organic carbon (0.55%). On the basis of pH and electrical conductivity the soil was well suited for field as well as horticultural crops (Table 3.1).

Table 3.1. Characteristics of experimental soil

Components	Contents	Method of determination
Available nitrogen (kg ha ⁻¹)	137.7	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha ⁻¹)	284	Olsen's method (Olsen <i>et al.</i> , 1954)
Available potassium (kg ha ⁻¹)	433.1	Flame photometric method (Jackson, 1973)
pH	8.3	1:2 soil water suspension (Jackson, 1967)
EC (dSm ⁻¹)	0.58	1:2 soil water suspension (Jackson, 1967)
Organic carbon (%)	0.55	Walkley and Black rapid titration method (Piper, 1966)

Experimental plant material

The seeds of marigold were taken from previously maintained germplasm.

Preparation of field

The experimental material consists of 30 genotypes of two species of marigold (*Tagetes* spp.); *T. erecta* (African type) genotypes and *T. patula* (French type) genotypes. There was 15 genotypes of each species (Table 3.2). A basal dose of well rotten farm yard manure @5 kg/m² was uniformly mixed in the soil a fortnight before transplanting. The fertilizer application was done @ 10 g : 8 g : 8 g per sq.m of nitrogen, phosphorus and potassium. Half the quantity of nitrogen and full phosphorus and potassium was applied before transplanting while the remaining dose of nitrogen was

Table 3.2. Details of the marigold genotypes

Genotypes	Type	Colour of floret
MG-1	African	Orange
MG-2	African	Orange
MG-3	African	Orange (Pusa Narangi)
MG-4	African	Orange
MG-5	African	Orange
MG-6	African	Orange (Single whorl)
MG-7	African	Dark orange
MG-8	African	Dark orange
MG-9	African	Yellow
MG-10	African	Yellow
MG-11	African	Golden yellow
MG-12	African	Golden yellow
MG-13	African	Lemon
MG-14	African	Lemon
MG-15	African	Pale lemon
MG-16	French	Orange
MG-17	French	Orange
MG-18	French	Double shade (Orange + rusty red)
MG-19	French	Double shade (Orange + rusty red)
MG-20	French	Double shade (Orange + rusty red)
MG-21	French	Yellow
MG-22	French	Yellow
MG-23	French	Double shade (Yellow + rusty red)
MG-24	French	Double shade (Yellow + rusty red)
MG-25	French	Mahogany
MG-26	French	Mahogany
MG-27	French	Rusty red
MG-28	French	Rusty red
MG-29	French	Golden yellow
MG-30	French	Golden yellow

applied one month after transplanting. The transplanting was done in randomized block design with three replications. The spacing between row-to-row and plant-to-plant was 40 cm x 40 cm. The plot size was 4.5 m x 1.5 m. One-month-old seedlings having 5 to 7 leaves were transplanted in the plots.

Experimental details

The study was undertaken on two species of marigold namely African (*Tagetes erecta*) and French marigold (*Tagetes patula*). The details of the experiment are as under:

Total number of genotypes	-	30
Design	-	Randomized Block Design
Replication	-	3
Spacing	-	40 cm x 40 cm
Plot size	-	4.50 m x 1.50 m
Number of plants/plot	-	40
Total number of plots	-	90

Observations recorded

The following observations were recorded during both the years.

The plant characters were identified on the basis of descriptors.

1	Plant growth habit	-	Compact/open
2	Branching habit	-	No branch/basal/middle/top/full
3	Stem colour	-	Green/dark green/purple/purple strips
4	Stalk shape	-	Smooth/ridged
5	Stem pubescence	-	Glabrous/non-glabrous
6	Leaf colour	-	Pale green/light green/dark green/purple

- | | | | |
|---|-----------------|---|---------------------------------|
| 7 | Leaflet shape | - | Narrow pointed/oval pointed |
| 8 | Leaflet margin | - | Smooth/serrated/highly serrated |
| 9 | Leaf pubescence | - | Glabrous/non-glabrous |

A. Plant character

1) Plant height (cm): Five plants were selected at random in each plot and plant height was measured in cm with the help of meter rod from the base of plant upto tip of apical shoot at full bloom stage. On the basis of height three categories were made as :

- (a) short < 50 cm
- (b) medium 50 – 75 cm
- (c) tall > 75 cm

2) Plant spread (cm): The plants selected for recording height at random in each plot was also studied for plant spread. The plant spread was recorded by measuring the distance covered by the plant in east to west and north to south directions and taking mean of sum for representative plants in each plot.

3) Number of branches: The number of branches arising from the main stem was counted at the time of full bloom on five representative plants in each plot.

4) Plant growth habit: Plant growth habit was observed on the nature of plant spread with narrow crotch angle or wide crotch angle and divided into

- (a) compact
- (b) open

5) Branching habit: The branching habit was recorded on the basis of origin of primary branches on the main stem and divided into

- (a) basal
- (b) middle
- (c) top
- (d) full

6) Stem colour: The stem colour was determined on the basis of visual observation of colour of the stem and divided into

- (a) green
- (b) dark green
- (c) purple strips
- (d) purple

7) Stalk shape: The stalk shape was determined on the presence or absence of ridges on the main stem and divided into

- (a) smooth
- (b) ridged

8) Stem pubescence: The stem pubescence classified on the basis of hairiness or smoothness of the stem surface and divided into

- (a) glabrous
- (b) non-glabrous

9) Leaf colour The leaf colour was determined on the basis of visual observation of leaf colour and classified into four classes

- (a) pale green
- (b) light green

(c) dark green

(d) purple

10) Leaflet shape: The leaflet shape was determined on the basis of visual observation of size and shape, whether the width of leaf is small and gradually tapering or the width of leaf is wider at the centre with sharply tapering towards the tip. It was categorized into two groups:

(a) narrow pointed

(b) oval pointed

11) Leaflet margin: The leaflet margin was determined on the basis of type of serration. The teeth present on the leaf margin are indistinct, fine, deep and distinct and were divided into the following categories:

a) smooth

b) serrated

(c) highly serrated

12) Leaf pubescence : The roughness and smoothness of leaf surface was examined and groups as:

(a) glabrous

(b) non-glabrous

B. FLORAL CHARACTERS

1) Days to first flower: The appearance of first flower in the representative plants in each plot was recorded and days taken were counted and it is divided into

(a) early - < 70 days

(b) medium - 70-85 days

(c) late - > 85 days

2) Duration of flowering: The number of days taken from the date of first flower opening to the opening of last flower constituted the duration of flowering and was recorded on representative plants in each plot. It is categorized into three categories:

- (a) early - < 35 days
- (b) medium - 35-45 days
- (c) late - > 45 days

3) Number of buds per plant: The total number of buds per plant was recorded on the representative plants in each plot.

4) Number of flowers per plant: The total number of flowers per plant was recorded on the representative plants in each plot and classified as follows.

- (a) low - < 75
- (b) medium - 75-175
- (c) high - > 175

5) Size of flower (cm): Size of flower was recorded at full bloom stage by using digital vernier calliper and mean of ten flowers from each representative plant in each plot which was expressed in centimeters and classified as:

- (a) small - < 4 cm
- (b) medium - 4-6 cm
- (c) big - > 6 cm

6) Fresh weight of flower (g): The mean weight of ten flowers plucked randomly from each plant was recorded immediately after harvest and expressed in grams.

- (a) less - < 5 g
- (b) medium - 5 - 10 g
- (c) more - > 10 g

7) Dry weight of flower (g): The flowers taken for fresh weight were shade dried till the reduction in weight become constant then the weight was recorded as mean of ten flower and expressed in grams.

8) Disc floret: On the basis of presence or absence of disc floret the flowers were grouped in two classes:

- (a) visible
- (b) not visible

9) Flower yield per plant (g): The fresh weight of a flower multiplied by number of flowers constituted the flower yield per plant and expressed in grams.

10) Flower yield per plot (kg): Flower yield of a randomly selected plant was multiplied by number of plants in the plot and recorded in kilograms.

11) Flower yield per hectare (q): The flower yield per plot was converted to hectare basis which reflect the yield per hectare.

12) Seed yield per plant (g): The mean weight of seeds in ten flower capsules were recorded and multiplied by number of flowers from each plant and the weight was recorded in grams.

SEED CHARACTERS

1) 1000 seed weight (g): One thousand seeds were drawn from each replication and weighed in digital electronic balance. It is categorized into

- (a) less - < 3 g
- (b) medium - 3.0 - 3.5 g
- (c) more - > 3.5 g

2) Seed shape (mm): The mean length and breadth of seeds were determined with digital vernier calipers and the seeds were classified as small, medium and large as follows:

Seed length		Seed breadth	
a) small	<9 mm	a) small	<1.25 mm
b) medium	9 – 10 mm	b) medium	1.25 – 1.5 m
c) long	>10 mm	c) wide	> 1.5 mm

3) Seed density (g/cc): It was measured as the ratio of weight of 100 seeds to the volume of ether displaced by these seeds.

$$\text{Seed density} = \frac{\text{Weight of 100 seeds}}{\text{Volume of ether displaced by these seeds}}$$

On the basis of seed density three classes were formed.

- a) low <0.8 g/cc
- b) medium 0.8 – 0.9 g/cc
- c) high >0.9 g/cc

4) Standard germination: Four replicates of 50 seeds each were kept in Petri plates adopting top of paper method and after the test period of ten days the normal seedlings were counted and per cent germination was calculated.

5) Seed vigour index: The vigour index values were computed adopting the procedure of Abdul Baki and Anderson (1973) as given below and expressed as whole number.

Vigour index I = germination (%) x total seedling length (cm)

Vigour index II = germination (%) x dry weight of seedling (g)

6) Root length (cm): At the time of germination count, five normal seedlings which were taken at random and the length between collar region to tip of the primary root was measured and the mean length was expressed in centimeter and grouped into three categories.

(a) small - < 2.5 cm

(b) medium - 2.5 – 3.5 cm

(c) long - > 3.5 cm

7) Shoot length (cm): The same five seedlings used for measuring the root length were used for measuring the shoot length between collar region to tip of the primary shoot and the mean value was expressed in cm and classified as below.

(a) small - < 5 cm

(b) medium - 5 – 8 cm

(c) long - > 8 cm

8) Seeding length (cm): The total of root length and shoot length give the seedling length, classified into three groups.

(a) small - < 8 cm

(b) medium - 8 – 10 cm

(c) long - > 10 cm

9) Dry weight of seedling: Ten seedlings taken at random were oven dried at 85°C for 24 hrs, then weighed and the mean was expressed in grams.

STATISTICAL ANALYSIS

The data obtained on various characters were subjected to statistical analysis as per randomized block design and interpretation of the data was carried out in accordance with Panse and Sukhatme (1995). The levels of significance used in F and t test were $P=0.05$. The critical difference was calculated wherever the F test was significant. The data collected on the above characters were subjected to the following analysis.

i) Analysis of variance

Source value	df	S.S.	M.S.S.	F
Replication	$r-1$	SSr	MSr	MSr/MSe
Genotypes	$g-1$	SSg	MSg	MSg/MSe
E error	$(r-1)(g-1)$	SSe	MSe	
Total	$rg-1$	TSS		

Variability

Mean: The mean value of each character was worked out by dividing the totals by corresponding number of observations.

$$\bar{X} = \frac{\sum X_{ij}}{n}$$

$\bar{X}$ = mean

X_{ij} = observation of j^{th} replication and i^{th} genotype

n = total number of observations

Range: It is the difference between the lowest and highest values for each character.

Standard error: Standard error of mean was calculated with the help of error mean squares from the analysis of variance table as under:

$$S.E_m = \frac{\sqrt{\sigma^2 e}}{r}$$

Phenotypic and Genotypic Coefficient of Variation (PCV:GCV)

The coefficient was computed according to method suggested by Burton (1952).

$$PCV = \frac{\sqrt{\sigma^2 p \times 100}}{X}$$

$$GCV = \frac{\sqrt{\sigma^2 g \times 100}}{X}$$

Genotypic and Phenotypic Variance

These were estimated according to formula given by Panse and Sukhatme (1995) for randomized block design

$$\text{Error variance } (\sigma^2 e) = MSe$$

$$\text{Genotypic variance } (\sigma^2 g) = \frac{MSg - MSe}{r}$$

$$\text{Phenotypic variance } (\sigma^2 p) = \sigma^2 g + \sigma^2 e$$

Mg = Mean sum of square for genotypes

Me = Mean sum of square for error

r = number of replications

$\sigma^2 e$ = error variance

Heritability (broad sense)

The total phenotypic variability depicted by a trait is composed of heritable and non-heritable components of variability. Heritability refers to the proportion of variability which is heritable in nature to the total variability. It is due to genetic causes whereas, non-heritable variability is contributed by error variance. Heritability in broad sense was calculated according to the following formula suggested by Hanson *et al.* (1956).

$$H(b) = \frac{\sigma^2g}{\sigma^2p} \times 100$$

$$H(b) = \text{heritability (broad sense)}$$

$$\sigma^2g = \text{genotypic variance}$$

$$\sigma^2p = \text{phenotypic variance}$$

Critical Difference

Critical difference for all the characters were calculated to compare the cultivars as per following formula

$$CD = S.E.m \sqrt{2} \times t_{0.05} \text{ at error d.f.}$$

Genetic Advance

The expected genetic advance represents the shift in a population mean towards superior side under some selection pressure after single generation. The formula given by Johnson *et al.* (1955) was used.

$$GA = H(b) \times K \times \sigma p$$

Where

$$GA = \text{expected genetic advance}$$

$$H(b) = \text{heritability (broad sense)}$$

K = selection differential K=2.06 at 5 per cent selection intensity (Allard, 1960)

σ_p = phenotypic standard deviation

Genetic Advance expressed as percentage of mean

It was calculated by the method suggested by Johnson (1955).

$$\text{Genetic advance} = \frac{\text{G.A.}}{X} \times 100$$

GA = expected genetic advance

X = mean of the character under study

Correlation coefficient

Genotypic and phenotypic correlation among all the characters under study were estimated as given by Searle (1961).

i) Genotypic correlation between x and y characters

$$r_{xy}(g) = \frac{\text{Cov}_{xy}(g)}{\sqrt{\sigma^2g(x) \cdot \sigma^2g(y)}}$$

ii) Phenotypic correlation between x and y characters

$$r_{xy}(p) = \frac{\text{Cov}_{xy}(p)}{\sqrt{\sigma^2p(x) \cdot \sigma^2p(y)}}$$

The test of significance for phenotypic correlation was tested at (n-2) degree of freedom using r table

$\text{Cov}_{xy}(g)$ and $\text{Cov}_{xy}(p)$ denote genotypic and phenotypic covariance respectively between characters x and y.

$\sigma^2g(x)$ and $\sigma^2p(x)$ denote genotypic and phenotypic variance for character x and $\sigma^2g(y)$ and $\sigma^2p(y)$ denote genotypic and phenotypic variance for character y.

Path Coefficient Analysis

The genotypic correlation coefficients were used to workout path coefficient analysis. Path coefficients were obtained according to Dewey and Lu (1959). A set of simultaneous equations in the following form were solved.

$$r_{ny} = P_{ny} + r_{n2} P_{2y} + r_{n3} P_{3y} + \dots + r_{nx} P_{xy}$$

$$r_{ny} = \text{correlation coefficient of one character and yield}$$

$$P_{ny} = \text{path coefficients between the character and the yield}$$

$r_{n2} r_{n3} \dots r_{nx}$ = represents correlation coefficient of that character and each of the yield components in turn

The following correlation matrices were formed.

Matrix A	Matrix B	
r_{1y}	$r_{11} r_{12} r_{13} \dots r_{1n}$	P_{1y}
r_{2y}	$r_{21} r_{22} r_{23} \dots r_{2n}$	P_{2y}
r_{3y}	$r_{31} r_{32} r_{33} \dots r_{3n}$	P_{3y}
.	.	.
.	.	.
.	.	.
r_{ny}	$r_{n1} r_{n2} r_{n3} \dots r_{nn}$	P_{ny}

The technique given by Goulden (1954) was followed by inversion (B^{-1}) of B matrix. Path coefficients P_{ij} were obtained as follows:

$$P_{ij} = (B^{-1}) \times (A)$$

The indirect effects for a particular character through other characters were obtained by multiplication of direct path and particular correlation coefficient between those two characters, respectively.

$$\text{Indirect effect} = r_{ij} \times P_{jj}$$

Where,

$$i = 1 \dots n$$

$$j = 1 \dots n \text{ and}$$

$$P_{ij} = P_{1y}, P_{2y}, \dots, P_{ny}$$

The individual factors, i.e. the variation in yield unaccounted for those association was calculated from the following formula:

$$\text{Residual factor (x)} = 1 - R^2$$

Where

$$R_2 = P_{1y} r_{1y} + P_{2y} r_{2y} + \dots + P_{ny} r_{ny}$$

R^2 is the squared multiple correlation coefficients and is the amount of variation in yield that can be accounted for by the effect of yield components on yield.

Chapter - IV

Experimental Results

Since variability is the basis of all crop improvement programmes, therefore the breeder has to depend on the extent of variability present in crop species which they consider for development of potential varieties having desirable characteristics.

The experimental results of this aspect relating to genetic variability, heritability, genetic advance, correlation and path analysis studies in marigold have been presented as under:

4.1 MEAN PERFORMANCES

The analysis of variance revealed that the mean sum of squares due to genotypes were significant for all the characters in both the years indicating the presence of significant genetic variability existing for all the characters under study (Table 4.1 and 4.2).

The mean values of the genotypes for different characters for the year 2002-03 and 2003-04 are presented in Table 4.3, 4.4, 4.5 and 4.6. However, grand mean along with standard error, range, phenotypic and genotypic variance are given in Table 4.10 and 4.11.

Table 4.1. Analysis of variance for different characters of marigold genotypes (2002-03)

Characters	Mean sum of square of genotypes (d.f. =29)
Plant height	1248.44**
No. of branches	187.46**
Plant spread	369.27**
Size of flower	14.65**
Days to first flower	318.28**
Duration of flowering	161.29**
No. of buds per plant	26859.54**
No. of flowers per plant	24108.48**
Fresh weight of flower	64.78**
Flower yield per plant	192574.44**
Flower yield per plot	270.01**
Flower yield per ha	69722.18**
Seed yield per plot	2763.38**
Dry weight of flower	0.71**
1000-seed weight	1.00**
Seed density	0.08**
Seed length	1.89**
Seed breadth	0.07**
Root length	1.96**
Shoot length	14.03**
Standard germination	465.54**
Seedling length	21.51**
Seed vigour-I	143707.78**
Seed vigour-II	470524.18**

*, **P $\leq$ 0.05 and 0.01, respectively

Table 4.2. Analysis of variance for different characters of marigold genotypes (2003-04)

Characters	Mean sum of square of genotypes (d.f. = 29)
Plant height	1408.20**
No. of branches	248.28**
Plant spread	534.41**
Size of flower	13.98**
Days to first flower	381.48**
Duration of flowering	349.84**
No. of buds per plant	32578.40**
No. of flowers per plant	26746.56**
Fresh weight of flower	67.00**
Flower yield per plant	262294.87**
Flower yield per plot	418.99**
Flower yield per ha	102469.09**
Seed yield per plot	3.61**
Dry weight of flower	0.70**
1000-seed weight	0.91**
Seed density	0.08**
Seed length	2.52**
Seed breadth	0.08**
Root length	2.97**
Shoot length	16.39**
Standard germination	687.85**
Seedling length	26.59**
Seed vigour-I	21580.40**
Seed vigour-II	424527.48**

*, **P ≤ 0.05 and 0.01, respectively

Plant height ranged from 31.93 to 109.93 cm was in African yellow MG-12 and minimum 31.93 cm in French MG-19. In second year plant height values ranged from 35.06 to 125.33 cm with general mean of 70.22 cm. The shortest (MG-19) and the tallest (MG-12) maintained their ranks in the second year also. The number of branches ranged from 15.06-45.07 with mean 28.59 in the first year while in second year it was 13.06 to 45.13 with mean 29.18. The maximum value was observed in the genotype MG-3 and minimum in the genotype MG-19.

The general mean for plant spread was 47.29 cm while it ranged from 21.43-75.70 cm in first year and 23.0-67.86 in the second year with maximum spread in MG-17 (75.70 and 67.86 cm) and minimum in MG-15 (21.43 and 23.0 cm) in both the years.

The size of flower varied from 3.12 (MG-30) to 10.98 cm (MG-7) with general mean 5.65 cm in first year. In second year the size varied from 3.2 to 10.6 cm with mean value of 5.5 cm.

Days to first flower ranged from 60.06 to 99.06 days and 57.13 to 106.33 days and mean value of 82.44 and 86.47 days in first and second year, respectively. The maximum and minimum days to first flower were observed in MG-12 and MG-10 in both the years.

The mean value for duration of flowering was 39.01 and 42.57 days with range 28.0 to 55.13 and 27.33 to 63.26 days in both the years. Minimum duration was reported in MG-4 in both the years, while maximum duration 55.13 and 63.26 days were observed in MG-28 during both the years.

The number of buds per plant ranged from 30.06 to 432.73 with mean value of 130.11 in first year whereas, during second year the mean value obtained was 135.74 with range from 23.06 to 390.06. The maximum number of buds were observed in MG-17 and minimum in MG-19 in both the years. Similarly, the number of flowers per plant varied from 22 to 400.06 and 18.86-370.66 with mean value of 118.51 and 118.73 during 2002-03 and 2003-04, respectively.

The mean value for fresh weight of flower was 6.74 g and ranged from 2.02-17.58 g in first year. In second year it ranged 1.88-16.36 g with mean value of 6.55g. In the first year the highest fresh weight of flower was obtained in MG-8 (17.58 g) and lowest in MG-16 in both the years.

The range for flower yield per plant during the first year was 62.53-1260.18 g (Table 4.3) with general mean of 539.17 g. The highest yield (1260.18 g) was obtained in MG-17 and lowest 62.53 g in MG-19, while in second year the yield per plant ranged from 49.56-1074.9 g (Table 4.5) with mean value of 528.94 g. The genotype MG-17 produced highest flower yield, whereas it was lowest in the genotype MG-19 (49.56 g).

Flower yield per ha computed from the plot yielded from 39.60-787.61q/ha and 30.82-671.82 q/ha with mean value of 336.92 q/ha and 330.53 q/ha in first and second year.

Seed yield per plot ranged from 0.016-0.463 kg with mean value of 0.199 kg in first year (Table 4.4) and in the second year the seed yield per plot varied from 0.011-0.386 kg (Table 4.6) with mean of 0.176 kg.

