

**Evaluation and selection of African Marigold
(*Tagetes erecta* L.) genotypes suitable for
commercial cultivation under coastal plain zone
of Odisha**

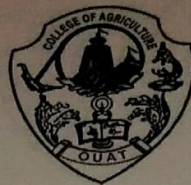
**A THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY, BHUBANESWAR**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOTHE
DEGREE OF MASTER OF SCIENCE IN AGRICULTURE
(FLORICULTURE AND LANDSCAPING)**

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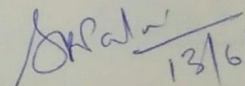
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CERTIFICATE I

This is to certify that the thesis entitled "**Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under the coastal plain zone of Odisha**" submitted in partial fulfillment of the requirements for the award of the Degree of **MASTER OF SCIENCE IN AGRICULTURE (FLORICULTURE and LANDSCAPING)** to the Orissa University of Agriculture and Technology, Bhubaneswar is an authentic record of bonafide research work carried out by **BANANI PRIYADARSHINI SAMANTARAY**, Adm. No. 03FLS/16, under my guidance and supervision. No part of this thesis has been submitted for anyother degree or diploma.

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


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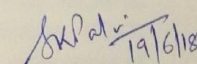


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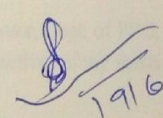
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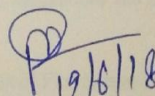
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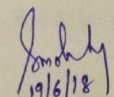
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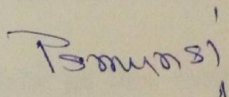
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CONTENTS

CHAPTER	PARTICULARS	PAGE
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-16
III	MATERIALS AND METHODS	17-29
IV	RESULTS	30-50
V	DISCUSSION	51-58
VI	SUMMARY AND CONCLUSION	59-61
	REFERENCES	i-vi

LIST OF TABLES

TABLES	PARTICULARS	PAGES
3.1	Meteorological data of Bhubaneswar from October 2017 to March 2018	18
3.2	Physio-chemical properties of the soil	18
3.3	Genotypes under study	19
3.4	Analysis of variance and expected mean sum of square	25
4.1	Analysis of Variance (ANOVA) of quantitative characters studied in 8 genotypes of African marigold	43
4.2	Mean values of quantitative characters in 8 genotypes of African marigold	44
4.3	Estimation of mean, range and variance in 8 genotypes of African marigold	45
4.4	Estimation of variability and genetic advance in 8 genotypes of African marigold	46
4.5	Phenotypic correlation between pairs of different characters studied in African marigold	47
4.6	Genotypic correlation between pairs of different characters studied in African marigold	48
4.7	Estimates of direct (diagonal) and indirect effects of component characters on weight (yield) of flowers per plant in African marigold	49
4.8	Assessment of Qualitative parameters	50

LIST OF FIGURES

FIGURES	PARTICULARS
3.1	Layout of the experimental field
3.2	Experimental plot at full bloom stage
3.3	Pictures of plant and flowers of different genotypes under study
3.4	Comparative view of the flowers
5.1	Graph between GCV, Heritability and GA for 14 characters in 8 genotypes of African marigold
5.2	Graph between Yield and Shelf life

LIST OF ABBREVIATIONS AND SYMBOLS

cm	-	Centimeter
RBD	-	Randomized block design
°C	-	Degree Centigrade
e.g.	-	Example
<i>et al.</i>	-	and others
etc.	-	and so on
Fig.	-	Figure
g	-	Gram
kg	-	Kilogram
i.e	-	that is
ha	-	hectare
m	-	meter
mm	-	milimeter
RH	-	Relative humidity
<i>Viz</i>	-	namely
%	-	percent
@	-	at the rate
EC	-	Electrical conductivity
CD	-	Critical difference
FYM	-	Farm Yard Manure
BM-1	-	BidhanMarigold-1
BM-2	-	Bidhan Marigold-2
BM-3	-	Bidhan Marigold-3
BSH	-	Bright Sunshine Hours
RH	-	Relative Humidity
AICPRP-		All India Coordinated Research Project