Mean value for dry weight of flower was 0.633 g and 0.628 g with

Table 4.3. Mean performance of marigold genotypes for different characters (2002-03)

Genotypes	Plant height (cm)	No of branches/plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/plant	No. of flowers/plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-1	95.06	15.13	43.10	9.46	72.06	37.93	60.00	54.00	10.60	572.55	22.89	357.51
MG-2	59.93	33.93	39.10	7.98	83.06	39.06	56.06	47.06	10.46	492.57	19.70	307.85
MG-3	90.40	45.06	53.00	6.56	79.06	34.13	62.06	54.93	9.21	505.77	20.23	316.11
MG-4	100.06	30.06	44.53	6.04	88.06	28.00	116.06	105.13	9.98	1048.80	41.95	655.50
MG-5	70.00	42.13	52.13	4.67	90.06	29.06	67.06	59.93	4.70	281.73	11.26	176.08
MG-6	62.13	30.06	35.46	6.86	97.06	33.00	44.13	34.93	7.21	306.00	12.24	191.25
MG-7	96.20	28.06	48.03	10.98	90.00	43.86	53.06	44.60	17.03	759.53	30.38	474.71
MG-8	58.20	20.13	39.00	9.56	95.06	36.00	46.73	32.60	17.58	573.01	22.92	358.13
MG-9	65.00	34.00	34.96	8.90	90.00	32.13	56.06	44.93	14.78	664.20	26.57	415.12
MG-10	68.06	30.00	33.96	8.78	97.73	37.06	43.06	35.93	12.56	450.39	18.01	281.49
MG-11	82.06	36.06	49.50	5.56	88.20	40.06	64.06	56.86	6.92	393.95	15.75	246.12
MG-12	109.93	34.00	44.53	5.68	99.06	28.13	66.06	60.93	5.02	327.05	13.08	204.37
MG-13	71.93	24.06	34.03	7.44	91.06	39.93	41.06	37.93	12.24	464.62	18.58	290.38
MG-14	63.06	20.20	36.40	6.84	89.13	30.06	35.86	30.00	9.34	280.84	11.22	175.54
MG-15	39.86	18.06	21.43	5.68	94.13	32.06	49.06	43.80	10.30	450.78	18.03	281.75
MG-16	48.00	28.00	51.80	4.13	68.06	39.06	176.06	162.00	2.02	327.22	13.08	204.40

Table 4.3 (contd..)

Genotypes	Plant height (cm)	No of branches/plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/plant	No. of flowers/plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-17	54.66	26.93	75.70	3.77	86.06	52.20	432.73	400.06	3.15	1260.18	50.40	787.61
MG-18	90.06	32.00	63.03	3.34	75.06	50.93	187.13	174.00	2.26	392.79	15.71	245.50
MG-19	31.93	15.06	34.03	4.58	60.06	29.86	30.06	22.00	2.84	62.53	2.50	390.60
MG-20	52.86	22.06	43.50	4.22	63.00	35.93	173.06	158.00	2.16	340.60	13.62	212.87
MG-21	86.26	32.06	55.53	4.82	80.06	40.06	204.93	185.06	4.35	805.10	32.20	503.18
MG-22	53.93	22.00	59.06	4.30	87.06	50.13	231.06	217.06	4.02	873.06	34.92	545.59
MG-23	68.06	32.00	52.03	3.51	75.13	58.06	253.00	235.80	4.06	1009.23	40.36	630.76
MG-24	55.00	36.06	48.93	4.01	82.93	40.06	269.06	252.06	2.32	585.16	23.40	365.73
MG-25	57.06	16.06	62.50	3.48	69.93	44.93	252.30	229.46	3.34	766.39	30.65	478.99
MG-26	35.20	20.06	50.06	3.68	74.06	42.96	223.06	202.00	2.85	574.28	22.97	358.92
MG-27	81.33	29.06	56.96	3.72	69.86	43.06	215.06	192.06	3.01	577.18	23.08	360.74
MG-28	51.86	38.06	59.00	4.32	71.93	55.13	173.06	161.93	3.21	519.89	20.79	323.93
MG-29	38.26	31.93	40.53	3.42	77.13	41.06	83.93	75.13	2.43	182.44	7.29	114.02
MG-30	78.06	36.06	66.50	3.12	79.06	37.10	198.07	184.86	3.03	560.03	22.40	350.02
SE	3.06	1.80	2.34	0.23	2.06	1.49	2.60	2.90	0.16	7.10	7.22	12.11
CD at 5%	8.70	5.13	6.65	0.67	5.84	4.24	7.40	8.43	0.45	62.72	2.64	39.19
CD at 1%	11.63	6.85	8.86	0.90	7.81	5.67	9.89	11.26	0.60	82.13	3.35	52.40

Table 4.4. Mean performance of marigold genotypes for different characters (2002-03)

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed vigour-I	Seed vigour- II
MG-1	0.152	0.92	3.16	1.05	9.58	1.24	3.24	6.98	58	10.22	592.76	1336.13
MG-2	0.088	0.90	3.86	0.96	10.22	1.12	3.15	6.50	70	9.65	675.34	1541.06
MG-3	0.269	0.81	2.85	0.95	9.34	1.03	2.30	6.12	64	8.42	538.88	1218.53
MG-4	0.463	0.85	3.26	0.81	8.48	1.26	3.21	7.50	40	10.71	428.40	922.93
MG-5	0.148	0.54	3.24	0.72	8.54	1.28	1.75	3.60	62	5.35	331.70	621.00
MG-6	0.114	0.66	3.58	0.81	9.62	1.52	3.15	6.20	78	9.35	729.30	1561.33
MG-7	0.135	1.89	4.50	0.90	8.94	1.16	4.80	9.20	74	14.00	1036.00	1868.13
MG-8	0.125	2.29	3.01	1.00	9.42	1.32	2.08	4.94	60	7.02	421.20	960.33
MG-9	0.116	0.59	3.52	0.88	10.40	1.46	3.30	10.20	80	13.50	1080.00	2008.26
MG-10	0.098	1.10	3.45	0.86	10.06	1.38	3.98	7.26	78	11.24	876.72	1873.46
MG-11	0.179	0.60	2.46	1.22	9.06	1.24	2.41	6.30	44	8.51	374.44	794.66
MG-12	0.166	0.58	3.57	1.15	11.50	1.20	2.26	5.61	46	7.87	362.02	795.86
MG-13	0.115	1.02	3.16	1.05	9.66	1.48	2.50	4.92	48	7.42	356.16	770.53
MG-14	0.075	0.80	2.31	0.92	9.56	1.34	1.98	4.24	32	6.22	199.04	450.26
MG-15	0.212	0.88	3.77	0.83	8.92	1.42	2.34	6.04	46	8.38	385.48	968.80
MG-16	0.155	0.27	3.39	1.13	10.56	1.04	2.50	8.60	46	11.10	510.60	915.46

Table 4.4 (contd....)

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed vigour-I	Seed vigour- II
MG-17	0.451	0.29	3.47	1.36	11.22	1.20	3.20	10.78	56	14.10	789.60	1345.33
MG-18	0.213	0.25	3.27	1.09	10.83	1.02	3.40	11.20	60	14.60	876.00	1562.26
MG-19	0.016	0.25	5.00	1.25	9.38	1.34	3.00	6.50	44	9.50	418.00	794.13
MG-20	0.121	0.20	2.66	0.75	9.42	1.14	2.00	8.50	54	10.50	567.00	1024.73
MG-21	0.124	0.38	2.73	0.91	10.66	1.54	2.90	9.80	50	12.70	635.00	1052.73
MG-22	0.300	0.39	3.06	1.22	10.34	1.06	3.60	10.20	46	13.80	634.80	1012.60
MG-23	0.462	0.42	3.57	1.19	10.48	1.10	3.20	10.50	62	13.70	849.40	1365.60
MG-24	0.327	0.24	2.74	0.91	9.40	1.18	3.40	8.50	68	11.90	809.20	1429.06
MG-25	0.404	0.30	2.78	0.92	9.89	1.34	2.80	8.96	54	11.76	635.66	1135.60
MG-26	0.295	0.28	3.34	1.10	10.80	1.36	3.20	11.50	44	14.70	646.80	1146.40
MG-27	0.171	0.30	2.91	0.94	10.24	1.24	2.46	9.50	68	11.96	813.28	1429.46
MG-28	0.239	0.32	3.47	0.88	10.76	1.48	5.50	9.30	48	14.80	710.49	1206.40
MG-29	0.071	0.24	2.73	1.05	11.12	1.10	2.40	8.20	62	10.60	657.20	1194.53
MG-30	0.179	0.30	2.52	0.71	9.76	1.28	3.00	9.20	66	12.20	805.20	1453.86
SE	0.009	0.01	0.06	0.04	0.17	0.03	0.13	0.31	2.39	0.42	48.21	76.89
CD at 5%	0.027	0.04	0.18	0.11	0.48	0.10	0.36	0.89	6.78	1.19	136.74	218.06
CD at 1%	0.036	0.06	0.24	0.15	0.64	0.27	0.48	1.18	8.99	1.59	181.38	289.25

Table 4.5. Mean performance of marigold genotypes for different characters (2003-04)

Genotypes	Plant height (cm)	No of branches/plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/plant	No. of flowers/plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-1	82.13	20.40	41.63	9.66	78.06	41.40	60.40	49.00	11.45	559.64	22.38	349.98
MG-2	52.00	39.13	33.66	8.08	88.13	37.26	54.13	41.80	10.81	450.25	18.01	281.41
MG-3	99.00	45.13	49.40	6.48	84.00	33.53	55.33	49.20	8.20	403.37	16.13	252.10
MG-4	107.53	31.93	53.23	5.94	89.40	27.33	126.73	94.40	9.29	874.35	34.97	546.05
MG-5	72.06	40.13	50.66	4.40	95.80	30.40	61.86	52.13	4.16	216.44	8.66	135.27
MG-6	78.06	44.93	41.43	6.30	102.60	31.40	50.53	40.06	6.88	277.12	11.08	173.20
MG-7	102.33	33.13	50.00	10.60	92.80	47.40	60.20	46.86	16.04	751.63	30.06	469.7
MG-8	69.00	16.00	34.70	9.05	101.00	31.33	41.53	32.13	16.36	522.71	20.91	326.74
MG-9	60.06	37.60	34.66	9.00	94.86	29.40	67.26	50.06	16.05	799.90	32.00	499.94
MG-10	65.06	31.80	37.66	8.44	103.13	34.26	48.93	35.13	12.23	432.96	17.32	270.48
MG-11	83.26	39.93	44.70	5.24	90.00	40.00	68.46	63.20	6.16	389.42	15.57	243.39
MG-12	125.33	35.66	46.26	5.46	106.33	30.53	72.13	64.86	4.88	315.68	12.62	197.30
MG-13	83.13	27.86	36.66	7.12	95.00	38.80	38.26	34.13	11.05	378.46	15.13	236.54
MG-14	60.06	13.66	30.43	6.58	87.33	32.46	42.73	32.53	8.47	276.47	11.05	172.79
MG-15	47.20	16.60	23.00	5.50	93.13	28.46	54.40	41.53	8.93	373.84	14.95	233.65
MG-16	54.33	32.93	54.86	4.06	85.06	48.33	152.26	139.80	1.88	262.44	10.49	163.02

Table 4.5 (contd.)

Genotypes	Plant height (cm)	No of branches/plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/plant	No. of flowers/plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-17	50.46	26.06	64.96	3.77	93.46	60.33	390.06	370.66	2.90	1074.91	42.99	671.82
MG-18	98.46	27.73	62.00	3.30	79.66	57.40	163.40	150.20	2.13	319.29	12.77	199.55
MG-19	35.06	13.06	27.10	4.41	57.13	34.26	23.06	18.86	2.62	49.56	1.98	30.82
MG-20	48.06	17.26	44.16	4.12	52.20	45.33	191.40	167.80	1.96	329.72	13.18	206.82
MG-21	90.26	36.13	60.16	4.50	87.06	48.40	223.86	198.80	3.90	775.09	31.00	484.37
MG-22	56.93	18.26	66.03	4.16	89.63	58.26	227.33	201.40	3.66	762.80	30.50	476.76
MG-23	72.53	32.33	64.10	3.60	78.93	55.40	277.86	235.80	4.03	950.27	38.00	593.92
MG-24	61.33	32.06	47.03	3.94	88.06	42.46	335.66	248.66	2.40	599.91	23.98	374.94
MG-25	55.06	19.00	65.06	3.60	74.80	54.40	231.06	214.93	3.05	655.75	26.22	409.84
MG-26	42.53	20.46	57.00	3.80	79.86	50.00	251.46	215.73	2.84	614.48	24.57	384.05
MG-27	73.06	26.53	58.06	3.50	73.53	55.60	214.40	208.46	2.74	572.03	22.88	357.05
MG-28	49.06	34.20	59.06	4.00	74.13	63.26	153.60	151.06	2.93	444.54	17.78	277.84
MG-29	48.93	33.33	38.00	3.30	86.13	47.40	60.46	56.73	3.14	178.49	7.13	111.56
MG-30	80.06	41.46	67.86	3.27	83.00	42.33	199.53	183.46	2.23	411.33	17.00	257.08
SE	5.90	2.79	3.36	0.14	4.07	3.03	4.39	4.96	0.37	33.58	1.35	20.98
CD at 5%	16.74	7.91	9.53	0.41	11.56	8.61	12.46	14.08	1.07	95.15	3.84	59.54
CD at 1%	22.37	10.58	12.74	0.55	15.45	4.29	16.66	18.82	1.44	127.16	5.14	79.57

Table 4.6. Mean performance of marigold genotypes for different characters (2003-04)

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed vigour-I	Seed vigour- II
MG-1	0.124	0.96	3.35	0.99	9.64	1.16	3.94	7.54	66	11.20	739.20	1378.53
MG-2	0.069	0.87	4.23	0.87	10.08	1.03	3.40	6.86	74	10.40	769.60	1509.86
MG-3	0.234	0.80	2.76	0.91	9.16	1.08	2.02	5.98	60	8.21	492.60	1129.46
MG-4	0.386	0.91	3.47	0.76	8.16	1.38	3.51	7.98	46	11.49	528.54	917.40
MG-5	0.112	0.51	3.28	0.71	8.62	1.32	2.11	3.90	62	6.01	372.62	661.26
MG-6	0.121	0.62	3.62	0.88	8.99	1.46	3.70	6.80	74	10.50	778.48	1523.40
MG-7	0.160	2.19	4.52	0.99	8.69	1.06	5.90	10.00	80	15.90	1272.00	1987.13
MG-8	0.119	2.10	3.11	0.93	9.27	1.37	1.99	4.60	54	6.59	355.86	853.93
MG-9	0.107	0.65	3.70	0.86	10.68	1.50	3.50	11.00	88	14.50	1276.00	2068.13
MG-10	0.077	0.99	3.50	0.85	9.77	1.30	4.08	7.72	88	11.80	1014.80	1862.53
MG-11	0.195	0.57	2.56	1.17	8.97	1.16	2.56	6.98	36	9.54	343.44	752.33
MG-12	0.138	0.56	3.48	1.18	11.67	1.23	2.30	5.50	46	7.80	358.80	753.60
MG-13	0.098	0.97	3.49	0.84	9.27	1.43	2.80	4.56	46	7.36	338.56	719.33
MG-14	0.077	0.78	2.67	0.70	9.27	1.25	1.70	4.11	28	5.81	162.68	436.00
MG-15	0.168	0.79	3.92	0.80	8.72	1.40	2.40	6.20	40	8.60	344.00	903.46
MG-16	0.127	0.25	3.27	1.17	10.24	0.99	2.67	9.10	50	11.77	588.50	963.86

Table 4.6 (contd.)

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed vigour-I	Seed vigour- II
MG-17	0.451	0.31	3.33	1.20	11.02	1.14	3.41	11.40	54	14.81	799.74	1421.13
MG-18	0.156	0.23	3.45	1.02	10.96	1.07	3.71	12.10	56	15.81	885.36	1515.13
MG-19	0.011	0.27	4.50	0.84	9.59	1.39	3.15	6.96	38	10.11	384.18	754.53
MG-20	0.112	0.20	2.56	0.78	9.27	1.25	1.76	8.33	58	10.10	585.80	1011.06
MG-21	0.122	0.39	2.41	0.76	10.55	1.42	3.50	10.50	50	14.00	700.00	1097.53
MG-22	0.243	0.37	3.03	1.20	10.55	1.02	3.80	10.50	50	14.30	715.09	1091.46
MG-23	0.447	0.42	3.38	1.25	10.66	1.13	3.50	10.92	60	14.42	865.20	1392.40
MG-24	0.323	0.26	2.65	0.94	9.28	1.15	3.30	8.90	72	12.43	894.96	1488.33
MG-25	0.252	0.36	2.77	1.15	9.78	1.48	3.20	9.33	50	12.53	626.50	1160.93
MG-26	0.271	0.28	3.50	0.91	10.93	1.41	3.40	11.70	40	15.10	604.00	1121.93
MG-27	0.173	0.29	2.79	0.82	10.35	1.28	2.20	9.10	72	11.30	813.60	1375.06
MG-28	0.207	0.31	3.45	0.90	10.90	1.57	5.80	9.50	42	15.30	642.68	1230.20
MG-29	0.154	0.23	2.80	0.72	11.49	1.03	2.70	8.40	58	11.10	643.80	1254.53
MG-30	0.051	0.33	2.78	0.99	9.90	1.33	2.90	9.40	62	12.30	771.84	1491.33
SE	0.008	0.01	0.07	0.02	0.25	0.02	0.18	0.41	1.62	0.57	41.77	90.20
CD at 5%	0.023	0.03	0.20	0.06	0.73	0.07	0.52	1.16	4.60	1.61	118.47	255.18
CD at 1%	0.031	0.04	0.26	0.07	0.97	0.19	0.68	2.54	6.11	2.14	157.16	339.36

the range of 0.020-0.229 g and 0.020-0.219 g for both the years, respectively. The highest dry weight (0.229 g) was recorded MG-8 in first year and 0.219 g for MG-7 in the second year while it was lowest in MG-20 for both the years.

The range for 1000-seed weight (test weight) was 2.31-5.00 g with mean value of 3.24g. The lowest value was obtained for the genotype MG-14 while it was highest in MG-19 during first year. The range of test weight in second year was 2.41-4.52g with mean value of 3.27g. The genotype MG-7 produced boldest heaviest seeds, whereas, MG-21 produced lighter seeds.

Range for seed density for both the years varied from 0.71 (MG-30) - 1.36 (MG-17) g/cc and 0.70 (MG-14) - 1.25 (MG-23) g/cc, respectively. The mean value was 0.988 and 0.936 g.

Seed length values ranged from 8.48 to 11.50 mm and 8.16-11.67 mm in the first and second years, respectively. The mean was 9.93 and 9.88 mm. The highest and the lowest values were obtained in MG-12 and MG-4 in both the years.

The range and mean values for seed breadth for the first year was recorded as 1.02 (MG-18) -1.54 mm (MG-21) and 1.26 mm while for second year, it was 0.99 (MG-16) -1.57 (MG-28) mm and 1.26 mm.

Highest and lowest root length 5.50 cm and 1.75 cm was obtained in MG-28 and MG-5 in first year with mean value of 2.96 cm while in second year the highest root length was observed in MG-7 and lowest in MG-14 with mean value of 3.16 cm and range 1.70-5.90 cm. Similarly,

the shoot length in first year ranged from 3.60 to 11.50 cm with mean 7.89 cm while in second year 3.90 to 12.10 cm with mean value of 8.19 cm.. The highest values were obtained for MG-26 (11.5 cm) and MG-18 (12.10 cm) in first and second years while it was lowest for MG-5 in both the years.

The standard germination for the first year ranged from 32-80 per cent while in the second year it was 28 - 88 per cent with mean value of 56 per cent. The highest per cent germination was recorded in MG-9 and lowest in MG-14 for both the years.

The seedling length varied form 5.35 cm in MG-5 to 14.70 cm in MG-26 with a mean value of 10.86 cm in the first year while in the second year it varied from 5.18 cm in MG-14 to 15.90 cm in MG-7.

The values for seed vigour-I ranged from 200.24 to 1081.01 in MG-14 and MG-9 with a mean value of 626.9 in the first year and 162.85 to 1287.04 in the second year in same genotypes i.e. MG-14 and MG-9 with a mean value to 657.88. The range and mean for seed vigour-II were 450.26 (MG-9) to 2008.26 (MG-14) and 1191.97 for the first year and 436 (MG-9) to 2068.13 (MG-14) and 1194.19 in the second year.

4.2 CATEGORIZATION BASED ON MORPHOLOGICAL CHARACTERS

In the present investigation 30 genotypes of marigold both African and French were evaluated and categorized on the basis of observation recorded for morphological parameters at different stages of growth. The results on the basis of mean of two years (Appendix -I and II) have been presented.

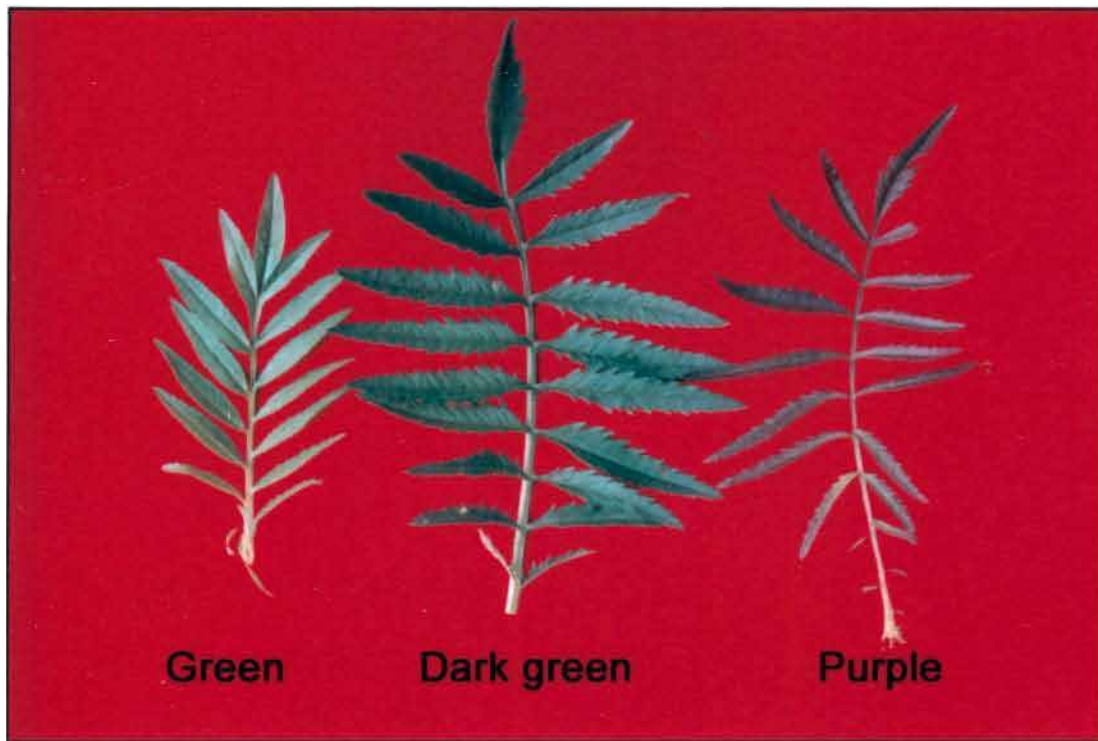


Plate 1. Leaf colour

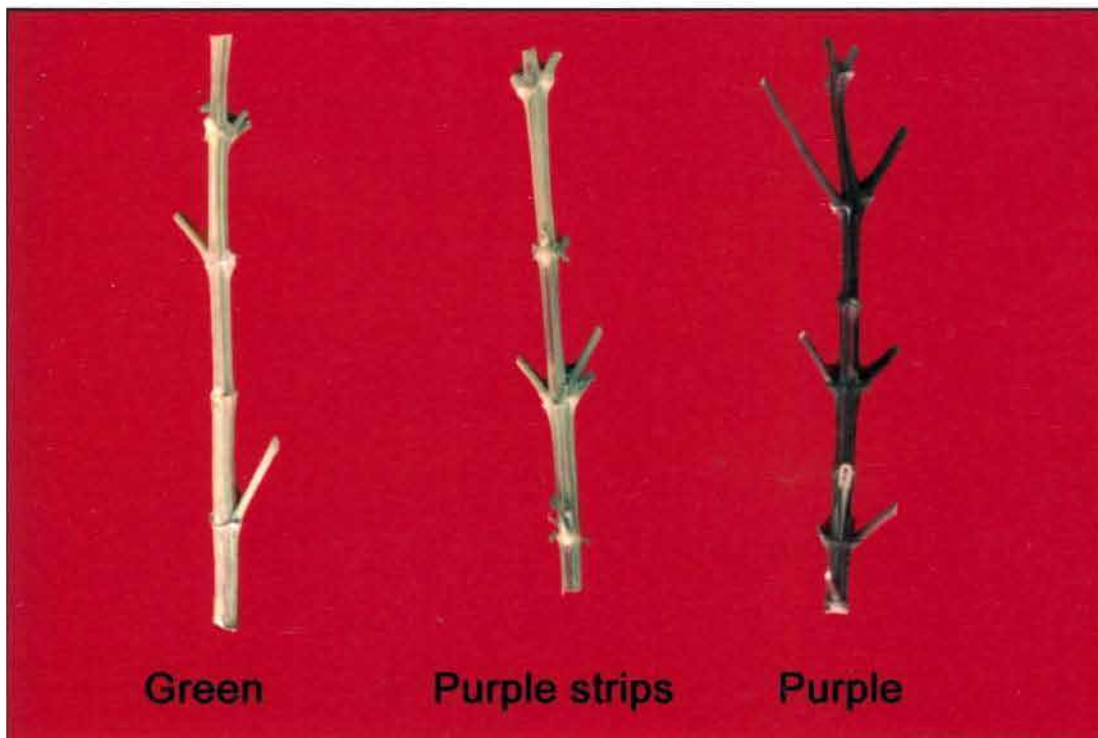


Plate 2. Stem colour

4.2.1 Plant character.

The categorization on the basis of plant character have been presented in Table 4.7.

i) **Plant height:** On the basis of height of plant six genotypes were grouped into dwarf (<50 cm). Thirteen genotypes were grouped in to medium category (50-75 cm) and twelve genotypes were grouped in tall (>75 cm). MG-12 was the tallest while MG-19 the shortest among all genotypes.

ii) **Plant growth habit:** Fourteen genotypes exhibited compact growth habit while sixteen genotypes show wider crotch angle with open growth habit. The spread of plant was maximum in MG-3 while minimum in MG-19.

iii) **Branching habit:** The branching habit was basal in seven genotypes while full branching habit was exhibited in twenty-three genotypes while there was no genotype for middle and top category.

iv) **Stalk shape:** The shape of stalk was divided into smooth and ridged categories. Sixteen genotypes had smooth shape and fourteen genotypes showed ridged stalk (Plate 4).

v) **Stem pubescence:** Based on presence of hairiness on stem surface, stem pubescence was divided into two categories i.e. glabrous and non-glabrous. All the 30 genotypes had glabrous nature.

vi) **Leaf colour :** Leaf colour was divided into four categories seven genotypes showed light green colour. Twelve genotypes showed dark green colour, while purple colour was observed in nine genotypes and pale green was exhibited in MG-1 and MG-21.



Plate 3. Leaflet shape

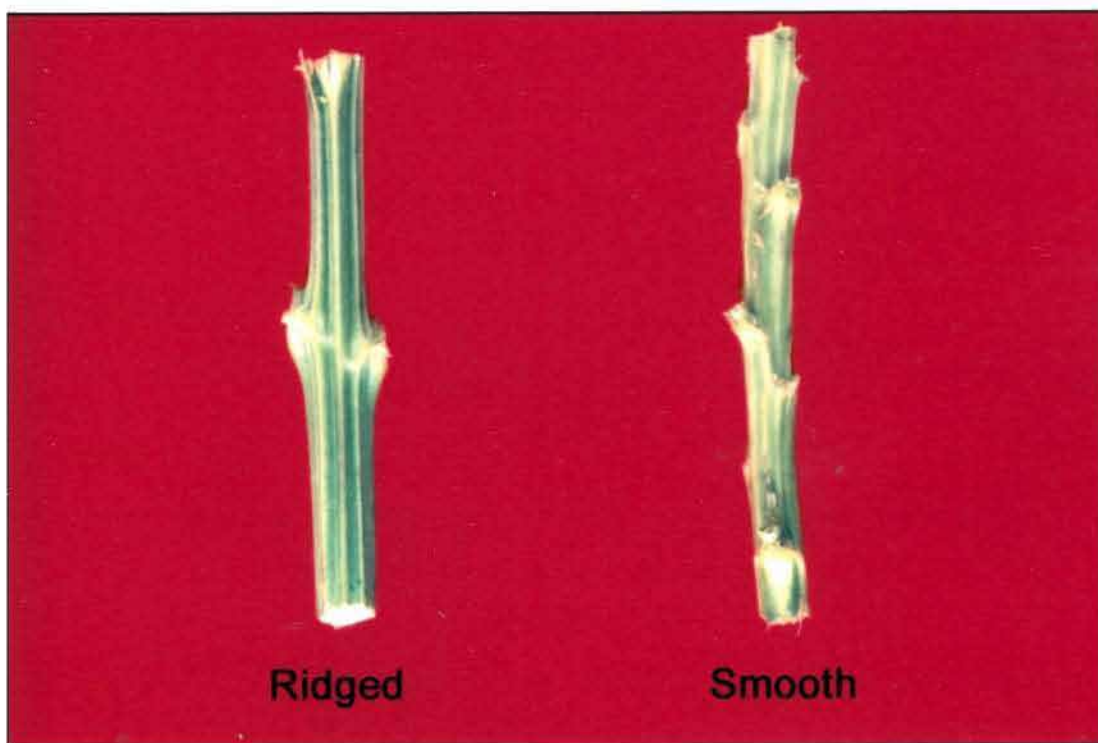


Plate 4. Stalk shape

Table 4.7. Categorization of marigold genotypes based on plant characters

Plant height

Dwarf (<50 cm)	Medium (50-75 cm)	Tall (>75 cm)
MG-15, 19, 20, 26, 28, 29	MG-2, 5, 6, 8, 9, 10, 14, 16, 17, 22, 23, 24, 25	MG-1, 3, 4, 7, 11, 12, 13, 18, 21, 27, 30

Plant growth habit

Compact	Open
MG-1, 2, 3, 9, 10, 11, 14, 17, 19, 20, 22, 26, 28, 30	MG-4, 5, 6, 7, 8, 12, 13, 15, 16, 18, 21, 23, 24, 25, 27, 29

Branching habit

Basal	Middle	Top	Full
MG-2, 8, 9, 10, 13, 14, 15	Nil	Nil	MG-1, 3, 4, 5, 6, 7, 11, 12, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Stalk shape

Smooth	Ridged
MG-3, 4, 5, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30	MG-1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 24, 25

Stem pubescence

Glabrous	Non-glabrous
MG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30	Nil

Stem colour

Green	Dark green	Purple strips	Purple
MG-3, 4, 5, 6, 8, 9, 11, 12, 16, 22, 29	MG-14, 15,	MG-1, 10, 17, 18, 19, 20, 21, 24, 27, 28, 30	MG-2, 7, 13, 23, 25, 26

Leaf colour

Pale green	Light green	Dark green	Purple
MG-1, 21	MG- 3, 6, 7, 8, 11, 12, 15	MG-4, 5, 9, 13, 14, 16, 18, 22, 24, 27, 28, 30	MG-2, 10, 17, 19, 20, 23, 25, 26, 29

Leaflet shape

Narrow pointed	Oval pointed
MG-2, 3, 4, 5, 6, 9, 11, 12, 13, 16, 17, 18, 21, 24, 28, 29, 30	MG-1, 7, 8, 10, 14, 15, 19, 20, 22, 23, 25, 26, 27

Leaflet margin

Smooth	Serrated	Highly serrated
MG-13, 15, 18, 21, 28	MG-3, 4, 5, 6, 9, 10, 11, 12, 14, 16, 17, 22, 24, 27, 29, 30	MG-1, 2, 7, 8, 19, 20, 23, 25, 26

Leaflet pubescence

Glabrous	Non-glabrous
MG-2, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 21, 22, 24, 28, 29, 30	MG-1, 3, 6, 10, 16, 17, 18, 19, 20, 23, 25, 26, 27



Plate 5. Leaflet margin

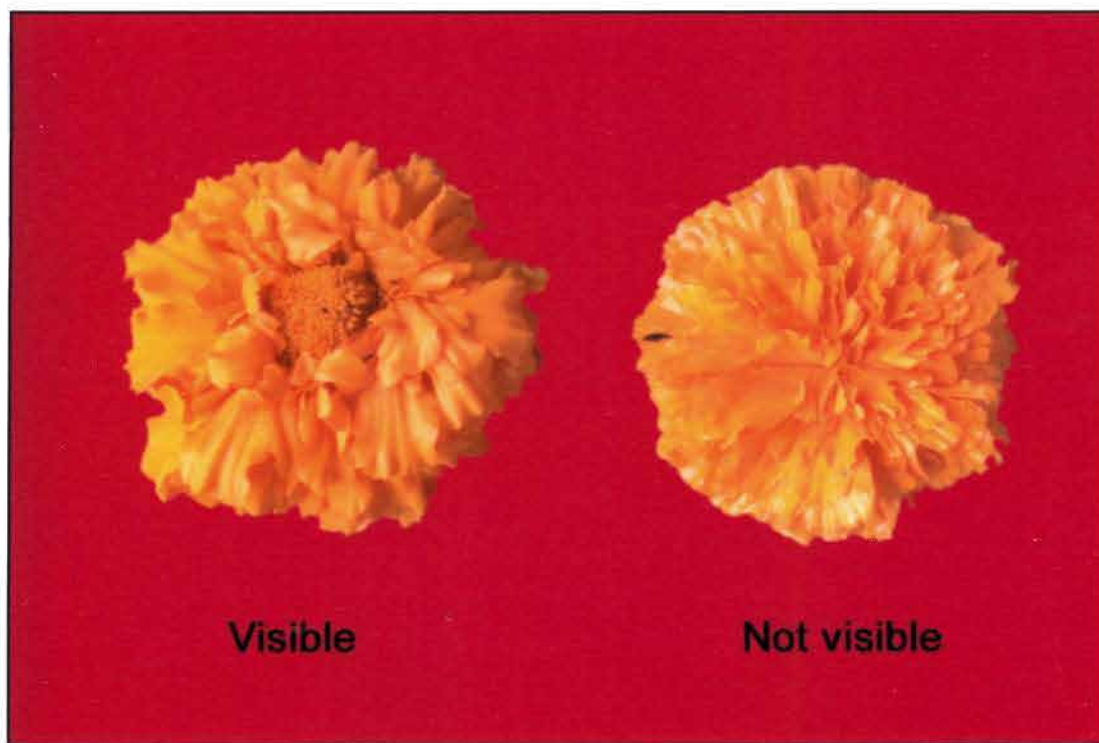


Plate 6. Disc floret

vii) **Leaflet shape:** Based on shape of leaflet, seventeen genotypes had narrow pointed and thirteen had oval pointed leaflet shape (Plate 3).

viii) **Leaflet pubescence:** The genotypes were distinguished based on smoothness of leaf surface into two types. Thirteen were placed in non glabrous while seventeen were placed in glabrous category.

4.2.2 Floral characters

The categorizations on the basis of floral^{chr} have been presented in Table 4.8.

i) **Days to first flower:** Two genotypes MG-19 and MG-20 took less than 70 days to flower while twelve genotypes were grouped in medium (70-85 days) and sixteen in late (>85 days) category. Maximum days to first flower was recorded in MG-11 while minimum in MG-19.

ii) **Duration of flowering:** On the basis of length of flowering period, ten genotypes showed less than 35 days of flower duration and were placed in early category. A medium duration (35-45 days) was observed in eleven genotype and a wider period of flowering was observed in nine genotypes and placed in late (>45 days) category. The maximum duration of flowering was seen in MG-28 while minimum in MG-4.

iii) **Fresh weight of flower:** Fresh weight of flower was divided into less (<5 g), medium (5-10g) and more (>10 g). Sixteen genotypes were observed in less weight category. Seven in medium weight category and seven in more. However, maximum fresh weight of flower was observed in MG-13 while minimum in MG-16.

iv) **Size of flower:** The size of flower was grouped into three types



Plate 7. Variability of buds in African marigold



Plate 8. Variability of buds in French marigold

Table 4.8. Categorization of marigold genotypes based on floral characters

Days to first flower

Early (< 70 days)	Medium (70-85 days)	Late (>85 days)
MG-19, 20	MG-1, 3, 16, 18, 21, 23, 25, 26, 27, 28, 29, 30	MG-2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 2, 24

Duration of flowering

Early (< 35 days)	Medium (35-45 days)	Late (>45 days)
MG-3, 4, 5, 6, 8, 9, 12, 14, 15, 19	MG-1, 2, 10, 11, 13, 16, 20, 21, 24, 29, 30	MG-7, 17, 18, 22, 23, 25, 26, 27, 28

Fresh weight of flower

Less (< 5 g)	Medium (5-10 g)	More (>10 g)
MG-5, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	MG-3, 4, 6, 11, 12, 14, 15	MG-1, 2, 7, 8, 9, 10, 13

Size of flower

Small (< 4 cm)	Medium (4-6 cm)	Big (>6 cm)
MG-17, 18, 23, 24, 25, 26, 27, 29, 30	MG-4, 5, 11, 12, 15, 16, 19, 20, 21, 22, 28	MG-1, 2, 3, 6, 7, 8, 9, 10, 13, 14

Number of flower

Less (< 75)	Medium (75-175)	More (>175)
MG-1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 29	MG-4, 16, 18, 20, 28	MG-17, 21, 22, 23, 24, 25, 26, 27, 30

Floret colour

Single	Double
MG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 21, 22, 27, 28, 29, 30	MG-18, 19, 20, 23, 24, 25, 26

Disc floret

Visible	Not visible
MG-3, 4, 5, 6, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	MG-1, 2, 7, 8, 9, 10

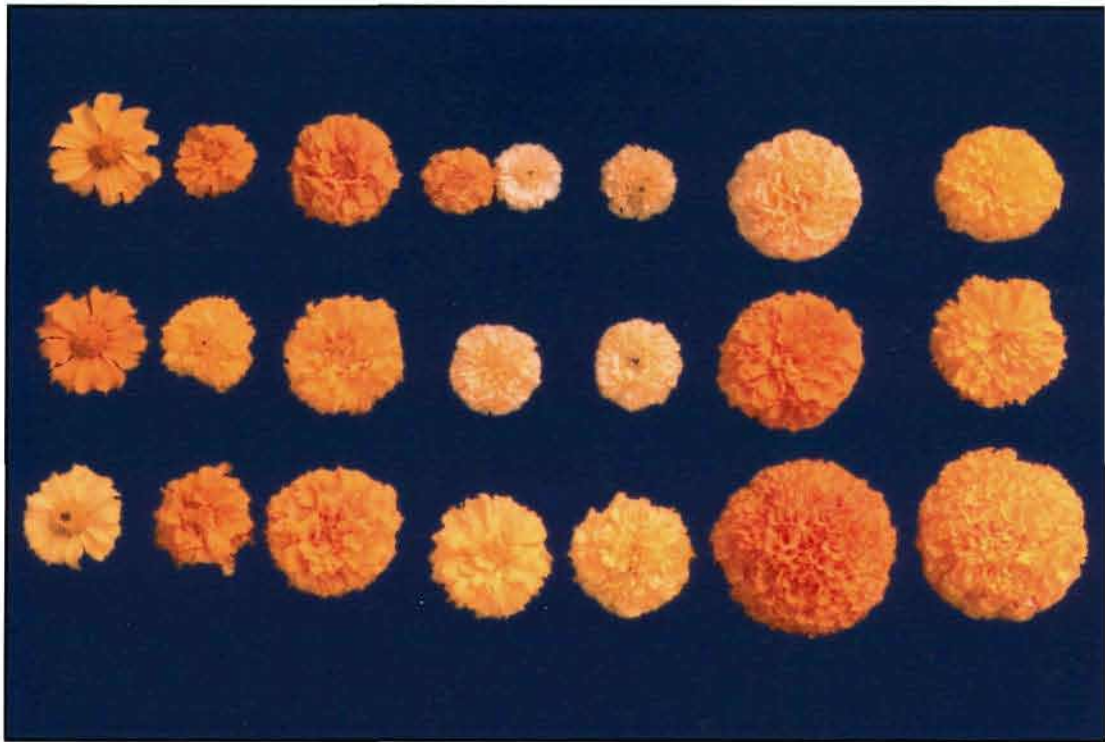


Plate 9. Variability of flowers in African marigold



Plate 10. Variability of flowers in French marigold

according to the size of flower. The first group had small (<4 cm) flowers and it included nine genotypes. Medium (4-6 cm) group had eleven genotypes and ten genotypes were included in big (>6 cm) group. The maximum flower size was exhibited in MG-7 and minimum shown in MG-30.

v) **Floret colour:** On the basis of flower shades twenty three genotypes showed single shade and seven genotypes showed double shade.

vi) **Disc floret:** The genotypes were grouped into visible and not visible group on the basis of presence or absence of disc. Twenty-four genotypes were placed in visible group and six in not visible group.

4.2.3 Seed characters

The classification on the basis of seed characters have been presented in Table 4.9.

i) **1000-seed weight:** Depending upon the weight of 1000-seed three classes have been made as less (<3 g), medium (3-3.5 g) and more (>3.5 g). Ten genotypes were placed in less group, thirteen in medium and seven in more weight group. Lowest seed weight was seen in MG-14 and highest value for 1000-seed weight was observed in MG-19.

ii) **Seed length:** On the basis of seed length the genotype could be grouped in to three categories. Four genotypes had small (<9 mm) seed length, thirteen varieties had medium (9-10 mm) seed length and thirteen were placed in long group (>10 mm). However, the seed length was maximum in MG-5 and minimum in MG-16.

iii) **Seed breadth:** The maximum seed breadth was observed in MG-5 while minimum in MG-16. Twelve genotypes was grouped in to small

Table 4.9. Categorization of marigold genotypes based on seed characters

1000-seed weight

Less (< 3 g)	Medium (3-3.5 g)	More (>3.5 g)
MG-3, 11, 14, 20, 21, 24, 25, 27, 29, 30	MG-1, 4, 5, 8, 10, 13, 16, 17, 18, 22, 23, 26, 28	MG-2, 6, 7, 9, 12, 15, 19,

Seed length

Small (< 9 mm)	Medium (9-10 mm)	Long (>10 mm)
MG-4, 5, 7, 15,	MG-1, 3, 6, 8, 10, 11, 13, 14, 19, 20, 24, 25, 30	MG-2, 9, 12, 16, 17, 18, 21, 22, 23, 26, 27, 28, 29

Seed breadth

Small (< 1.25 mm)	Medium (1.25-1.5 mm)	Wide (>1.5 mm)
MG-2, 3, 7, 11, 16, 17, 18, 20, 22, 23, 24, 29	MG-1, 4, 5, 8, 10, 12, 14, 19, 26, 28, 30	MG-6, 9, 13, 15, 21, 25, 27

Seed density

Low (< 0.8 g/cc)	Medium (0.8-0.9 g/cc)	High (>0.9 g/cc)
MG-4, 5, 6, 9, 10, 14, 15, 20, 21, 27, 28, 29, 30	MG-2, 3, 7, 8, 13, 19, 24	MG-1, 11, 12, 16, 17, 18, 22, 23, 25, 26

Root length

Small (< 2.5cm)	Medium (2.5-3.5cm)	Long (>3.5cm)
MG-3, 5, 8, 11, 12, 14, 15, 20, 27	MG-2, 4, 6, 9, 13, 16, 17, 19, 21, 23, 24, 25, 26, 29, 30	MG-1, 7, 10, 18, 22, 28

Shoot length

Small (<5cm)	Medium (5-8 cm)	Long (>8cm)
MG-5, 8, 13, 14	MG-1, 2, 3, 4, 6, 10, 11, 12, 15, 19	MG-7, 9, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Seedling length

Small (<8cm)	Medium (8-10 cm)	Long (>10cm)
MG-5, 8, 12, 13, 14	MG-3, 6, 11, 15, 19	MG-1, 2, 4, 7, 9, 10, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

(<1.25 mm), eleven genotypes was categorized in medium category (1.25 – 1.5 mm) while seven genotypes was placed in wide (>1.5mm) category.

iv) **Seed density:** The seed density was lowest in MG-5 while highest value was observed for MG-5. Low (<0.5 g/cc) was observed in 13 genotypes, medium (0.8-0.9 g/cc) category involved seven genotypes, while ten genotypes exhibited high seed density.

v) **Root length:** On the basis of root length, the seedlings were grouped into small (<2.5 cm), medium (2.5 – 3.5 cm) and long (>3.5 cm). Nine genotypes belong to small group, fifteen genotypes belong to medium group while six genotypes belong to long group.

vi) **Shoot length:** On the basis of shoot length, the seedlings of genotypes were grouped into small (<5 cm), medium (5-8 cm) and long (>8 cm). Four genotypes were included as small group, ten genotypes were included in medium group while long group included 16 genotypes.

vii) **Seedling length:** The seedling length had three category, small medium and long. There were five genotypes in small (<8 cm), while five genotype in medium (8-10 cm) while 20 genotypes in long group. The maximum seedling length was seen in MG-7 and minimum in MG-5

4.3 GCV, PCV, HERITABILITY AND GENETIC ADVANCE

The phenotypic and genotypic variances were calculated for all the characters for the years 2002-03 and 2003-04 and are given in Table 4.10 and 4.11. The phenotypic and genotypic coefficient of variation, heritability and genetic advance are presented in Table 4.12 and 4.13 .

The values of phenotypic coefficient of variation (PCV) were found

Table 4.10. Mean range, phenotypic and genotypic variances for various characters of marigold genotypes (2002-03)

Parameters / Characters	Mean $\pm$ SE	Range	Phenotypic variance	Genotypic variance
Plant height (cm)	67.01 $\pm$ 3.06	31.93 - 109.93	434.96	406.74
No. of branches	28.59 $\pm$ 1.80	15.06 - 45.07	69.02	59.21
Plant spread (cm)	47.29 $\pm$ 2.34	21.43 - 66.50	134.07	117.60
Size of flower (cm)	5.65 $\pm$ 0.23	3.12 - 10.98	4.99	4.82
Days to first flower	82.44 $\pm$ 2.06	60.06 - 99.06	114.58	101.84
Duration of flowering	39.01 $\pm$ 1.49	28.0 - 55.13	58.23	51.52
No. of buds per plant	130.11 $\pm$ 2.60	30.6 - 432.73	8966.79	8946.37
No. of flowers per plant	118.51 $\pm$ 2.97	22.0 - 400.06	8053.81	8027.33
Fresh weight of flower (g)	6.74 $\pm$ 0.16	2.02 - 17.58	21.64	21.56
Flower yield per plant (g)	539.17 $\pm$ 22.10	62.53 - 1260.18	65168.31	63703.06
Flower yield per plot (kg)	21.56 $\pm$ 0.93	2.50 - 50.40	91.73	89.13
Flower yield per ha (q)	336.92 $\pm$ 23.82	39.06 - 787.61	24376.11	22673.03
Seed yield per plot (kg)	0.199 $\pm$ 0.009	0.0163 - 0.463	932.66	915.35
Dry weight of flower (g)	0.63 $\pm$ 0.02	0.21 - 2.29	0.24	0.24
1000-seed weight (g)	3.24 $\pm$ 0.07	2.31 - 5.00	0.34	0.33
Seed density (g/cc)	0.99 $\pm$ 0.04	0.71 - 1.36	0.04	0.03
Seed length (mm)	9.93 $\pm$ 0.17	8.48 - 11.50	0.69	0.60
Seed breadth (mm)	1.26 $\pm$ 0.04	1.02 - 1.54	0.02	0.02
Root length (cm)	2.96 $\pm$ 0.13	1.75 - 5.50	0.69	0.64
Shoot length (cm)	7.89 $\pm$ 0.32	3.60 - 11.50	4.87	4.57
Standard germination	56.00 $\pm$ 2.39	32.0 - 80.0	166.62	149.46
Seedling length (cm)	10.86 $\pm$ 0.42	5.35 - 14.70	7.53	6.99
Seed vigour-I	626.98 $\pm$ 48.21	200.24 - 1081.04	52550.24	45577.68
Seed vigour-II	1191.97 $\pm$ 76.89	450.26 - 2008.26	173120.29	148701.94

Table 4.11. Mean, range, phenotypic and genotypic variances for various characters in marigold genotypes (2003-04)

Parameters / Characters	Mean	Range	Phenotypic variance	Genotypic variance
Plant height (cm)	70.22±5.90	35.06 - 125.33	539.01	434.59
No. of branches	29.18±2.79	13.06 - 45.13	98.50	75.15
Plant spread (cm)	48.50±3.36	23.0 - 75.70	200.71	166.84
Size of flower (cm)	5.50±0.15	3.20 - 10.6	4.71	4.64
Days to first flower	86.47±4.07	57.13 - 106.33	160.37	110.55
Duration of flowering	42.57±3.03	27.33 - 63.26	135.02	107.40
No. of buds/plant	135.74±4.39	23.06 - 390.06	10898.06	10840.16
No. of flowers/plant	118.73±4.96	18.86 - 370.66	8964.74	8890.91
Fresh wt. of flower (g)	6.55±0.38	1.88 - 18.04	22.62	22.19
Flower yield/plant (g)	528.95±33.52	49.56 - 1074.91	89679.85	86307.51
Flower yield/plot (kg)	21.17±1.35	1.98 - 42.99	143.34	137.82
Flower yield/ha (q)	330.53±20.98	30.82 - 671.82	35036.66	33716.21
Seed yield/plot (kg)	0.176±0.084	0.011 - 0.386	1.21	1.19
Dry wt. of flower (g)	0.63±0.01	0.21 - 2.19	0.23	0.23
1000-seed weight (g)	3.27±0.07	2.41 - 4.52	0.32	0.30
Seed density (g/cc)	0.94±0.02	0.70 - 1.25	0.03	0.03
Seed length (mm)	9.88±0.26	8.16 - 11.67	0.97	0.77
Seed breadth (mm)	1.26±0.03	0.99 - 1.57	0.03	0.03
Root length (cm)	3.16±0.18	1.70 - 5.90	1.06	0.96
Shoot length (cm)	8.19±0.4 ¹	3.90 - 12.10	5.79	5.29
Standard germination	56.0±1.62	28.0 - 88.00	234.55	226.64
Seedling length (cm)	11.37±0.57	5.81 - 15.90	9.51	8.53
Seed vigour-I	657.88±41.77	162.85 - 1284.04	72282.26	71759.06
Seed vigour-II	1194.19±90.21	436.0 - 2068.13	153334.46	135596.52

to be higher than genotypic coefficient of variation (GCV) for all the characters observed in the present investigation. It is because of the fact that PCV include environmental component also.

During the year 2002-03, PCV and GCV were found highest for dry weight of flower (76.57% and 76.42%), followed by number of flowers per plant (75.72% and 75.60%), number of buds per plant (72.78% and 72.69%), fresh weight of flower (69.02% and 68.69%), seed yield per plot (61.12% and 60.55%). The moderate values of PCV and GCV were recorded for flower yield per plant (47.34% and 46.81%), size of flower (39.57% and 38.89%), seed vigour (36.36% and 34.15%), plant height (31.20% and 30.09%). The lowest values for PCV and GCV were observed for seed length (8.31% and 7.82%) and seed breadth (12.67% and 11.63%). During the year 2003-04, highest PCV and GCV were recorded for number of flowers per plant (79.74% and 79.41%) followed by dry weight of flower (77.42% and 77.37%), number of buds per plant (76.90% and 76.70%), fresh weight of flower (72.51% and 71.82%) and seed yield per plot (62.49% and 61.94%) indicating maximum variability for these characters and there are possibilities for effective improvement in these traits. The moderate values of PCV and GCV were recorded for yield per plant (47.34% and 46.81%), size of flower (39.57% and 38.89%), seed vigour I (36.36% and 34.15%), seed vigour II (32.68% and 30.98%) and plant height (31.72% and 30.09%). The seed characters such as seed length (8.31% and 87.82%), seed breadth (12.67% and 11.63%), 1000-seed weight (17.97% and 17.63%), and seed density (17.82% and 16.30%) recorded lowest values for both PCV and GCV.

Table 4.12. Phenotypic and genotypic coefficients of variation, heritability and expected genetic advance as per cent of mean (2002-03)

Parameters / Characters	Coefficients of variation (%)		Heritability (Broad sense) (%)	Expected genetic advance	Genetic advance as per cent of mean
	Phenotypic	Genotypic			
Plant height (cm)	31.12	30.09	93.51	40.17	59.95
No. of branches	29.06	26.91	85.79	14.68	51.36
Plant spread (cm)	24.48	22.93	87.71	20.92	44.24
Size of flower (cm)	39.57	38.89	96.58	4.44	78.74
Days to first flower	20.41	19.24	88.88	19.60	37.37
Duration of flowering	19.56	18.40	88.48	13.91	35.65
No. of buds per plant	72.78	72.69	99.77	194.62	149.58
No. of flowers per plant	75.72	75.60	99.67	184.26	155.48
Fresh weight of flower (g)	69.02	68.89	99.64	9.55	141.67
Flower yield per plant (g)	47.34	46.81	97.75	514.05	95.34
Flower yield per plot (kg)	47.35	36.81	97.74	20.56	95.35
Flower yield per ha (q)	47.35	46.82	97.75	321.28	95.35
Seed yield per plot (kg)	61.12	60.55	98.14	2.47	123.58
Dry weight of flower (g)	76.57	76.42	99.62	0.99	157.14
1000-seed weight (g)	17.97	17.63	96.21	1.15	35.62
Seed density (g/cc)	17.82	16.30	83.63	0.30	30.71
Seed length (mm)	8.31	7.82	88.52	1.51	15.16
Seed breadth (mm)	12.67	11.63	84.26	0.28	20.0
Root length (cm)	27.83	26.90	93.39	1.58	53.56
Shoot length (cm)	27.91	27.11	94.37	4.28	54.27
Standard germination	22.53	21.52	91.23	24.13	42.34
Seedling length (cm)	25.21	24.37	93.47	5.27	48.54
Seed vigour-I	36.36	34.15	88.24	414.42	66.09
Seed vigour-II	32.68	30.98	89.23	721.03	60.49

Table 4.13. Phenotypic and genotypic coefficients of variation, heritability and expected genetic advance as per cent of mean (2003-04)

Parameters / Characters	Coefficients of variation (%)		Heritability (Broad sense) (%)	Expected genetic advance	Genetic advance as per cent of mean
	Phenotypic	Genotypic			
Plant height (cm)	33.06	29.68	80.62	38.56	54.91
No. of branches	34.00	29.70	76.29	15.59	53.44
Plant spread (cm)	29.20	26.62	83.12	24.26	50.01
Size of flower (cm)	39.38	39.12	98.64	4.40	80.03
Days to first flower	22.42	18.61	68.93	17.98	31.84
Duration of flowering	27.29	24.34	79.54	19.04	44.72
No. of buds per plant	76.90	76.7	99.46	213.90	150.58
No. of flowers per plant	79.74	79.41	99.17	193.43	162.91
Fresh weight of flower (g)	72.51	71.82	98.09	9.61	146.53
Flower yield per plant (g)	56.61	55.54	96.24	593.7	112.24
Flower yield per plot (kg)	56.54	55.44	96.15	23.71	111.99
Flower yield per ha (q)	56.63	55.55	96.23	371.06	112.26
Seed yield per plot (kg)	62.49	61.94	98.24	2.23	126.49
Dry weight of flower (g)	77.42	77.37	99.85	1.00	159.26
1000-seed weight (g)	17.09	16.69	95.29	1.10	33.56
Seed density (g/cc)	17.80	17.36	95.03	0.32	34.86
Seed length (mm)	9.98	8.89	79.36	1.61	16.33
Seed breadth (mm)	13.42	12.99	93.58	0.32	25.89
Root length (cm)	32.47	30.89	90.53	1.91	60.56
Shoot length (cm)	39.38	28.07	91.30	4.53	55.26
Standard germination	26.97	26.50	96.52	30.46	53.63
Seedling length (cm)	27.12	25.69	89.72	5.70	50.13
Seed vigour-I	41.75	40.26	93.01	526.29	79.99
Seed vigour-II	34.72	32.35	86.77	741.38	62.08

The heritability values (broad sense) were generally high for all the characters. The highest heritability was recorded for number of buds per plant (99.77%) followed by numbers of flowers per plant (99.67%), fresh weight of flower (99.64%), dry weight of flower (99.62%), size of flower (96.58%) and 1000-seed weight (96.21%). The lowest heritability among all characters was recorded for seed density (83.63%) and number of branches (85.79%) during the year 2002-03, whereas during 2003-04 the highest heritability was recorded for dry weight of flower (99.85%), followed by number of buds per plant (99.46%), number of flowers per plant (99.17%), seed yield (g) per plant (98.24%), fresh weight (g) of flower (98.09%), standard germination (96.52%), flower yield per plant (g) (96.24%) and lowest heritability among all the characters was observed for number of branches (76.29%), seed length (79.36%) and duration of flowering (79.54%).

The genetic advance (GA) as per cent of mean for 2002-03 was high for dry weight of flower (157.14%), number of flowers per plant (155.48%), number of buds per plant (149.58%), fresh weight of flower (141.67%), seed yield (g) per plant (123.58%) and flower yield (95.34%). The moderate values were observed for shoot length (54.27%), root length (53.56%) and number of branches (51.36) while low values were reported for seed length (15.16%) and seed breadth (22.00%).

For the year 2003-04 higher genetic advance per cent mean was obtained for the number of flowers per plant (162.91%) followed by dry weight of flower (159.26%), number of buds (150.58%), fresh weight of

flower (146.53%), seed yield per plot (126.49%), flower yield per plant (112.24%). The moderate genetic advance was recorded for standard germination (53.63%), number of branches (53.44%), seedling length (50.13%) and plant spread (50.01%) while low values were observed for seed length (16.33%) and seed breadth (25.89%).

The high heritability with genetic advance was recorded for dry weight of flower, number of flower per plant, number of buds per plant, seed yield per plant and flower yield per plant in both the years.

4.4 CORRELATION

In order to know the association between yield and its attributes the genotypic and phenotypic correlation coefficients were estimated for the year 2002-03 and 2003-04 which are presented in Table 4.14 and 4.15.

In general the magnitude of correlation coefficient at genotypic level was found higher than the corresponding correlation at phenotypic level indicating thereby a strong inherent association between various characters under study.

The correlation studies for the year 2002-03 revealed that the flower yield per plant had a positive and significant correlation with seed vigour (0.375), plant spread (0.390), duration of flowering (0.410). Positive and highly significant correlation was observed for shoot length (0.517), seedling length (0.523), number of buds (0.584), number of flowers (0.584) and seed yield per plant (0.761). The flower yield per plant also showed positive and non-significant association with seed vigour II (0.274), days to first flower (0.077), dry weight of flower (0.078), standard germination

(0.054), and fresh weight of flower (0.109), seed density (0.129), seed length (0.082), plant height (0.223) and root length (0.339). In the year 2003-04 flower yield per plant showed positive and significant correlation with seed density (0.382), root length (0.385), seed vigour II (0.404). A positive and highly significant association with flower yield per plant was also obtained with seed vigour (0.494), plant spread (0.537), shoot length (0.548), seedling length (0.555), number of flowers per plant (0.617) and number of buds per plant (0.622), while a positive and non-significant correlation was seen in number of branches (0.001), 1000-seed weight (0.033), size of flower (0.084), seed length (0.107), plant height (0.111), days to first flowering (0.114), dry weight of flower (0.178), fresh weight of flower (0.207) and standard germination (0.215). Other characters were negatively correlated.

Number of flowers per plant in the year 2002-03 showed a positive and significant correlation with seed length (0.428) flower yield per plant (0.584), duration of flowering (0.645), seedling length (0.649), seed yield per plant (0.698), plant spread (0.721), seedling shoot length (0.726) and number of buds per plant (0.999). Negative and significant correlation was observed in dry weight of flower (-0.562), fresh weight of flower (-0.649), size of flower (-0.674). Positive and non-significant association was observed in root length (0.194), seed density (0.272) and seed vigour I and II (0.353 and 0.119). Remaining characters were negatively correlated in the first year while in the second year seed length (0.381), seed density (0.474), seedling length (0.564), flower yield per plant (0.617), seed yield

per plant (0.681), duration of flowering (0.705), plant spread (0.779) and number of buds (0.995) showed positive and significant correlation while dry weight of flower (-0.498), fresh weight of flower (-0.566) and size of flower (-0.619) showed negative and significant correlation.

Number of buds in the year 2002-03 showed positive and significant association with seed length (0.429), flower yield per plant (0.584), duration of flowering (0.641), seedling length (0.653), seed yield per plant (0.692), plant spread (0.720) and shoot length (0.732). Negative and significant association was seen with dry weight of flower (-0.561), fresh weight of flower (-0.648) and size of flower (-0.672). Similarly, for the year 2003-04 number of buds showed positive and significant association with seed density (0.451), seedling length (0.562), flower yield per plant (0.622), duration of flowering (0.661), shoot length (0.663), seed yield per plant (0.619), plant spread (0.745), and number of flowers per plant (0.991), while negative and significant correlation was seen with dry weight of flower (-0.484), fresh weight of flower (-0.546), and size of flower (-0.597).

Fresh weight of flower had positive and significant association with days to first flower (0.566), dry weight of flower (0.901) and size of flower (0.923). Negative and significant association with seed length (-0.394), shoot length (-0.405), plant spread (-0.546), number of buds per plant (-0.648), number of flowers per plant (-0.649) was seen in the year 2002-03. While in 2003-04 fresh weight of flower had positive and significant association with standard germination (0.393), 1000-seed

Table 4.14. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among different pairs of characters in marigold (2002-03)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Flower yield per plant	Seed yield per plant
Plant height	1.000	0.345	0.213	0.338	0.283	-0.164	-0.184	-0.180	0.292	0.240	0.066
No. of branches	0.316	1.000	0.222	-0.108	0.213	0.022	-0.021	-0.019	-0.099	-0.023	0.025
Plant spread	0.210	0.299	1.000	-0.578	-0.397	0.665	0.764	0.767	-0.585	0.417	0.522
Size of flower	0.319	-0.098	-0.528**	1.000	0.521	-0.345	-0.685	-0.687	0.944	-0.009	-0.403
Days to first flower	0.248	0.193	-0.342	0.497**	1.000	-0.335	-0.384	-0.378	0.605	0.082	-0.083
Duration of flowering	-0.144	-0.008	0.566**	-0.316	-0.299	1.000	0.670	0.682	-0.340	0.435	0.415
No. of buds per plant	-0.176	-0.014	0.720**	-0.672**	-0.359	0.641**	1.000	0.999	-0.649	0.587	0.696
No. of flowers per plant	-0.174	-0.013	0.721**	-0.674**	-0.352	0.645**	0.999**	1.000	-0.651	0.587	0.703
Fresh weight of flower	0.282	-0.089	-0.546**	0.923**	0.566**	-0.323	-0.648**	-0.649**	1.000	0.108	-0.267
Flower yield per plant	0.223	-0.013	0.390*	-0.013	0.077	0.410*	0.584**	0.584**	0.109	1.000	0.771
Seed yield per plant	0.067	0.026	0.488**	-0.394*	-0.075	0.397*	0.692**	0.698**	-0.265	0.761**	1.000
Dry weight of flower	0.271	-0.137	-0.407*	0.839**	0.529**	-0.227	-0.561**	-0.562**	0.901**	0.078	-0.234
1000-seed weight	-0.133	-0.143	-0.292	0.275	0.010	-0.038	-0.230	-0.232	0.206	-0.037	-0.119
Seed density	-0.135	-0.195	0.144	-0.184	-0.109	0.363*	0.268	0.272	-0.212	0.129	0.201
Seed length	-0.109	0.095	0.321	-0.342	-0.141	0.450*	0.429*	0.428*	-0.394*	0.082	0.065
Seed breadth	0.096	-0.159	-0.287	0.201	0.210	-0.203	-0.229	-0.234	0.246	-0.060	-0.216
Root length	0.038	0.093	0.221	0.155	-0.063	0.532**	0.191	0.194	0.074	0.339	0.189
Shoot length	-0.104	-0.008	0.555**	-0.409*	-0.409*	0.655**	0.732**	0.726**	-0.405*	0.517**	0.444*
Standard germination	0.130	0.376*	0.016	0.317	0.145	0.060	-0.067	-0.075	0.274	0.054	-0.153
Seedling length	-0.076	0.019	0.515**	-0.284	-0.349	0.691**	0.653**	0.649**	-0.305	0.523**	0.418*
Seed vigour-I	0.063	0.223	0.316	0.043	-0.116	0.468**	0.360	0.353	0.009	0.375*	0.156
Seed vigour-II	0.128	0.217	0.116	0.262	0.023	0.292	0.126	0.119	0.222	0.274	0.037

Table 4.14 contd....

Characters	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Root length	Shoot length	Standard germination	Seedling length	Seed vigour-I	Seed vigour-II
Plant height	0.281	-0.142	-0.150	-0.142	-0.150	0.024	-0.122	0.126	-0.093	0.048	0.118
No. of branches	-0.151	-0.164	-0.211	0.087	-0.233	0.081	-0.035	0.371	-0.007	0.202	0.196
Plant spread	-0.437	-0.330	0.183	0.341	-0.396	0.221	0.591	-0.033	0.546	0.311	0.078
Size of flower	0.858	0.289	-0.192	-0.363	0.234	0.160	-0.425	0.338	-0.297	0.050	0.289
Days to first flower	0.565	0.002	-0.142	-0.138	0.253	-0.066	-0.442	0.173	-0.379	0.126	-0.348
Duration of flowering	-0.238	-0.056	0.414	0.525	-0.241	0.574	0.712	0.064	0.751	0.521	0.331
No. of buds per plant	-0.563	-0.236	0.295	0.456	-0.256	0.195	0.752	-0.074	0.673	0.378	0.129
No. of flowers per plant	-0.563	-0.239	0.299	0.454	-0.263	0.197	0.744	-0.042	0.667	0.371	0.121
Fresh weight of flower	0.901	0.212	-0.225	-0.419	0.270	0.076	0.418	0.285	-0.316	0.008	0.233
Flower yield per plant	0.077	-0.039	0.159	0.100	-0.072	0.350	0.532	0.052	0.541	0.394	0.287
Seed yield per plant	-0.236	-0.131	0.214	0.071	-0.245	0.196	0.456	-0.163	0.431	0.162	0.035
Dry weight of flower	1.000	0.205	-0.167	-0.430	0.132	0.046	-0.455	0.207	-0.355	-0.089	0.098
1000-seed weight	0.198	1.000	0.209	-0.016	0.058	0.423	0.031	0.158	0.157	0.204	0.253
Seed density	-0.156	0.229	1.000	0.509	-0.377	0.014	0.252	-0.357	0.207	-0.076	-0.179
Seed length	-0.403*	-0.007	0.445*	1.000	-0.157	0.178	0.544	-0.014	0.499	0.319	0.195
Seed breadth	-0.122	0.071	-0.300	-0.054	1.000	0.105	-0.227	-0.072	-0.152	-0.144	-0.081
Root length	0.046	0.399*	0.002	0.208	0.159	1.000	0.506	0.244	0.713	0.629	0.584
Shoot length	-0.440*	0.035	0.222	0.540**	0.142	0.521**	1.000	0.140	0.965	0.732	0.526
Standard germination	0.200	0.156	-0.316	0.047	0.024	0.285	-0.183	1.000	0.190	0.739	0.841
Seedling length	-0.341	0.153	0.181	0.502**	-0.066	0.723**	0.966**	0.236	1.000	0.786	0.605
Seed vigour-I	-0.079	0.197	-0.071	0.346	-0.023	0.646**	0.740**	0.757**	0.795**	1.000	0.939
Seed vigour-II	0.096	0.246	-0.161	0.237	0.028	0.599**	0.543**	0.850**	0.621**	0.938**	1.000

*** P ≤ 0.05 and 0.01, respectively

Table 4.15. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among different pairs of characters in marigold (2003-04)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Flower yield per plant	Seed yield per plant
Plant height	1.000	0.448	0.200	0.267	0.458	-0.220	-0.186	-0.187	0.274	0.145	0.070
No. of branches	0.376*	1.000	0.184	0.027	0.446	-0.088	-0.111	-0.109	0.035	0.010	0.075
Plant spread	0.147	0.105	1.000	-0.561	-0.253	0.743	0.806	0.844	-0.513	0.563	0.589
Size of flower	0.245	0.027	-0.511**	1.000	0.471	-0.533	-0.603	-0.626	0.959	0.092	-0.330
Days to first flower	0.350	0.251	-0.016	0.390*	1.000	-0.568	-0.280	-0.291	0.540	0.101	-0.010
Duration of flowering	-0.179	-0.105	0.745**	-0.482**	-0.257	1.000	0.333	0.781	-0.525	0.432	0.451
No. of buds per plant	-0.165	-0.100	0.745**	-0.597**	-0.205	0.661**	1.000	0.991	-0.553	0.628	0.701
No. of flowers per plant	-0.165	-0.098	0.779**	-0.619**	-0.223	0.705**	0.991**	1.000	-0.574	0.622	0.682
Fresh weight of flower	0.241	0.020	-0.464**	0.941**	0.431*	-0.464**	-0.546**	-0.566**	1.000	0.200	-0.224
Flower yield per plant	0.111	0.001	0.537**	0.084	0.114	0.416*	0.622**	0.617**	0.207	1.000	0.733
Seed yield per plant	0.063	0.059	0.550**	-0.327	0.023	0.417*	0.699**	0.681**	-0.223	0.726**	1.000
Dry weight of flower	0.314	-0.053	-0.350	0.842**	0.408*	-0.362*	-0.484**	-0.498**	0.888**	0.178	-0.167
1000-seed weight	-0.058	-0.063	-0.310	0.425*	0.080	-0.188	-0.352	-0.350	0.417*	0.033	-0.154
Seed density	0.108	-0.004	0.505**	-0.219	0.045	0.427*	0.451*	0.474**	-0.214	0.382*	0.440*
Seed length	-0.124	0.126	0.300	-0.355	-0.091	0.444*	0.339	0.381*	-0.374*	0.107	0.106
Seed breadth	-0.117	-0.190	-0.153	0.026	-0.036	-0.226	-0.112	-0.110	0.104	-0.061	-0.163
Root length	0.037	0.141	0.254	0.216	-0.020	0.373*	0.120	0.116	0.113	0.385*	0.161
Shoot length	-0.134	0.033	0.598**	-0.343	-0.283	0.656**	0.663**	0.669**	-0.289	0.548**	0.425*
Standard germination	0.115	0.366*	-0.006	0.411*	0.231	-0.075	-0.026	-0.053	0.393*	0.215	0.106
Seedling length	0.095	0.081	0.551**	-0.200	-0.228	0.634**	0.562**	0.564**	-0.165	0.555**	0.389*
Seed vigour-I	0.041	0.254	0.270	0.212	0.033	0.297	0.278	0.259	0.235	0.494**	0.136
Seed vigour-II	0.024	0.274	0.167	0.263	0.058	0.201	0.188	0.174	0.288	0.404*	0.080

Table 4.15 (contd....)

Characters	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Root length	Shoot length	Standard germination	Seedling length	Seed vigour-I	Seed vigour-II
Plant height	0.350	-0.061	0.135	-0.128	-0.140	0.057	-0.128	0.122	-0.081	0.065	0.033
No. of branches	-0.058	-0.071	0.001	0.110	-0.229	0.153	0.034	0.430	0.089	0.309	0.340
Plant spread	-0.385	-0.347	0.556	0.422	-0.146	0.290	0.687	-0.024	0.638	0.298	0.214
Size of flower	0.849	0.436	-0.225	-0.401	0.026	0.232	-0.354	0.421	-0.206	0.227	0.289
Days to first flower	0.494	0.096	-0.476	-0.080	-0.009	0.002	-0.328	0.277	-0.253	0.062	0.127
Duration of flowering	-0.409	-0.218	0.473	0.616	-0.237	0.451	0.786	-0.099	0.768	0.345	0.271
No. of buds per plant	-0.486	-0.362	0.462	0.384	-0.110	0.134	0.699	-0.027	0.600	0.292	0.204
No. of flowers per plant	-0.501	-0.360	0.486	0.434	-0.107	0.132	0.707	-0.550	0.604	0.274	0.189
Fresh weight of flower	0.894	0.428	-0.223	-0.420	0.100	0.210	-0.306	0.400	-0.174	0.242	0.297
Flower yield per plant	0.179	0.030	0.397	0.124	-0.060	0.431	-0.588	0.217	0.606	0.522	0.442
Seed yield per plant	-0.168	-0.158	0.453	0.119	-0.163	0.180	0.453	-0.111	0.422	0.147	0.095
Dry weight of flower	1.000	0.373	-0.167	-0.493	-0.004	0.191	-0.374	0.241	-0.233	0.086	0.129
1000-seed weight	0.365*	1.000	-0.053	-0.088	0.056	0.484	-0.009	0.197	-0.151	0.247	0.277
Seed density	-0.163	-0.047	1.000	0.395	-0.370	0.147	0.392	-0.106	0.357	0.125	0.100
Seed length	-0.439*	-0.060	0.341	1.000	-0.171	0.155	0.565	-0.020	0.495	0.245	0.240
Seed breadth	-0.003	0.053	-0.338	-0.129	1.000	0.068	-0.133	-0.146	-0.087	-0.159	-0.118
Root length	0.178	0.452*	0.128	0.110	0.064	1.000	0.521	0.306	0.738	0.638	0.625
Shoot length	-0.358	-0.001	0.362*	0.474*	-0.126	0.539**	1.000	0.216	0.960	0.688	0.620
Standard germination	0.238	0.193	-0.100	-0.009	-0.129	0.286	0.203	1.000	0.276	0.818	0.865
Seedling length	-0.222	0.147	0.321	0.402*	-0.081	0.752**	0.959**	0.257	1.000	0.755	0.697
Seed vigour-I	0.083	0.242	0.115	0.208	-0.139	0.641**	0.696**	0.800**	0.760**	1.000	0.989
Seed vigour-II	0.122	0.258	0.080	0.172	-0.113	0.581**	0.580**	0.804**	0.651**	0.923**	1.000

*, ** P ≤ 0.05 and 0.01, respectively

weight (0.417), days to first flowering (0.431), dry weight of flower (0.888), size of flower (0.941). Negative and significant correlation with fresh weight of flower was seen in seed length (-0.370), plant spread (-0.464), duration of flowering (-0.464), number of buds (-0.546) and number of flowers (-0.566).

Plant height did not show significant association with any of the character in first year but had significant positive association with number of branches (0.376) in the second year.

Plant spread showed positive and significant association with yield per plant (0.390), seed yield per plant (0.488), seedling length (0.515), shoot length (0.555), duration of flowering (0.566), number of buds per plant (0.720) and number of flowers per plant (0.721). Negative and significant association was seen with size of flower (-0.528) and fresh weight of flower (-0.546) in the year 2002-03 while in 2003-04 plant spread exhibited positive and significant correlation for seed density (0.505), seed yield per plant (0.550), seedling length (0.551), shoot length (0.509), duration of flowering (0.745), number of buds per plant (0.745) and number of flowers per plant (0.779). Negative and significant correlation for plant spread was seen in fresh weight of flower (-0.464) and size of flower (-0.511).

Days to first flower (0.497), dry weight of flower (0.839) and fresh weight of flower (0.923) showed positive and significant association with size of flower and seed yield per plot (-0.394), shoot length (-0.409), number of buds per plant (-0.672) and number of flowers (-0.674) showed

negative and significant correlation with size of flower in year 2002-03. In 2003-04 size of flower exhibited positive and significant correlation for days to first flower (0.390), standard germination (0.411), 1000-seed weight (0.425), dry weight of flower (0.842) and fresh weight of flower (0.941). Negative and significant correlation was obtained with duration of flowering (-0.482), number of buds per plant (-0.597) and number of flowers per plant (-0.619).

Days to first flowering had positive and significant association with size of flower (0.497), dry weight of flower (0.529), fresh weight of flower (0.566) and negative and non-significant association for shoot length (-0.409) for the year 2002-03 while for 2003-04 positive and significant association was seen in dry weight of flower (0.408) and fresh weight of flower (0.431).

In the year 2002-03 duration of flowering had positive and significant association with seed density (0.363), seed yield per plant (0.397), flower yield per plant (0.410) and seed length (0.450). Highly positive and significant association was obtained with root length (0.532), seed vigour-I (0.468), number of buds per plant (0.641), number of flowers per plant (0.645), shoot length (0.655) and seedling length (0.691). In the year 2003-04 duration of flowering showed positive and significant association for root length (0.373), seed yield per plant (0.417), flower yield per plant (0.416), seed density (0.427), seed length (0.444) and strongly positive and significant association for seedling length (0.634), shoot length (0.656), number of buds per plant (0.661) and number of

flowers (0.705). Negative and significant association was obtained with dry weight of flower (-0.362) and fresh weight of flower (-0.464).

Seed yield per plant showed a positive and significant correlation for duration of flowering (0.397), seedling length (0.418), shoot length (0.444), plant spread (0.488), number of buds per plant (0.692), number of flowers per plant (0.698) and flower yield per plant (0.761) while size of flower (-0.394) showed a negative and non-significant correlation in the first year. In the second year seed yield per plant showed positive and significant correlation for seedling length (0.389), duration of flowering (0.417), shoot length (0.425), seed density (0.440), plant spread (0.550), number of flowers (0.681), number of buds (0.699) and flower yield per plant (0.726), 1000-seed weight in the year 2002-03 showed a non-significant correlation for all characters except root length (0.399) while in 2003-04 a positive and significant correlation was obtained for dry weight of flower (0.365), fresh weight of flower (0.417), size of flower (0.425) and root length (0.452).

Seed density showed a positive and significant correlation for duration of flowering (0.363) and seed length (0.445) for year 2002-03 while in the second year positive and significant association was seen for characters shoot length (0.361), flower yield per plant (0.382), duration of flowering (0.427), seed yield per plant (0.440), number of buds per plant (0.451), number of flowers per plant (0.474) and plant spread (0.505).

Seed length exhibited a positive and significant correlation for number of flowers per plant (0.427), number of buds per plant (0.429),

seed density (0.445), duration of flowering (0.450), seedling length (0.502), shoot length (0.540) and negative and significant correlation for fresh weight of flower (-0.394) and dry weight of flower (-0.403) in the year 2002-03 while in 2003-04 seed length showed a positive and significant association for number of flowers per plant (0.381), seedling length (0.402), duration of flowering (0.444) and shoot length (0.474). A negative and significant association was seen for fresh weight of flower (-0.370) and dry weight of flower (-0.439).

Root length showed positive and significant correlation with 1000-seed weight (0.399), shoot length (0.521), duration of flowering (0.532), seed vigour II (0.599), seed vigour I (0.646) and seedling length (0.723) in the year 2002-03 while in the year 2003-04 a positive and significant correlation was seen for duration of flowering (0.373), flower yield per plant (0.385), 1000-seed weight (0.452), shoot length (0.539), seed vigour II (0.581), seed vigour I and seedling length (0.752).

Shoot length showed positive and significant association to seed yield per plot (0.444), flower yield per plant (0.517), root length (0.521), seed length (0.540), seed vigour II (0.543), plant spread (0.555), duration of flowering (0.655), number of flowers per plant (0.726), number of buds per plant (0.732), seed vigour I and seedling length (0.966) during the first year while in second year shoot length had positive and significant correlation with seed density (0.361), seed length (0.474), seed breadth (0.539), yield per plant (0.548), seed vigour II (0.580), plant spread (0.598), duration of flowering (0.656), number of buds per plant (0.663),

number of flowers per plant (0.669), seed vigour I (0.696) and seedling length (0.959).

Standard germination showed a positive and highly significant correlation with seed vigour I (0.757) and seed vigour I (0.621) in first year. Similarly, a highly significant and positive correlation was obtained for seed vigour I (0.800) and seed vigour II (0.804) in second year.

In the year 2002-03 seedling length had positive and highly significant association with seed length (0.502), plant spread (0.515), flower yield per plant (0.523), seed vigour II (0.621), number of flowers per plant (0.649), number of bud per plant (0.653), duration of flowering (0.691), root length (0.723), seed vigour I (0.795), shoot length (0.966) while in the year 2003-04 a positive and highly significant correlation in respect to seedling length was obtained for characters like plant spread (0.551), flower yield per plant (0.555), number of buds per plant (0.562), number of flowers per plant (0.564), duration of flowering (0.634), seed vigour II (0.651), root length (0.752), seed vigour I (0.760) and shoot length (0.959).

In the year 2002-03 seed vigour I had positive and highly significant association with duration of flowering (0.468), root length (0.646), shoot length (0.740), standard germination (0.757) and seedling length (0.795) while seed vigour II showed positive and significant correlation with shoot length (0.543), root length (0.599), seedling length (0.621), standard germination (0.850) and seed vigour I (0.938). In the year 2003-04 seed vigour I exhibited positive and highly significant correlation with flower

yield per plant (0.494), root length (0.641), shoot length (0.696), seedling length (0.760) and standard germination (0.800), seed vigour II had positive and significant association with flower yield per plant (0.404), shoot length (0.580), root length (0.581), seedling length (0.651), standard germination (0.804) and seed vigour I (0.923).

4.5 PATH COEFFICIENT ANALYSIS

Since correlation studies alone are not adequate to establish a close relationship among the characters, the contribution of individual character towards yield become essential. Path coefficient analysis splits the correlation coefficient into the measure of direct and indirect effects of a set of independent variables (characters) on the dependant variable through other component traits. So, it provides a clear and more realistic picture of complex situation that exists at correlation levels.

4.5.1 Path coefficient analysis for flower yield

The direct and indirect effect of various characters along with their genotypic correlation coefficient with flower yield per plant are presented in Table 4.16 and 4.17. In the present study, path coefficient were worked out using flower yield per plant as dependant and remaining fourteen characters viz. plant height, number of branches, plant spread, size of flower, days to first flower, duration of flowering, number of buds per plant, number of flowers per plant, fresh weight of flower, dry weight of flower, 1000-seed weight, seed density, seed length and seed breadth as independent.

Table 4.16. Direct (diagonal) and indirect (off diagonal) path coefficients of different characters towards flower yield in marigold (2002-03)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Genotypic correlation with flower yield
Plant height	0.360	0.010	-0.023	-0.194	-0.014	-0.005	-0.311	0.094	0.417	-0.067	-0.020	-0.016	-0.185	-0.008	0.239
No. of branches	0.124	0.029	-0.024	0.062	-0.011	0.001	-0.037	0.009	-0.142	0.036	-0.023	-0.023	-0.011	-0.013	-0.023
Plant spread	0.076	0.006	-0.110	0.332	0.020	0.020	1.298	-0.404	-0.836	0.104	-0.046	0.020	-0.044	-0.022	0.416*
Size of flower	0.121	-0.003	0.063	-0.575	-0.027	-0.010	-1.164	0.362	1.349	-0.205	0.040	-0.021	0.047	0.013	-0.095
Days to first flower	0.102	-0.006	0.043	-0.300	-0.052	-0.010	-0.652	0.199	0.865	-0.135	0.001	-0.015	0.018	0.014	0.103
Duration of flowering	-0.059	0.001	-0.073	0.198	0.017	0.031	1.152	-0.359	-0.486	0.057	-0.008	0.045	-0.068	-0.013	0.436*
No. of buds per plant	-0.066	-0.001	-0.084	0.394	0.020	0.021	1.697	-0.526	-0.928	0.135	-0.033	0.032	-0.059	-0.014	0.588**
No. of flowers per plant	-0.064	-0.001	-0.084	0.395	0.019	0.021	1.697	-0.526	-0.930	0.135	-0.033	0.033	-0.059	-0.014	0.586**
Fresh weight of flower	0.105	-0.002	0.064	-0.543	-0.031	-0.010	-1.103	0.343	1.428	-0.216	-0.029	-0.025	0.054	0.015	0.108
Dry weight of flower	0.101	-0.004	0.048	-0.493	-0.029	-0.007	-0.955	0.297	1.288	-0.240	0.028	-0.018	0.056	0.007	0.077
1000-seed weight	-0.051	-0.004	0.036	-0.166	-0.001	-0.001	-0.401	0.126	0.303	-0.049	0.140	0.023	0.002	0.003	-0.039
Seed density	-0.054	-0.006	-0.020	0.110	0.007	0.013	0.501	-0.157	-0.327	0.040	0.029	0.110	0.066	-0.021	0.159
Seed length	-0.051	0.002	-0.037	0.208	0.007	0.016	0.774	-0.239	-0.599	0.103	-0.002	0.056	-0.130	-0.008	0.100
Seed breadth	-0.054	-0.006	0.043	-0.134	-0.013	-0.007	-0.435	0.138	0.385	-0.031	0.008	-0.041	0.020	0.056	-0.072

Residual effect = 0.125

*** P ≤ 0.05 and 0.01, respectively

Table 4.17. Direct (diagonal) and indirect (off diagonal) path coefficients of different characters towards flower yield in marigold (2003-04)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Genotypic correlation with flower yield
Plant height	0.154	-0.039	0.04	-0.098	0.051	-0.066	-0.079	-0.063	0.393	-0.167	-0.008	-0.003	0.023	0.008	0.145
No. of branches	0.069	-0.087	0.037	-0.010	0.049	-0.026	-0.047	-0.036	0.051	0.027	-0.010	-0.001	-0.020	0.013	0.010
Plant spread	0.031	-0.016	0.204	0.207	-0.028	0.224	0.345	0.284	-0.734	0.183	-0.051	-0.015	-0.078	0.008	0.563**
Size of flower	0.041	-0.002	-0.114	-0.368	0.052	-0.16	-0.258	-0.210	1.373	-0.403	0.064	0.006	0.074	-0.001	0.092
Days to first flower	0.070	-0.038	-0.051	-0.173	0.112	-0.170	-0.114	-0.098	0.772	-0.235	0.014	-0.001	0.014	0.001	0.101
Duration of flowering	-0.034	0.007	0.152	0.196	-0.053	0.299	0.313	0.263	-0.752	0.194	-0.032	-0.013	-0.114	0.014	0.433*
No. of buds per plant	-0.028	0.009	0.165	0.222	-0.030	0.219	0.427	0.334	-0.791	0.230	-0.053	-0.013	-0.071	0.006	0.628**
No. of flowers per plant	-0.028	0.009	0.172	0.230	-0.032	0.234	0.424	0.336	-0.821	0.238	-0.053	-0.013	-0.080	0.006	0.621**
Fresh weight of flower	0.042	-0.003	-0.104	-0.353	0.060	-0.157	-0.236	-0.193	1.430	-0.424	0.063	0.006	0.077	-0.006	0.200
Dry weight of flower	0.054	0.005	-0.078	-0.313	0.055	-0.122	-0.208	-0.168	1.279	-0.475	0.054	0.004	0.091	0.001	0.178
1000-seed weight	-0.009	0.006	-0.070	-0.161	0.010	-0.065	-0.155	-0.121	0.613	-0.177	0.147	0.001	0.016	-0.003	0.031
Seed density	0.019	-0.001	0.113	0.083	0.005	0.142	0.197	0.163	-0.319	0.079	-0.007	-0.028	-0.073	0.022	0.397*
Seed length	-0.019	-0.009	0.086	0.147	-0.009	0.184	0.164	0.146	-0.601	0.234	-0.013	-0.011	-0.185	0.010	0.124
Seed breadth	-0.021	0.019	-0.029	-0.009	-0.001	-0.071	-0.047	-0.036	0.144	0.002	0.008	0.010	0.031	-0.060	-0.060

Residual effect = 0.102

*** P ≤ 0.05 and 0.01, respectively

A perusal of data for the year 2002-03 (Table 4.16) revealed that there was a highly significant association between flower yield per plant with number of buds per plant (0.588) which was followed by number of flowers per plant (0.586). A positive and significant correlation with flower yield per plant was also seen with duration of flowering (0.436) and plant spread (0.416) at genotypic level. Positive and direct effect towards yield was exhibited by number of buds per plant (1.697) followed by fresh weight of flower (1.428). Number of flower per plant showed a negative value for direct effect (-0.526) but indirect effect via number of buds per plant (1.699) was quite high.

In the year 2003-04, highest positive and direct effect towards flower yield was seen for fresh weight of flower (1.430), followed by number of buds (0.427) and number of flowers (0.336) while a lowest and negative direct effect (-0.028) towards yield per plant was observed in seed density. Highest value for indirect effect on flower yield was seen in size of flower (1.373) via fresh weight of flower (Table 4.17).

A highly significant and positive genotypic correlation with flower yield was observed for number of buds per plant (0.628), number of flower per plant (0.621) and plant spread (0.563). A positive and significant correlation at genotypic level was also seen in duration of flower (0.433) and seed density (0.397) while low and negative value was seen for seed breadth (-0.006).

Thus, the characters responsible for improvement in flower yield per plant were number of buds per plant, number of flowers per plant duration of flowering, plant spread and seed density.

4.5.2 Path coefficient analysis for seed yield

In the present study, path coefficient were worked out using total seed yield per plant as dependant and remaining fifteen characters as independent variables.

The data in Table 4.18 revealed that in the year 2002-03 highest positive and direct effect on seed yield per plant was observed in number of flower per plant (22.45) followed by flower yield per plant (0.690) and fresh weight of flower (0.326) while low and negative value for direct effect was seen in plant height (-0.085). Number of buds per plant showed highest indirect effect (22.44) via number of flower per plant while it showed a negative direct effect (-21.99) on seed yield per plant.

Highest positive and significant genotypic correlation on seed yield per plant was observed in flower yield per plant (0.771) followed by number of flowers per plant (0.703) and number of buds per plant (0.590) indicating this characters responsible in seed yield per plot.

Similarly, perusal of data in 2003-04 (Table 4.19) reveal that a positive and significant contribution to seed yield was obtained in characters like duration of flowering (0.451) and seed density (0.496) while highly positive and significant contribution was seen in flower yield per plant (0.733) followed by number of buds per plant (0.701), number of flowers per plant (0.681), plant (0.589) and 1000-seed weight (0.496). However, highest positive direct effect was seen in flower yield per plant (1.099) followed by number of buds (0.904) while low and negative value for direct effect was seen in 1000-seed weight (-0.027). Number of flowers

Table 4.18. Direct (diagonal) and indirect (off diagonal) path coefficients of different characters towards seed yield in marigold (2002-03)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Flower yield per plant	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Genotypic correlation with seed yield
Plant height	-0.085	0.059	0.006	-0.177	-0.102	0.073	4.035	-4.044	0.095	0.165	0.085	-0.008	-0.011	-0.006	-0.019	0.065
No. of branches	-0.029	0.174	0.006	0.056	-0.077	-0.010	0.479	-0.426	-0.032	0.016	-0.045	-0.010	-0.016	0.003	-0.029	0.025
Plant spread	-0.018	0.038	0.028	0.304	0.143	-0.298	-16.822	17.225	-0.191	-0.016	-0.133	-0.020	0.014	0.014	-0.050	0.218
Size of flower	-0.028	-0.018	-0.016	-0.535	-0.188	0.154	15.082	-15.443	0.308	0.288	0.261	0.0181	-0.015	-0.015	-0.029	-0.108
Days to first flower	-0.024	0.036	-0.011	-0.275	-0.361	0.150	8.459	-8.501	0.197	-0.006	0.172	0.001	-0.011	-0.006	0.320	-0.146
Duration of flowering	0.014	0.003	0.018	0.181	0.121	-0.448	-14.936	15.320	-0.111	0.056	-0.072	-0.003	0.032	0.022	-0.030	0.168
No. of buds per plant	0.015	-0.003	0.021	0.36	0.138	-0.304	-21.996	22.446	-0.212	0.300	-0.170	-0.014	0.023	0.019	-0.032	0.590**
No. of flowers per plant	0.015	-0.003	0.021	0.361	0.136	-0.306	-21.99	22.451	-0.213	0.405	-0.171	-0.015	0.023	0.019	-0.033	0.703**
Fresh weight of flower	-0.025	-0.017	-0.016	-0.496	-0.218	0.152	14.294	-14.627	-3.269	0.074	0.274	0.013	-0.017	-0.018	0.034	-0.267
Flower yield per plant	-0.020	-0.004	-0.011	0.005	-0.029	-0.195	-12.932	13.182	0.035	0.690	0.023	0.002	0.012	0.004	-0.009	-0.771**
Dry weight of flower	-0.024	-0.026	-0.012	-0.451	-0.204	0.106	12.384	-12.660	0.294	0.053	0.304	0.012	-0.013	-0.018	0.016	-0.188
1000-seed weight	0.012	-0.028	-0.009	-0.151	-0.001	0.025	5.206	-5.374	0.069	-0.027	0.062	0.062	0.016	-0.001	0.007	-0.131
Seed density	0.012	-0.036	0.005	0.101	0.051	-0.186	-6.503	6.719	-0.074	0.110	-0.050	0.013	0.078	0.022	-0.047	0.214
Seed length	0.012	0.015	0.009	0.190	0.050	-0.235	-10.037	10.204	-0.137	0.692	-0.131	-0.001	0.039	0.043	-0.019	0.071
Seed breadth	0.012	-0.040	0.011	-0.123	-0.091	0.108	5.645	-5.917	0.088	-0.499	0.040	0.003	-0.029	-0.006	0.012	-0.350

Residual effect = 0.114

*, ** P ≤ 0.05 and 0.01, respectively

Table 4.19. Direct (diagonal) and indirect (off diagonal) path coefficients of different characters towards seed yield in marigold (2003-04)

Characters	Plant height	No. of branches	Plant spread	Size of flower	Days to first flower	Duration of flowering	No. of buds per plant	No. of flowers per plant	Fresh weight of flower	Flower yield per plant	Dry weight of flower	1000-seed weight	Seed density	Seed length	Seed breadth	Genotypic correlation with seed yield
Plant height	0.063	0.071	-0.097	-0.147	0.020	-0.028	-0.168	0.205	-0.130	0.160	0.074	0.001	0.025	0.021	0.001	0.070
No. of branches	0.028	0.158	-0.089	-0.014	0.011	-0.011	-0.101	0.120	-0.017	0.011	-0.012	0.001	0.001	-0.018	-0.002	0.075
Plant spread	0.012	0.029	-0.484	0.309	-0.011	0.096	0.729	-0.125	0.244	0.619	-0.081	0.009	0.112	-0.071	-0.001	0.589**
Size of flower	0.016	0.004	0.272	-0.551	0.020	-0.068	-0.545	0.686	-0.457	0.101	0.179	-0.012	-0.045	0.067	0.001	-0.331
Days to first flower	0.029	0.070	0.122	-0.260	0.043	-0.073	-0.242	0.319	-0.257	0.111	0.104	-0.002	0.009	0.013	0	-0.011
Duration of flowering	-0.014	-0.013	-0.362	0.294	-0.024	0.129	0.663	-0.856	0.250	0.475	-0.086	0.006	0.095	-0.104	-0.002	0.451*
No. of buds per plant	-0.011	-0.017	-0.391	0.332	-0.011	0.094	0.904	-1.086	0.263	0.690	-0.102	0.009	0.092	-0.064	-0.001	0.701**
No. of flowers per plant	-0.011	-0.017	-0.409	0.345	-0.012	0.101	0.896	-1.095	0.273	0.683	-0.105	0.009	0.098	-0.073	-0.001	0.681**
Fresh weight of flower	0.017	0.005	0.248	-0.529	0.023	-0.067	-0.500	0.629	-0.476	0.220	0.188	-0.011	0.045	0.071	0.001	-0.224
Flower yield per plant	0.009	0.001	-0.273	-0.051	0.004	0.035	0.568	-0.681	-0.095	1.099	0.037	-0.001	0.080	-0.021	-0.001	0.733**
Dry weight of flower	0.022	-0.009	0.187	-0.468	0.002	-0.052	-0.439	0.549	-0.425	0.196	0.210	-0.010	-0.033	0.083	0	-0.188
1000-seed weight	-0.003	-0.011	0.168	-0.240	0.004	-0.028	0.327	0.395	-0.204	0.033	0.078	-0.027	-0.010	0.014	0	0.496**
Seed density	0.007	0.001	-0.269	0.124	0.002	0.061	0.417	-0.532	0.106	0.437	-0.035	0.001	0.201	-0.066	-0.002	0.453*
Seed length	-0.008	0.017	-0.204	0.221	-0.003	0.079	0.347	-0.475	0.200	0.137	-0.104	0.002	0.079	-0.168	-0.001	0.119
Seed breadth	-0.008	-0.036	0.070	-0.014	-0.001	-0.030	-0.099	0.117	-0.047	-0.066	-0.001	-0.001	-0.074	0.028	0.003	-0.162

Residual effect = 0.189

*** P ≤ 0.05 and 0.01, respectively

per plant had high negative direct effect (-1.095) but had high positive indirect effect (0.896) via number of buds per plant.

Thus, path coefficient analysis result confirm that for improvement in seed yield per plant, flower yield per plant is given top priority, followed by number of buds per plant, number flowers per plant and plant spread. Other characters like duration of flowering and seed density although less significant could be considered to bring improvement in seed yield per plant.

Chapter - V

Discussion

5.1 VARIABILITY

Presence of adequate genetic variability forms the basis of all crop improvement programmes. The variability is a foremost prerequisite for an effective improvement in any crop.

In the present investigation, analysis of variance for 24 characters indicated highly significant differences which revealed a high range of variability available among the genotypes studied (Table 4.1 and 4.2). The mean values for flower yield over both the years showed highest flower yield in the genotype MG-17 while it was lowest in the genotype MG-19.

The estimates of genotypic coefficients of variation for all the characters were found to have substantial values which reflected the role of genotypic variation among genotypes for various characters. Among floricultural crops similar observations were reported by Anuradha *et al.* (1999) in gerbera. It was further observed that the characters such as number of buds per plant, number flowers per plant, dry weight of flower and fresh weight of flower had high genotypic coefficients of variation

thus indicating that direct selection of such characters will be effective for increasing the flower yield since they are less affected by environment. Raghava *et al.* (1992) reported similar results in chrysanthemum for flower yield per plant, number of flower per plant and flower size. Singh and Sen (2000) reported similar results in African marigold for dry weight of flower.

5.2 HERITABILITY AND GENETIC ADVANCE

Estimates of heritability (broad sense) and genetic advance are of real significance which determines the direction and effectiveness of selection. Heritability indicates the effectiveness with which selection of genotypes can be made based on phenotypic performance while genetic advance reflects the progress over the genetic improvement that could be achieved by selection of superior genotypes.

Estimates of heritability in broad sense were high for number of buds per plant, number of flowers per plant, fresh weight of flower, dry weight of flower, size of flower, flower yield and 1000-seed weight. These results were in agreement with the findings of Chaugule (1985) and Singh *et al.* (1987) in chrysanthemum. Kshirsagar *et al.* (1995) obtained similar results for 100-seed weight in sunflower. The simple mass selection can be followed successfully for the characters which are highly heritable in the beginning of the crop improvement programme.

The genetic advance (as per cent of mean) was found to be high for dry weight of flower, number of flowers per plant, number of buds per plant, fresh weight of flower, seed yield per plot and flower yield. Similar

results were reported by Syamal *et al.* (2002) in dahlia, Pal (2002) in chrysanthemum and Sujatha *et al.* (2002) in sunflower.

High heritability with high genetic advance was reported for dry weight of flower, number of buds per plant, number of flowers per plant, seed yield and flower yield. Barad (1992) observed high heritability along with high genetic advance for characters like number of flowers per plant, fresh weight of flowers per plant and yield of flowers per hectare in marigold. Therefore, early success may be attained for characters having high heritability and genetic advance with simple selection.

5.3 CORRELATION

Importance of correlation studies in plant breeding has been amply recognized by many workers as this measures the mutual relationship between various plant characters and determine the component character on which selection can be based for improvement in yield. The strong inherent association between various traits under study is indicated by the fact that the magnitude of genetic correlation were in general higher than their corresponding phenotypic coefficient for all the characters (Table 4.14 and 4.15). This is in accordance to Wahi and Bhattacharjee (1986) in *Hippeastrum*. Yield is dependant character and highly influenced by environment, so improvement of this trait, knowledge of its association with its main components is beneficial in formulating breeding programmes.

From Table 4.14, it is found that flower yield per plant in year 2002-03 had positively and highly significant correlation with seed yield,

number of flowers per plant, number of buds per plant, seedling length and shoot length while in 2003-04 (Table 4.15) flower yield had positive and highly significant correlation with number of flowers per plant, seedling length, shoot length, plant spread and seed vigour. Bhanu Pratap (1999) reported positive and significant correlation for flower yield and size with plant spread. It was also supported by Sirohi and Behera (1999) in chrysanthemum. Janakiram and Rao (1995) in marigold stated all characters except flower size and flower weight to be positively correlated with yield.

Number of flowers per plant in both the years show a highly significant and positive correlation with number of buds per plant, shoot length, plant spread, seed yield per plant, seedling length, duration of flowering, and flower yield, which is in accordance to findings of Sashikala (1995) in dahlia where total flowers exhibited positive association with duration of flowering and internode length and negative association with days to flowering (Singh *et al.*, 1987).

Seed yield in (Table 4.14 and 4.15) had a positive and significant correlation for flower yield per plant, number of flowers per plant, number of buds per plant, plant spread, shoot length, seed density, seedling length and duration of flowering. This was supported by findings of Rao *et al.* (2003) in sunflower where seed yield was correlated with number of filled seeds per head and head diameter. The results were also supported by findings of Lakshmanaiah (1980) in sunflower, Mishra and Saini (1990) in gladiolus and Hondelmann and Strauss (1990) in euphorbia.

The above mentioned discussion reveals that study of any character in isolation is not only undesirable but meaningless. The knowledge about associations between characters helps us to identify characters that have importance in selection programme. The associations are either negative or positive in nature. If the association is positive, improvement in one character will simultaneously bring about an improvement in other character, but if they are negatively correlated improvement in one character may be adversely affected. In such cases a proper balance is necessary in order to obtain maximum gains. Thus, the result indicated that the characters namely number of buds per plant, number of flowers per plant, plant spread and seed vigour are important yield determiners.

The characters like number of buds per plant, number of flowers per plant, flower yield per plant, plant spread, duration of flowering exhibited significant association with seed yield showing thereby importance of these yield contributing characters. These traits could be appropriately used as selection criteria.

5.4 PATH COEFFICIENT ANALYSIS

Correlation gives the extent of relationship between the variables, it further reveal whether the characters under study are associated or not, but it is difficult to perceive that which one of them is affecting the other. The path coefficient which is standardized partial regression coefficient provides better picture of correlation in terms of direct and indirect effects of each characters on the ultimate character of economic importance i.e. flower yield and seed yield. It reflects a true relationship between them

and selection would be very effective for such a character in order to improve yield. But if the correlation is mainly due to indirect effect of the character through another component trait, the breeder has to select for the latter trait through which the indirect effect is exerted. A greater yield response is obtained when the character in which selection is practiced has a high heritability and a high correlation with yield.

5.4.1 Path coefficient analysis for flower yield

The path coefficient was worked out using flower yield per plant as dependant variable and fourteen characters as independant.

The data from Table 4.16 and 4.17 for the year 2002-03 and 2003-04 show a positive and significant correlation of flower yield, with number of buds per plant, number of flowers per plant, plant spread, duration of flowering. These results are in confirmation with earlier findings of Shanmugam *et al.* (1972), Singh *et al.* (1987) and Raghava *et al.* (1992) in chrysanthemum, Sashikala (1995) in dahlia and Bhanu Pratap *et al.* (1999) in marigold, indicating that more the plant spread and duration of flowering, the more will be the number of buds and number of flowers through better vegetative growth, thus, ultimately increasing the flower yield. The high positive direct effect in the year 2002-03 and 2003-04 were observed in number of flowers, number of buds and fresh weight of flower. These findings are in agreement with Raghava *et al.* (1992) in chrysanthemum and Mishra and Saini (1990) in gladiolus. The residual effect was low indicating all the important characters correlated with yield have been considered. On the basis of results of path coefficient analysis,

it is concluded that number of buds per plant, number of flowers per plant and fresh weight of flower are important characters effecting flower yield since they had high positive direct effect.

5.4.2 Path coefficient analysis for seed yield

The path coefficient analysis for seed yield was studied using seed yield per plant as dependant variable and fifteen characters as independant.

The data from Table 4.18 and 4.19 for the year 2002-03 and 2003-04 show a positive and significant direct effect of seed yield with number of flowers per plant, number of buds per plant, fresh weight of flower and flower yield per plant. Similar findings were also reported by Lakshmanaiah (1980) and Rao *et al.* (2003) in sunflower. The positive and significant correlation with seed yield in both the year was exhibited with flower yield per plant, number of buds per plant, number of flowers per plant, plant spread, duration of flowering, dry weight of flower, 1000-seed weight, seed density and duration of flowering. These results were in accordance with the findings of Lakshmanaiah (1980), Marinkovic (1992) and Rao *et al.* (2003) in sunflower, Hondelman and Strauss (1990) in euphorbia, Mishra and Saini (1990) in gladiolus. Thus, on the basis of results of path coefficient analysis, it is revealed that characters like number of buds per plant, number of flowers per plant, fresh weight of flower and flower yield per plant are the important contributors towards seed yield, since they had highest positive direct effect on seed yield.

5.5 CHARACTERIZATION

Establishment of World Trade Organization (WTO) gave a new dimension also to international trade in agriculture. In India, it has lead to enactment of the Plant Variety Production and Farmers Right Act 2001. This act enshrines the registration of novel varieties and genotypes based upon distinctness, uniform and stable characters. To establish these criterions, the characterization of the genotype is must, based upon morphological, biochemical and physiological parameters and may be also the electrophoretic patterns of the protein, isoenzymes and DNA. Based upon the exigencies and necessity, the present investigation was also conducted on the characterization of marigold genotypes using morphological descriptors. Thus, distinguishing characters were studied on the basis of plant, floral and seed characters (Table 5.1, 5.2 and 5.3).

In marigold, negligible work has been done on this aspect, therefore, morphological descriptors given by Mahajan *et al.* (2000) for horticultural crops has been adopted. Similarly, work done by Moghali and Virupakshapa (1994) in sunflower has been taken into consideration.

Morphological descriptors of marigold as plant height, plant growth habit, branching habit, stalk shape, stem pubescence, leaf colour and shape, leaflet margin, leaf pubescence, floret colour, disc floret, days to flower, duration of flowering, seed weight, seed length and breadth, seed density, root length, shoot length were utilized for characterization.

Based upon the variation showed for different characters among the 30 genotypes, schematic flow chart (Fig. 5.1) has been prepared.

Table 5.1 Distinguishing marigold genotypes based on plant characters

Genotypes	Plant height	Plant growth habit	Bunching habit	Stem colour	Stalk shape	Stem pubescence	Leaf colour	Leaflet shape	Leaflet margin	Leaflet pubescence
MG-1	Tall	Compact	Full	Purple strips	Ridged	Glabrous	Pale green	Oval pointed	Highly serrated	Non-glabrous
MG-2	Medium	Compact	Basal	Purple	Ridged	Glabrous	Purple	Narrow pointed	Highly serrated	Glabrous
MG-3	Tall	Compact	Full	Green	Smooth	Glabrous	Light green	Narrow pointed	Serrated	Non-glabrous
MG-4	Tall	Open	Full	Green	Smooth	Glabrous	Dark green	Narrow pointed	Serrated	Glabrous
MG-5	Medium	Open	Full	Green	Smooth	Glabrous	Dark green	Narrow pointed	Serrated	Glabrous
MG-6	Medium	Open	Full	Green	Ridged	Glabrous	Light green	Narrow pointed	Serrated	Non-glabrous
MG-7	Tall	Open	Full	Purple	Ridged	Glabrous	Light green	Oval pointed	Highly serrated	Glabrous
MG-8	Medium	Open	Basal	Green	Ridged	Glabrous	Light green	Oval pointed	Highly serrated	Glabrous
MG-9	Medium	Compact	Basal	Green	Ridged	Glabrous	Dark green	Narrow pointed	Serrated	Glabrous
MG-10	Medium	Compact	Basal	Purple strips	Ridged	Glabrous	Purple	Oval pointed	Serrated	Glabrous
MG-11	Tall	Compact	Full	Green	Ridged	Glabrous	Light green	Narrow pointed	Serrated	Glabrous
MG-12	Tall	Open	Full	Green	Ridged	Glabrous	Light green	Narrow pointed	Serrated	Glabrous
MG-13	Tall	Open	Basal	Purple	Ridged	Glabrous	Dark green	Narrow pointed	Smooth	Glabrous
MG-14	Medium	Compact	Basal	Dark green	Ridged	Glabrous	Dark green	Oval pointed	Serrated	Glabrous
MG-15	Short	Open	Basal	Dark green	Ridged	Glabrous	Light green	Oval pointed	Smooth	Glabrous
MG-16	Medium	Open	Full	Green	Smooth	Glabrous	Dark green	Narrow pointed	Serrated	Non-glabrous
MG-17	Medium	Compact	Full	Purple strips	Smooth	Glabrous	Purple	Narrow pointed	Serrated	Non-glabrous
MG-18	Tall	Open	Full	Purple strips	Smooth	Glabrous	Dark green	Narrow pointed	Smooth	Non-glabrous
MG-19	Short	Compact	Full	Purple strips	Smooth	Glabrous	Purple	Oval pointed	Highly serrated	Non-glabrous
MG-20	Short	Compact	Full	Purple strips	Smooth	Glabrous	Purple	Oval pointed	Highly serrated	Non-glabrous
MG-21	Tall	Open	Full	Purple strips	Smooth	Glabrous	Pale green	Narrow pointed	Smooth	Glabrous
MG-22	Medium	Compact	Full	Green	Smooth	Glabrous	Dark green	Oval pointed	Serrated	Glabrous
MG-23	Medium	Open	Full	Purple	Smooth	Glabrous	Purple	Oval pointed	Highly serrated	Non-glabrous
MG-24	Medium	Open	Full	Purple strips	Ridged	Glabrous	Dark green	Narrow pointed	Serrated	Glabrous
MG-25	Medium	Open	Full	Purple	Ridged	Glabrous	Purple	Oval pointed	Highly serrated	Non-glabrous
MG-26	Short	Compact	Full	Purple	Smooth	Glabrous	Purple	Oval pointed	Highly serrated	Non-glabrous
MG-27	Tall	Open	Full	Purple strips	Smooth	Glabrous	Dark green	Oval pointed	Serrated	Non-glabrous
MG-28	Short	Compact	Full	Purple strips	Smooth	Glabrous	Dark green	Narrow pointed	Smooth	Glabrous
MG-29	Short	Open	Full	Green	Smooth	Glabrous	Purple	Narrow pointed	Serrated	Glabrous
MG-30	Tall	Compact	Full	Purple strips	Smooth	Glabrous	Dark green	Narrow pointed	Serrated	Glabrous

Table 5.2. Distinguishing marigold genotypes based on floral characters

Genotypes	Days to flower	Duration of flowering	Fresh weight of flower	Size of flower	Number of flower	Floret colour	Disc floret
MG-1	Medium	Medium	More	Big	Less	Single	Not visible
MG-2	Late	Medium	More	Big	Less	Single	Not visible
MG-3	Medium	Early	Medium	Big	Less	Single	Visible
MG-4	Late	Early	Medium	Medium	Medium	Single	Visible
MG-5	Late	Early	Less	Medium	Less	Single	Visible
MG-6	Late	Early	Medium	Big	Less	Single	Visible
MG-7	Late	Late	More	Big	Less	Single	Not visible
MG-8	Late	Early	More	Big	Less	Single	Not visible
MG-9	Late	Early	More	Big	Less	Single	Not visible
MG-10	Late	Medium	More	Big	Less	Single	Not visible
MG-11	Late	Medium	Medium	Medium	Less	Single	Visible
MG-12	Late	Early	Medium	Medium	Less	Single	Visible
MG-13	Late	Medium	More	Big	Less	Single	Visible
MG-14	Late	Early	Medium	Big	Less	Single	Visible
MG-15	Late	Early	Medium	Medium	Less	Single	Visible
MG-16	Medium	Medium	Less	Medium	Medium	Single	Visible
MG-17	Late	Late	Less	Small	More	Single	Visible
MG-18	Medium	Late	Less	Small	Medium	Double	Visible
MG-19	Early	Early	Less	Medium	Less	Double	Visible
MG-20	Early	Medium	Less	Medium	Medium	Double	Visible
MG-21	Medium	Medium	Less	Medium	More	Single	Visible
MG-22	Late	Late	Less	Medium	More	Single	Visible
MG-23	Medium	Late	Less	Small	More	Double	Visible
MG-24	Late	Medium	Less	Small	More	Double	Visible
MG-25	Medium	Late	Less	Small	More	Double	Visible
MG-26	Medium	Late	Less	Small	More	Double	Visible
MG-27	Medium	Late	Less	Small	More	Single	Visible
MG-28	Medium	Late	Less	Medium	Medium	Single	Visible
MG-29	Medium	Medium	Less	Small	Less	Single	Visible
MG-30	Medium	Medium	Less	Small	More	Single	Visible

Table 5.3 Distinguishing marigold genotypes based on seed characters

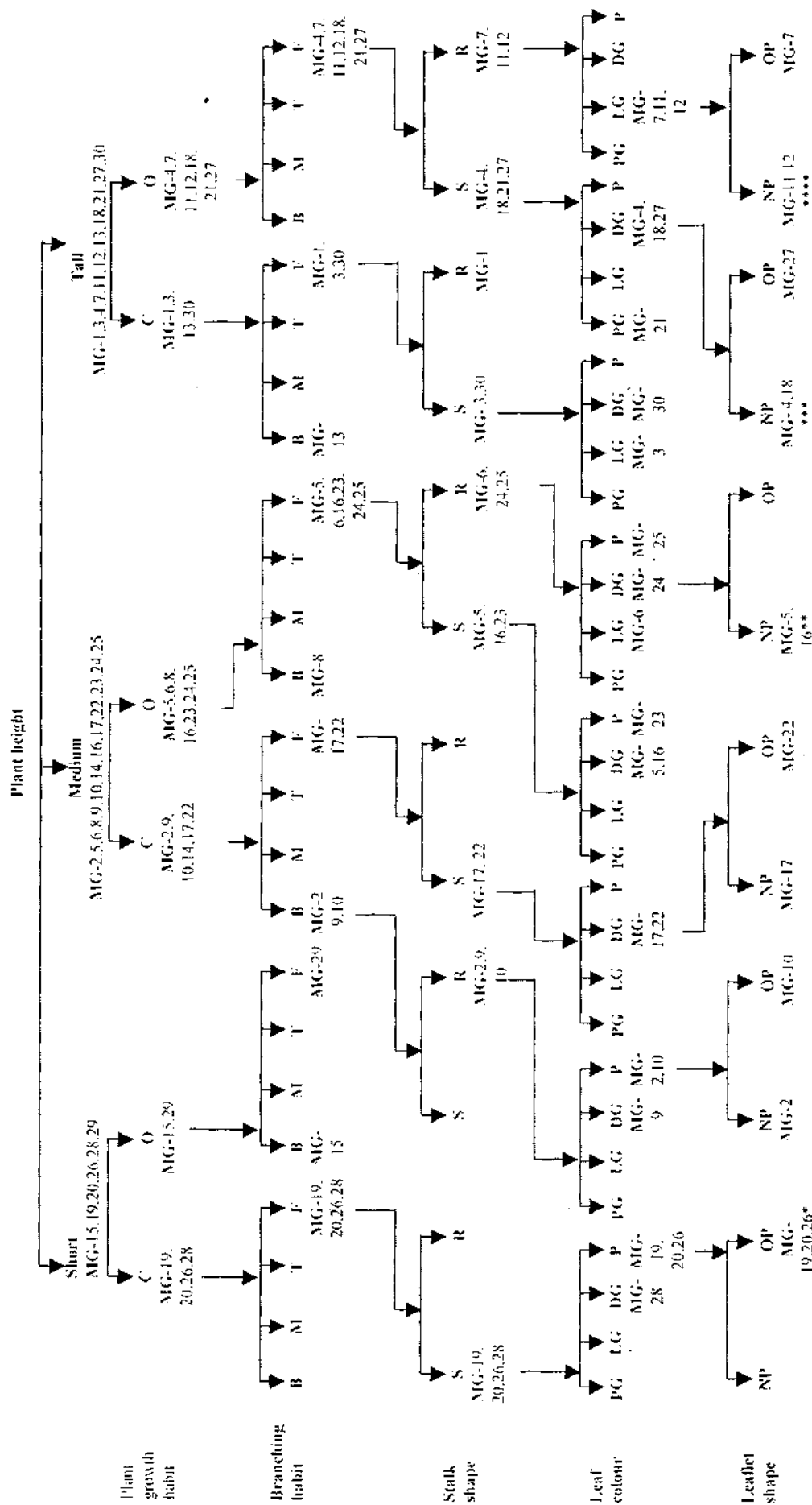
Genotypes	1000-seed weight	Seed length	Seed breadth	Seed density	Root length	Shoot length	Seedling length
MG-1	Medium	Medium	Medium	High	Long	Medium	Long
MG-2	More	Long	Small	Medium	Medium	Medium	Long
MG-3	Less	Medium	Small	Medium	Small	Medium	Medium
MG-4	Medium	Small	Medium	Low	Medium	Medium	Long
MG-5	Medium	Small	Medium	Low	Small	Small	Small
MG-6	More	Medium	Wide	Low	Medium	Medium	Medium
MG-7	More	Small	Small	Medium	Long	Long	Long
MG-8	Medium	Medium	Medium	Medium	Small	Small	Small
MG-9	More	Long	Wide	Low	Medium	Long	Long
MG-10	Medium	Medium	Wide	Low	Long	Medium	Long
MG-11	Less	Medium	Small	High	Small	Medium	Medium
MG-12	More	Long	Medium	High	Small	Medium	Small
MG-13	Medium	Medium	Wide	Medium	Medium	Small	Small
MG-14	Less	Medium	Medium	Low	Small	Small	Small
MG-15	More	Small	Wide	Low	Small	Medium	Medium
MG-16	Medium	Long	Small	High	Medium	Long	Long
MG-17	Medium	Long	Small	High	Medium	Long	Long
MG-18	Medium	Long	Small	High	Long	Long	Long
MG-19	More	Medium	Medium	Medium	Medium	Medium	Medium
MG-20	Less	Medium	Small	Low	Small	Long	Long
MG-21	Less	Long	Wide	Low	Medium	Long	Long
MG-22	Medium	Long	Small	High	Long	Long	Long
MG-23	Medium	Long	Small	High	Medium	Long	Long
MG-24	Less	Medium	Small	Medium	Medium	Long	Long
MG-25	Less	Medium	Wide	High	Medium	Long	Long
MG-26	Medium	Long	Medium	High	Medium	Long	Long
MG-27	Less	Long	Wide	Low	Small	Long	Long
MG-28	Medium	Long	Medium	Low	Long	Long	Long
MG-29	Less	Long	Small	Low	Medium	Long	Long
MG-30	Less	Medium	Medium	Low	Medium	Long	Long

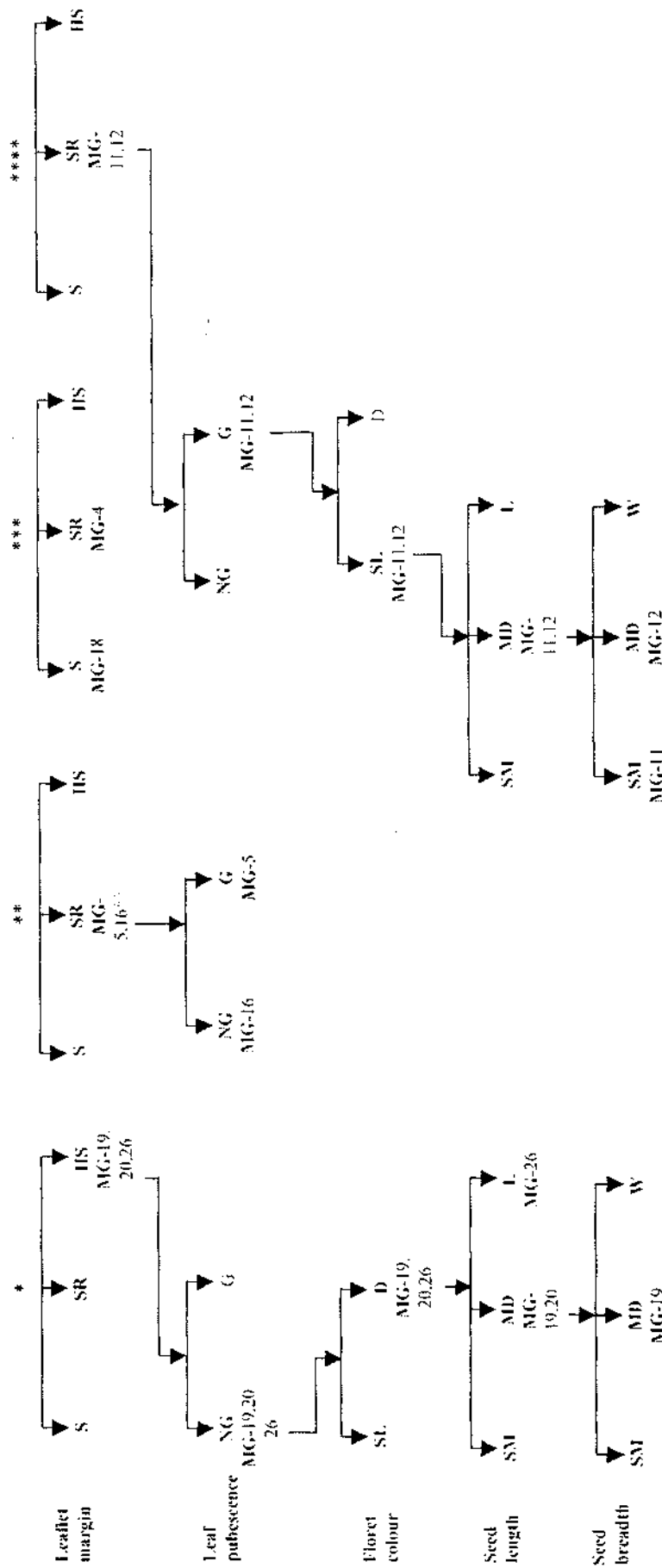
Morphological descriptors like plant growth habit, branching habit, stalk shape, leaf colour, leaflet shape, leaf colour, leaflet shape, leaflet margin, leaf pubescence, floret colour, seed length and seed breadth discriminated all the genotypes. Similar studies based upon morphological characters have been reported by Prakash (1998) in cotton, Kumar *et al.* (1997) in rapeseed and mustard, and Dahiya *et al.* (1993) in chickpea. There was no variation observed for stem pubescence in all the genotypes.

It was inferred from the present investigation that a combination of characters/descriptors has to be utilized for the identification of the genotypes done by Chauhan (2003) in fenugreek, Shergill (2002) in barley and Singh (2001) in chickpea.

Though the key characters of the individual genotypes will help in easy identification of the cultivars. Such key characters will prove beneficial in seed production and certification. The characters like plant growth habit, stalk shape, leaflet shape and margin, floret colour, disc floret and specific flower colour can be utilized for the development of passport of individual genotypes. It is also suggested for biochemical and molecular characterization as reported by Mor (2004) in marigold.

Fig. 5.1 : Flow chart for Marigold genotypes on the basis of Morphological Parameters





C = Compact
O = Open
B = Basal
M = Middle
T = Top
F = Full

S = Smooth
R = Ridged
PG = Pale green
LG = Light green
DG = Dark green
P = Purple

NP = Narrow pointed
OP = Oval pointed
SR = Serrated
HS = Highly serrated
G = Glabrous
NG = Non-glabrous

Chapter - VI

Summary and Conclusion

Marigold (*Tagetes* species Linn) a member of family Asteraceae is one of the most important flowers grown commercially. It has attracted the attention of flower growers due to its wide spectrum of attractive colours, shape, size and good keeping quality. The leaves and flowers of marigold have medicinal properties and also used as food additives. Looking at the importance, the present investigation '**Genetical studies and characterization in marigold**' was conducted at the experimental orchard, Department of Horticulture of Chaudhary Charan Singh Haryana Agricultural University, Hisar to estimate genetic variability, heritability and genetic advance to find out the yield contributing attributes and to characterize the genotype based upon field descriptors and laboratory parameters.

The experimental material consisted of 30 genotypes of African and French marigold (*Tagetes* spp. L.). These were evaluated in the field in a randomized block design with three replication during winter season in the year 2002-03 and 2003-04. The observations were recorded for plant,

floral and seed characters. The result of the present investigation is summarized as below.

The analysis of variance revealed that significant variation existed among the genotypes for all the characters. The mean performances of both the year (Appendix-I and II) showed that maximum number of flowers per plant was in MG-17 followed by MG-24. The maximum fresh weight of flower was recorded in MG-13 while dry weight of flower was maximum in MG-8. The genotype MG-17 produced highest flower yield per plant followed by MG-25 while lowest was produced in MG-19. The seed yield per plot was maximum in MG-23.

The genotypic coefficient of variation was high for dry weight of flower, number of flowers per plant, number of buds per plant and fresh weight of flower. High heritability with high genetic advance as per cent mean was observed in dry weight of flower, number of flowers per plant, number of buds per plant and seed yield per plot, respectively. The plant traits such as number of buds per plant, number of flowers per plant, dry weight of flower and plant spread may be utilized for marigold improvement through selection.

Flower yield per plant had positive and highly significant correlation with number of flower per plant, number of buds per plant and plant spread while the seed yield had positive and significant association with flower yield per plant, number of buds per plant, number of flowers per plant, plant spread and duration of flowering.

The number of flowers, number of buds and fresh weight of flower had direct positive effect on flower yield while number of buds per plant, number of flowers per plant, fresh weight of flower and flower yield per plant on seed yield as revealed by path coefficient analysis. The schematic flow diagram was used to discriminate all the genotypes through the morphological characters. The plant growth habit, leaflet shape, leaf colour, stalk shape, disc floret, floret colour have been suggested the key characters for varietal characterization.

It can therefore, be concluded from the present study that there is sufficient genetic variability in the marigold genotypes for various characters. The highest flower yield per plant was exhibited in MG-17 while seed yield per plot was maximum in MG-23. High heritability with high genetic advance as per cent of mean was observed in dry weight of flower, number of flower per plant, number of buds per plant and seed yield per plot indicating scope for improvement through selection. Correlation and path coefficient analysis revealed that traits like number of buds per plant, number of flowers per plant, fresh weight of flower contributed directly to seed yield.

The estimates of genetic variability, heritability, genetic advance and path analysis suggested that for the improvement and development of high flower and seed yielding marigold genotypes, the characters like number of bud per plant, number of flowers per plant, fresh and dry weight of flower and plant spread should be considered in breeding methodology.

Literature Cited

- Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Sci.* 13: 6.
- Agarwal, R.L. 1984. *Identification of crop varieties*. Oxford and IBH Publishing Co., New Delhi.
- Alam, M.S.; Hossain, M.N.; Khair, A.B.M.A. and Khan, M.S. 1987. Genetic parameters and relationship among some agronomic characters in sunflower (*Helianthus annuus* L.). *Bangladesh J. Agric.* 12(2): 89-93.
- Alavarez, D.; Luduena, P. and Frutos, E. 1992. Variability and genetic advance in sunflower. Proc. 13th International Sunflower Conf. Vol. 2, 7-11.
- Allard, R.W. 1960. *Principles of Plant Breeding*. John Wiley and Sons Inc., New York. pp 82-98.
- Anonymous. 2002. Agricultural Research Data Book. Indian Agricultural Statistics Research. ICAR, New Delhi. pp 121.
- Anuradha, S. and Gowda, J.V.N. 1990. Genetic variability in gladiolus. *Prog. Hort.* 22(1-4): 55-59.
- Anuradha, S. and Gowda, J.V.N. 1994. Genetic variability in gladiolus. *Curr. Res.* 23(7-8): 83-84.
- Anuradha, S. and Gowda, J.V.N. 1999. Quantitative genetic studies in gerbera. *Mysore J. agric. Sci.* 33: 224-227.

- Anuradha, S.; Gowda, J.V.N. and Jayaprasad, K.V. 2002. Path coefficient analysis in gladiolus. *J. Ornamental Hort.* (New series) 5(1): 32-34.
- Aswath, C.; Parthasarathy, V.A. and Bhowmik, G. 1998. Genetic studies in economic characters of gerbera. *J. Maha. Agric. Univ.* 23(2): 140-142.
- Barad, A.V. 1992. Germplasm evaluation, variability, heterosis, combining ability and induced mutation studies in African marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*). M.Sc. (Ag.) Thesis submitted to Gujarat Agricultural University, Navsari.
- Bhanu Pratap; Tewari, G.N.; Mishra, L.N. and Pratap, B. 1999. Correlation studies in marigold. *J. Ornamental Hort.* New Series. 2(2): 84-88.
- Bichoo, G.A.; Jhon, A.Q. and Wani, S.A. 2002. Genetic variability in quantitative characters of gladiolus. *J. Ornamental Hort.* 5(1): 22-24.
- Burton, G.W. 1952. Quantitative inheritance in grasses. Proc. 6th Intl. Grassland Congr. 1: 277-283.
- Chandhoke N. and Ghatak, B.T.R. 1969. Studies on *Tagetes minuta* : some pharmacological action of the essential oil. *Indian J. Med. Res.* 57(5): 864-876.
- Chattopadhyay, T.K.; Biswas, M.R.; Malla, G.; Sarangi, D.K. and Jana, S.C. 1992. Studies on genetic variability, heritability and correlation in chrysanthemum. *Experimental Genetics.* 8(1-2) 11-14.
- Chaudhary, S.K. and Anand, I.J. 1987. Genetic and morphological variability for quantitative characters in sunflower. *J. Oilseeds Res.* 4(1): 97-102.
- Chaugule, B.B. 1985. Studies on genetic variability in chrysanthemum (*Chrysanthemum morifolium*). M.Sc. (Ag.) Thesis submitted to M.P.A.U. Rahuri.

- Chauhan, P. 2003. Characterization and vigour assessment studies in fenugreek. Ph.D. Thesis, Department of Seed Science & Technology, CCS HAU, Hisar.
- Dadlani, N.K.; More, T.A.; Brijendra Singh and Singh, B. 1996. Variability and correlation studies in *Jasminum*. *Indian J. Agric. Res.* **30**(2): 133-141.
- Dahiya, B.S.; Ram, C.; Deswal, D.P. and Punia, R.C. 1993. Varietal identification in chickpea. STC Bull. 2, CCS Haryana Agril. Univ., Hisar.
- De, L.C. and Mishra, R.L. 1994. Studies on correlation and path-coefficient analysis in gladiolus. *J. Ornamental Hort.* **2**(1-2): 14-19.
- Desraj; Mishra, R.L. and Raj, D. 1998. Genetic variability in gladiolus. *J. Ornamental Hort.* **4**(1-2): 1-8.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* **51**: 515-518.
- Dhanavel. 2003. Say it flowers. The New Indian Express, 27th Jan. pp 12.
- Dhane, A.V.; Nimbalkar, C.A. and Sonawane, P.C. 2002. Variability and heritability studies in dahlia. *J. Maha. Agric. Univ.* **27**(2): 138-140.
- Gill, H.S.; Sheoran, R.K.; Lokendra Kumar; Naveen, C.; Kumar, L. and Chandra, N. 1997. Genetic variability, heritability and genetic advance for seed yield and component traits in sunflower (*Helianthus annuus*). *Annals of Biology.* **13**(2): 279-328.
- Goulden, C.H. 1954. Methods of statistical analysis (2nd edn.). John Wiley and Sons Inc., New York, U.S.A.
- Gupta, Y.C.; Raghava, S.P.S. and Mishra, R.L. 2001. Heterobeltiosis in African marigold (*Tagetes erecta* L.). *Indian J. Genet.* **61**(1): 65-68.
- Hanson, C.H.; Robinson, H.F. and Comstock, R.E. 1956. Biometrical studies of yield in segregating populations of Korean lespedeza. *Agron. J.* **48**: 268-272.

- Hemlata, B.; Patil, A.A.; Nalawadi, U.G. and Barigheid, H. 1992. Variability studies in chrysanthemum. *Prog. Hort.* **24**(1-2): 55-59.
- Hondelmanm, W. and Strauss, D.D. 1990. Path coefficient analysis of seed yield components in *Euphorbia lathyris*. *Plant Breed.* **105**(2): 112-116.
- Huang, H. and Harding, J. 1998. Quantitative analysis of correlations among flower traits in gerbera hybrids. *Theor. Appl. Genet.* **97**(1-2): 316-322.
- Jackson, M.L. 1967. *Soil Chemical Analysis*. Asia Publishing House, Bombay.
- Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, India.
- Jagdish, G.V.; Virupakshappa, K.; Venkataraman, M. and Ramaiah, H. 1994. Hand book on diagnostic characters of sunflowers (*Helianthus annuus* L.). NSP-GKVK, Bangalore.
- Janakiram, T. and Rao, T.M. 1994. Genetic improvement of marigold. *Floriculture Technology, Trade and Trends*. Oxford and IBH Publishing Co., New Delhi. Pp 331-335.
- Janakiram, T. and Rao, T.M. 1995. Effect of plant density on genetic parameters in African marigold. *Indian J. Hort.* **52**(4): 309-312.
- Johnson, H.W.; Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybeans, *Agron. J.* **47**: 314-318.
- Kahre, D.; Raut, N.D. and Bhale, M.S. 1998. Verification of soybean varieties. *Seed Tech. News.* **28**(4): 58.
- Kannan, M. and Ramdas, S. 1990. Variability and heritability studies in gerbera. *Prog. Hort.* **22**(1-4): 72-76.
- Kannan, P.; Rajalingham, G.V. and Haripriya, K. 1998. Correlation and path coefficient analysis in tuberose (*Polianthus tuberosa* L.). *Journal of Spices and Aromatic Crops.* **7**(2): 149-153.

- Karmakar, P.G. and Şrivastava, H.C. 1986. Correlation and path analysis in pin and thrum types of open pollinated progeny in *Jasminum auriculatum*. *Herba Hungarica* 25(2): 119-128.
- Kaul, V.K.; Singh, B. and Sood, R.P. 1997. Cultivation and utilization of aromatic plants. CSIR Jammu. Pp 255-261.
- Kennedy, R.R. 1997. Genetic variability for seed characters in marigold. *Madras Agric. J.* 84(6): 328-330.
- Kshirsagar, A.R.; Deshmukh, D.T. and Dudha, R.S. 1995. Study of genetic variability in sunflower. *PKV Res. J.* 19(2): 175.
- Kumar, D. 1994. Seed quality and field parameters of some promising genotypes of cotton (*Gossipium hirusutum* L.). M.Sc. Thesis, CCS Haryana Agricultural University, Hisar..
- Kumar, S. 1997. Characterization of rapeseed and mustard (*Brassica* sp.) cultivars using field and laboratory techniques. Ph.D. Thesis, CCS Haryana Agril. Univ., Hisar.
- Lakshmanaiah, V.H. 1980. Genetic variability and association of morphological characters with seed yield and oil content in sunflower. *Mysore J. Agric. Sci.* 14(2): 259.
- Lal, S.D.; Shah, A. and Seth, J.N. 1985. Genetic variability in gladiolus. Phenotypic variability and its heritable component in some important quantitative characters contributing towards spike weight. *Prog. Hort.* 17(1): 28-30.
- Lalitha, S. and Kumar, N. 1993. Genetic variability in quantitative characters of crossandra (*Crossandra infundibuliformis* L.) in the M3 and M4 generations. *South Indian Hort.* 41(5): 287-292.
- Mahajan, R.K.; Sapra, R.L.; Srivastava, U.; Singh, M. And Sharma, G.D. 2000. Minimal descriptors for characterization and evaluation of agri-horticultural crops,. NBPGR, Pusa Campus, New Delhi. pp 32-36.

- Mahanta, P.; Choudhary, S.; Paswan, L. and Talukdar, M.C. 1998. Studies on variability and heritability of some quantitative characters in gerbera (*Gerbera jamesonii*). *South Indian Hort.* 46(1-2): 43-46.
- Mahanta, P.; Choudhary, S.; Paswan, L.; Talukdar, M.C. and Sharma, D. 1998. Correlation and path coefficient analysis in gerbera (*Gerbera jamesonii*). *Hort J.* 11(2): 79-85.
- Manjunath Rao, T. 1982. Studies in genetic variability and correlation in China Aster (*Callistephus chinensis*). M.Sc. (Hort.) Thesis, U.A.S., Bangalore.
- Marinkovic, R. 1992. Path coefficient analysis of some yield components of sunflower (*Helianthus annuus.*). *Euphytica* 60(3): 201-205.
- Mishra, R.L. and Saini, H.C. 1988. Genotypic and phenotypic variability in gladiolus. *Indian J. Hort.* 45: 148-152.
- Mishra, R.L. and Saini, H.C. 1990. Correlation and path coefficient studies in gladiolus. *Indian J. Hort.* 47: 127-132.
- Mishra, Y.K.; Joshi, R.P. and Solanki, S.S. 1997. Genetic variability in dahlia (*Dahlia variabilis*). *Prog. Hort.* 29(1-2): 61-64.
- Moghali, S.C. and Virupakshappa, K. 1994. Characterization and evaluation of sunflower (*Helianthus annuus* L.) germplasm. *Indian J. Genet. Pl. Breed.* 54(4): 360-365.
- Mor, V.S. 2004. Studies on quality seed production and molecular characterization in marigold (*Tagetes* spp.). Ph.D. Thesis, Department of Seed Science & Technology, CCS HAU, Hisar.
- More, T.A. 1980. Studies on correlation, regression and path analysis in *Jasminum*. *Haryana J. Hort. Sci.* 9: 146-151.
- Morris, L.F. and Payne, R.C. 1977. Phenotypic characteristics of 116 soybean varieties. *AOSA Newsletter.* 51(2): 206-208.
- Mousamee Mishra; Mohanty, C.R.; Mahapatra, K.C. and Mishra, M. 2001. Genetic variability with respect to floral traits in dahlia. *J. Ornamental Hort.* 4(2): 79-82.

- Muhammad-Tarig; Ghulam, I.; Asadullah, T.; Idrees, G. and Tahir, A. 1992. Genetic variability and correlation studies in sunflower. *Sarhad J. Agric.* 8(6): 659-663.
- Negi, S.S.; Raghava, S.P.S.; Sharma, R.S. and Srinivasan, V.R. 1983. Studies on variability and correlation in china aster. *Indian J. Hort.* 42(3-4): 303-307.
- Negi, S.S.; Sharma, T.V.R.S.; Raghava, S.P.S. and Srinivasan, V.R. 1982. Variability studies in gladiolus. *Indian J. Hort.* 39: 269-272.
- Niharika-Pattanaik; Mohanty, C.R.; Pattanaik, N. 2002. Genetic variability, genetic advance in African marigold. *Orissa J. Hort.* 30(2): 35-38.
- Olsen, S.R.; Cole, C.V.; Watanable, F.S. and Dean, T.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular U.S. Dept. Agric. Pp 939.
- Pal, P. and George, S.V. 2002. Genetic variability and correlation studies in chrysanthemum. *Hort. J.* 15(2): 75-81.
- Panse, V.G. and Sukhatme, P.V. 1995. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi. pp 359.
- Pant, C.C. and Lal, S.D. 1991. Genetic variability in gladiolus. *Prog. Hort.* 23(1-4): 1-4.
- Parkash, O.M. 1998. Studies on stability analysis and varietal identification in cotton. Ph.D. Thesis, CCS Haryana Agril. Univ., Hisar.
- Parkash, S. and Singhal, N.C. 1997. Characterization of some Indian pea (*Pisum sativum* L.) cultivars. *Seed Res.* 25(1): 53-58.
- Patil, B.R.; Rudraradhya, M.; Vijaykumari, C.H.M.; Basappa, H.; Virupakshappa, K. 1996. Genetic variability in sunflower. *J. Oilseed Res.* 13(2): 157-161.
- Piper, C.S. 1966. Soil and plant analysis. Hans Publication, Bombay. pp.368.
- Ponnusuamy, V.; Chezhiyan, N.; Khader, J.M.A. and Thamburaj, S. 1985. Genetic variability in chrysanthemum. *South Indian Hort.* 33(3): 211-213.

- Raghava, S.P.S.; Negi, S.S. and Nancharaiah, D. 1992. Genetic variability, correlation and path analysis in chrysanthemum. *Indian J. Hort.* 49(2): 200-204.
- Ram, C.; Punia, R.C. and Dahiya, B.S. 1998. Cultivar identification of black gram by laboratory and field techniques. *Seed Tech News*. 28(4): 83.
- Rao, N.V.; Mohan, Y.C. and Reddy, S.S. 2003. Variability and character association in the elite lines of sunflower (*Helianthus annuus* L.). *Research on Crops* 4(1): 104-109.
- Reddy, M.C.S.; Haripriya, K. and Kamalakannan 2002. Genetic variability in crossandra (*Crossandra infundibuliformis*). *Advances in Plant Sciences* 15(2): 539-541.
- Sashikala Beura; Maharana, T. and Jagadev, P.N. 1995. Genetic variability and character association in dahlia. *J. Trop. Agric.* 33(1): 20-22.
- Searle, S.R. 1961. Phenotypic, genotypic and environmental correlation. *Biometrics* 17: 474-480.
- Shanmugam, A.; Muthusuamy, S. and Srinivasan, N. 1972. Interrelationship between yield and certain growth and floral attributes in two chrysanthemum (*Chrysanthemum indicum* Linn.) varieties. *South Indian Hort.* 20: 85-86.
- Shergill, R. 2002. Characterization of barley cultivars using field and laboratory parameters. M.Sc. Thesis, Department of Seed Science & Technology, CCS HAU, Hisar.
- Singh, A.K.; Singh, O.P. and Gupta, S.R. 2000. Genetic variability and character association in gladiolus (*Gladiolus floribundas*). *Advances in Plant Sciences*. 13(1): 39-42.
- Singh, D. and Sen, N.L. 2000. Genetic variability, heritability and genetic advance in marigold. *J. Ornamental Hort.* (New Series) 3(2): 75-78.
- Singh, R. 2001. Characterization of chickpea cultivars by field and laboratory techniques. Ph.D. Thesis, Department of Seed Science & Technology, CCS HAU, Hisar.

- Singh, S. 1995. Genetic gain, stability and varietal identification in upland cotton (*Gossipium hirsutum* L.). Ph.D. Thesis. CCS Haryana Agril. Univ., Hisar.
- Singh, S.P.; Rao, B.R.R. and Singh, A.K. 1987. The genetic variation of yield components in pyrethrum (*Chrysanthemum cinerariaefolium*). *Genetica Agraria* 41(2): 173-178.
- Singh, S.P.; Rao, B.R.R.; Sharma, J.R. and Sharma, S. 1987. Genetic improvement of pyrethrum. Assessment of genetic variability and clonal selection. *Pyrethrum Post*. 16(4): 120-124.
- Sirohi, P.S. and Behera, T.K. 1999. Correlation and path analysis studies in chrysanthemum. *J. Ornamental Hort.* 3(1-2): 45-48.
- Soorianathasundaram, K. and Nambisan, K.M.P. 1991. Studies of variability and certain genetic parameters in gladiolus. *South Indian Hort.* 39(4): 207-209.
- Sreekala, C.; Raghava, S.P.S.; Mishra, R.L. and Voleti, S.R. 2002. Assessment of variability for carotenoids and yield components in African marigold. *J. Ornamental Hort.* 5 (2): 5-7.
- Srinivas, P.T. and Gowda, J.V.N. 1995. Genetic variability in dahlia. *Crop Res.* 9(3): 358-362.
- Srivastava, A.N. and Mishra, R. 1976. Genotypic and phenotypic variability in quantitative characters in sunflower (*Helianthus annuus* L.). *Madras agric. J.* 63(3): 209-210.
- Srivastava, H.C. and Devaiah, K.A. 1988. Correlation and path analysis in Jasmine. *Plant Breed.* 100(3): 235-237.
- Subbaih, B.V. and Asija, G.L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Curr. Sci.* 25: 259-260.
- Sujatha, H.L.; Chikkadevaiah and Nandini. 2002. Genetic variability study in sunflower inbreds. *Helia.* 25(33): 93-99.
- Syamal, M.M. and Kumar, A. 2002. Genetic variability and correlation studies in dahlia. *J. Ornamental Hort.* 5(1): 40-42.

- Szabo, L.; Sipas, S.Z.I and Harwath, S. 1983. Identification of Hungarian , and Foreign soybean varieties and strains by colour characters. *Novenytermeles*. **32**(2): 105-106.
- Verma, S.K.; Singh, R.K.; Arya, R.R.; Misra, R.L. and Sanyal Mishra 2002. Genotypic and phenotypic variability in marigold. Floriculture research trend in India. Proc. National Symp. on Indian Floriculture in the new millennium. Pp 330-331.
- Villalobos, E. and Fournier, L.A. 1978. Morphological identification of some soybean selection introduced into Costa Rica. *Agronomia Losfarricense*. **2**(1): 23-27.
- Wahi, S.D. and Bhattacharjee, S.K. 1986. Correlation and path coefficient analysis in *Hippeastrum hybridum*. *South Indian Hort*. **34**(4): 244-251.

Appendix-I. Mean value of marigold genotypes for different characters for the years 2002-03 and 2003-04

Genotypes	Plant height (cm)	No of branches/plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/plant	No. of flowers/plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-1	88.59	17.76	42.36	9.56	75.06	39.66	60.20	51.50	11.02	566.09	22.64	353.74
MG-2	55.96	36.53	36.38	8.03	85.59	38.16	55.09	44.43	10.63	471.41	18.85	294.63
MG-3	94.70	45.10	51.20	6.52	81.53	33.83	58.69	52.06	8.70	454.57	18.18	284.10
MG-4	103.79	31.00	48.88	5.99	88.73	27.66	121.39	99.76	9.63	961.57	38.46	600.78
MG-5	71.03	41.13	51.39	4.53	92.93	29.73	64.46	56.03	4.43	249.08	9.96	155.67
MG-6	70.09	32.50	38.45	6.58	99.83	32.20	47.33	37.49	7.04	291.59	11.66	182.22
MG-7	99.26	30.60	49.01	10.79	91.40	45.63	56.63	45.73	16.53	755.58	30.22	472.24
MG-8	63.60	18.06	36.85	9.30	98.03	33.66	41.63	32.36	16.97	547.90	21.91	342.43
MG-9	62.53	35.80	34.81	8.95	92.43	30.76	61.66	47.24	15.41	732.05	29.28	457.53
MG-10	66.56	30.90	35.81	8.61	100.43	35.66	45.99	35.53	12.39	441.67	17.66	275.99
MG-11	82.66	38.00	47.10	5.40	133.20	40.03	66.26	60.03	6.54	391.68	15.66	244.76
MG-12	117.63	34.83	45.39	5.59	106.69	29.33	69.09	62.89	4.95	321.37	12.85	200.83
MG-13	77.53	25.96	35.34	7.28	93.03	39.36	39.66	36.03	17.76	421.54	16.85	263.46
MG-14	61.56	16.93	33.40	6.71	88.23	31.26	39.30	31.26	8.90	278.65	11.13	179.16
MG-15	43.53	17.33	22.21	5.59	93.63	30.26	51.73	42.66	9.61	412.31	16.49	257.69
MG-16	51.16	30.46	53.33	4.09	76.56	43.69	164.17	150.90	1.95	294.83	11.78	183.71

Appendix-I contd.

Genotypes	Plant height (cm)	No of branches/ plant	Plant spread (cm)	Size of flower (cm)	Days to first flower	Duration of flowering (days)	No. of buds/ plant	No. of flowers/ plant	Fresh wt. of flower (g)	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ha (q)
MG-17	50.46	24.49	70.33	3.77	89.76	56.26	406.39	385.36	3.02	1167.54	46.69	729.71
MG-18	52.56	29.86	62.53	3.27	77.36	54.16	175.26	162.10	2.19	356.04	14.24	222.53
MG-19	33.49	14.06	62.51	4.49	58.59	32.06	26.56	20.43	2.73	56.05	2.24	35.20
MG-20	50.46	19.66	43.83	4.17	62.60	40.63	182.23	162.90	2.06	505.46	13.40	209.47
MG-21	88.26	34.09	57.85	4.66	83.56	44.23	214.39	191.93	4.12	790.04	31.60	493.78
MG-22	55.43	20.13	62.54	4.23	88.34	54.19	229.19	209.23	3.84	817.93	32.71	511.17
MG-23	70.30	32.16	58.06	3.55	77.03	56.73	265.43	242.16	4.04	979.75	39.18	612.34
MG-24	58.06	34.06	47.98	3.97	85.49	41.23	302.36	250.36	2.36	592.54	23.69	370.33
MG-25	56.06	17.53	63.78	3.54	72.36	49.66	241.68	222.19	3.19	1094.26	28.43	444.41
MG-26	38.86	20.26	53.53	3.74	76.96	46.48	237.26	208.86	2.84	881.52	23.77	371.48
MG-27	77.18	27.80	56.53	3.61	71.69	49.33	214.73	200.26	2.87	594.65	22.98	359.13
MG-28	50.46	36.13	59.03	4.16	73.03	59.19	249.86	156.50	3.07	482.22	19.28	300.88
MG-29	43.60	32.63	39.26	3.36	81.63	44.23	72.20	65.93	2.78	180.47	7.21	112.79
MG-30	79.06	38.76	67.18	3.21	81.03	39.71	198.80	184.16	2.63	485.68	19.70	312.55
Mean	68.66	28.88	47.89	5.57	84.45	40.79	132.92	118.61	6.64	534.06	21.36	333.72

Appendix-II. Mean value of marigold genotypes for different characters for the years 2002-03 and 2003-04

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed - vigour-I	Seed vigour-II
MG-1	0.138	0.94	3.25	1.02	9.61	1.20	1.62	7.26	62	10.71	664.31	1357.33
MG-2	0.078	0.88	4.03	0.91	10.15	1.07	3.27	6.71	72	10.02	725.73	1525.46
MG-3	0.251	0.80	2.80	0.93	9.25	1.05	2.16	6.05	62	8.31	516.13	1173.99
MG-4	0.423	0.88	3.36	0.78	8.32	1.32	3.36	7.74	42	11.06	482.06	920.16
MG-5	0.134	0.52	3.26	0.71	8.58	1.94	1.93	3.75	62	5.68	354.17	641.13
MG-6	0.117	0.64	3.60	0.84	9.30	1.49	3.42	6.50	76	9.92	753.49	1542.36
MG-7	0.147	2.04	4.51	0.90	8.81	1.11	5.35	9.60	78	14.95	1165.92	1927.64
MG-8	0.157	2.19	3.06	0.96	9.34	1.34	2.03	7.24	58	6.80	388.68	907.13
MG-9	0.111	0.62	3.61	1.87	10.54	1.48	3.40	10.60	84	14.00	1184.04	2038.19
MG-10	0.087	1.04	3.47	0.85	9.91	1.34	4.03	7.49	82	11.52	946.49	1867.99
MG-11	0.187	0.58	2.51	1.19	9.01	1.20	2.48	6.64	40	9.02	359.44	773.49
MG-12	0.152	0.57	3.52	1.16	11.60	1.21	1.13	5.55	46	7.83	360.99	774.73
MG-13	0.106	0.99	3.32	0.94	9.46	1.45	2.65	4.74	48	7.39	361.07	744.93
MG-14	0.076	0.79	2.49	0.81	9.41	1.29	1.07	4.17	30	6.01	181.54	443.13
MG-15	0.190	0.83	3.84	0.81	8.82	1.41	2.37	6.12	44	8.49	368.24	936.13
MG-16	0.141	0.26	3.33	1.15	10.40	1.01	2.58	8.85	48	11.43	550.50	939.66

Appendix-II contd.

Character/ Genotypes	Seed yield per plot (kg)	Dry weight of flower (g)	1000-seed weight (g)	Seed density (g/cc)	Seed length (mm)	Seed breadth (mm)	Root length (cm)	Shoot length (cm)	Standard germination (%)	Seedling length (cm)	Seed vigour-I	Seed vigour-II
MG-17	0.451	0.30	3.40	1.28	11.12	1.17	3.30	11.09	56	14.45	795.34	1383.23
MG-18	0.181	0.24	3.36	1.05	10.89	1.04	3.52	11.65	58	15.20	891.05	1538.69
MG-19	0.013	0.26	4.75	1.04	9.48	1.36	3.07	6.73	42	9.80	438.06	774.33
MG-20	0.116	0.20	2.61	0.76	9.34	1.19	1.88	8.41	56	10.30	576.66	1061.13
MG-21	0.123	0.38	3.93	0.83	10.60	1.48	3.20	10.15	50	13.35	671.92	1075.13
MG-22	0.271	0.38	3.04	1.21	10.44	1.04	3.70	10.35	48	14.05	674.92	1056.03
MG-23	0.454	0.42	3.47	1.22	10.57	1.11	3.35	10.71	62	14.06	852.77	1379.00
MG-24	0.325	0.25	2.69	0.92	9.34	1.16	3.35	8.70	70	12.16	859.81	1458.69
MG-25	0.328	0.33	2.77	1.03	9.83	1.41	3.00	9.14	52	12.14	630.72	1148.26
MG-26	0.283	0.28	3.42	1.00	10.86	1.38	3.30	11.60	42	14.90	626.16	1134.16
MG-27	0.172	0.29	2.85	1.35	10.29	1.26	2.33	9.30	70	11.63	816.26	1402.26
MG-28	0.223	0.31	3.46	0.89	10.83	1.52	5.65	9.40	46	15.05	676.58	1218.30
MG-29	0.112	0.23	2.76	0.88	11.34	1.06	2.55	8.30	60	10.85	654.50	1224.53
MG-30	0.115	0.31	2.65	0.85	9.83	1.30	2.95	9.30	64	12.25	789.16	1472.59
Mean	0.187	0.63	3.25	0.96	9.95	1.26	3.06	8.04	56.9	11.12	642.43	1193.08

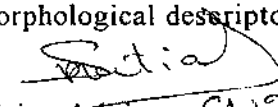
ABSTRACT

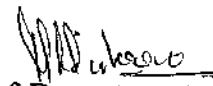
Title of Thesis	:	Genetical studies and characterization in marigold
Full Name of Degree Holder	:	Reena Mathew 2001A25D
Title of Degree	:	Doctor of Philosophy
Name and Address of Major Advisor	:	Dr. S.K. Bhatia Senior Scientist Department of Horticulture CCS Haryana Agricultural University Hisar-125 004, India
Degree awarding University/Institute	:	CCS Haryana Agricultural University Hisar-125 004, India
Year of award of degree	:	2004
Major subject	:	Horticulture
Total number of pages in Thesis	:	113 + x
Number of words in abstract	:	Approx. 300

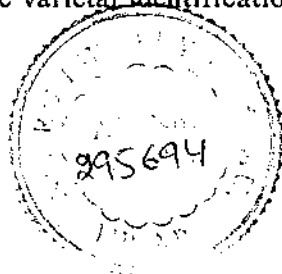
Marigold (*Tagetes* spp) is an important commercial flower crop and has shown wide adaptability to different soil and climatic conditions. It shows wide variation in colour, shape and size and has good shelf life. The medicinal value and utility as bio-control agent also added new dimensions of its importance in the present agricultural scenario. The present investigation was carried out at the experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2002-03 and 2003-04 as winter season crop on 30 genotypes of both African and French marigold to estimate the genetic variability, heritability, genetic advance and varietal characterization. The observations were recorded for plant, floral and seed parameters.

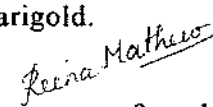
All the genotypes differed significantly which indicated a wide range of variation existed among the genotypes under study. The highest flower yield per plant was exhibited by MG-17 while seed yield per plot was maximum in MG-23. The estimates of heritability and genetic advance as per cent mean were high for dry weight of flower, number of flowers per plant, number of buds per plant and seed yield per plot.

The correlation and path coefficient analysis revealed that number of flowers per plant, number of buds per plant, fresh weight of flower and plant spread contributed directly as well as indirectly to flower yield. The characters, which contributed to seed yield, were flower yield per plant, number of buds per plant, number of flower per plant, plant spread and duration of flowering indicating selection of these characters for crop improvement and breeding strategies. Through the schematic flow chart all the genotypes were differentiated. The plant growth habit, leaflet shape, leaf colour, stalk shape, disc floret, floret colour were the key characters, therefore, can be used as morphological descriptors for the varietal identification in marigold.


Major Advisor 6/12/04


Head of Department 7/12/04




Signature of student