ABSTRACT

The present experiment was undertaken in 14 quantitative and 3 qualitative parameters of 8 genotypes of African marigold to select a suitable variety for commercial cultivation in Odisha. The experiment was conducted during October 2017 to March 2018 at Biotechnology-cum-Tissue Culture Center (BTCC), Bhubaneswar, Odisha. In mean performance of genotypes, wide difference was found for almost all characters. For vegetative parameters like plant height, plant spread (both north-south and east-west), number of primary branches, number of secondary branches, stem diameter Pusa Narangi Gaiinda had the highest values. Plant height lowest in BM-3, lowest plant spread (north-south) was observed in BM-2, plant spread (east-west) and number of primary branches lowest in Arka Alankar, number of secondary branches was lowest in Arka Agni, stem diameter was lowest in BM-1. Earliest flower bud appearance and flower bud opening was seen in Arka Bangara and the late bud appearance and opening was in Pusa Basanti Gaiinda. Large blooms were seen in Arka Bangara and the smallest bloom in BM-3. Highest flower weight was found in Arka Agni while the lowest in BM-3. Maximum flower numbers were in Arka Agni while the lowest number in Pusa Basanti Gaiinda. BM-2 flowers remained fresh a maximum day while the flowers of Pusa Basanti Gaiinda were fresh for the least number of days. The yield was maximum for the variety Arka Agni followed by BM-2 and minimum in Pusa Basanti Gaiinda. Maximum range of variation was observed for number of flowers per plant while the minimum was for weight (yield) of flowers per plant (kg). Characters like shelf life of flowers recorded the maximum CV (PCV and GCV) coupled with high heritability and high genetic advance (as % of mean). For effective selection and crop improvement in African marigold, the characters like weight of flowers per plant, flower weight, days for flower bud appearance, number of flowers per plant, days taken for flower bud opening, duration of flowering, flower diameter, number of primary branches, plant height and shelf life of flowers could be relied upon as it has a higher heritability. Correlation studies revealed that at both phenotypic and genotypic level yield had a positive correlation with plant height, stem diameter, flower diameter, flower weight, number of flowers per plant, duration of flowering and shelf life of flowers. Path coefficient analysis of various quantitative characters revealed that number of flowers per plant, flower weight, number of primary branches, plant spread (E-W) and plant height had positive direct effect on yield. Thus, during improvement programme more attention should be paid to number of flowers per plant and individual flower weight. The assessment of qualitative parameters i.e. flower type, flower colour and flower compactness was done to find the variety most suitable as loose flowers with a greater acceptance for garland purpose. The cultivar BM-2 was found suitable for commercial cultivation in coastal plain zone of Odisha

INTRODUCTION

Floriculture has emerged as a viable agribusiness by improving the productivity of land, generating vast employment opportunities from grower's field to retailer's shop and ultimately improving the economic status of the farmers and entrepreneurs. In India, commercial floriculture has increased its credibility by diversification in agriculture and also evolved as a foreign-exchange earner. The Indian subcontinent is gifted with diverse agro-climatic conditions providing opportunities for the production of all major loose flowers like marigold, jasmine, chrysanthemum, rose, crossandra, tuberose, china aster, *etc.* and also the abundance cheap labour is another advantage for low production cost to compete in the international market.

In India, the growth of floriculture industry has been very slow in the first 40 years of independence due to more concentration paid to the cultivation of food grains. But, after liberalization of economic policies in the 1990s, a very significant expansion in floriculture has been recorded from mere 53 thousand hectares area and production of 233 thousand tonnes of loose flowers in 1993-94 (Kumar *et al.*, 2011) to a remarkable 3.09 lakh hectares area and production of 1652.99 thousand tonnes of loose flowers in the year 2016-17. The contribution to loose-flower production in Odisha is 72.88 thousand tonnes from an area of 6.57 thousand hectares (NHB Database, 2017).

Marigold (*Tagetes* spp.) belonging to the family Asteraceae is one of the important loose flower grown commercially in many parts of the world. The name *Tagetes* is from the name of the Etruscan Tages, a demigod born from the ploughing of the earth. According to Marshal (1969), the king Curtez after conquering Mexico got fascinated by the beauty of flowers and carried it to Spain. It was then offered to the attar of Virgin Mary and thus named as Mary's gold, now, popularly known as Marigold.

Genus *Tagetes* consists of 33 species, out of which, *Tagetes erecta* L., commonly called African marigold, and *Tagetes patula* L. popular as French marigold are of great horticultural importance and is grown commercially. The African

marigold is taller and is a profuse branching annual with large sized blooms of orange/yellow colours, whereas French marigold is short in height with smaller flowers.

Marigold is native to Central and South America especially Mexico. During early sixteen century it spread to various parts of the world from Mexico (Kaplan, 1960). African marigold first reached Spain and was popular as Rose of Indies in southern Europe. In India marigold was introduced by Portuguese and it became popular and spread quickly because of its wide adaptability to varying climatic and soil conditions.

African marigold is popular due to its wide variation of attractive colours, shape and good keeping quality which has attracted the attention of flower growers. They produce marketable flowers within a short time and are widely used for social and religious functions as well as garden display. They are extensively used as loose flower, potted plant and also as a bedding plant. Loose flowers are in great demand for garland making as well as in religious and social functions. They are even used to decorate the religious places. They are highly preferred for decorating pandals, places of social meetings and gatherings. The plant is very useful as both the leaves and the flowers are equally important from a medicinal point of view. The paste and extracts from the plant are used as a cure for boils, earache, eye disease and ulcers. The oil is reported to have bronchodilator, tranquilizing and anti-inflammatory properties (Chandhoke and Ghatak, 1969). Marigold cultivation controls the nematode population in soil and is used for making mosquito repellent products (Gupta *et al.*, 2001). Flower extract is used as a blood purifier as well as a good remedy for eye diseases and ulcer. The carotenoids extracted from petals of marigold are the major source of pigment for poultry industry as a feed additive to intensify the yellow color of egg yolks and broiler skin (Narsude *et al.*, 2010 and Kaul and bedi 2006). Lutein, which is the major constituent of xanthophyll, is used for coloring foodstuffs (Singh and Singh, 2006).

Marigold is one of the most important commercial loose flower crop grown in almost all the states of India. In Odisha due to the suitability of climatic and soil conditions, it has got a good production capacity. The daily requirement of marigold

is high due to high flower requirement for religious offerings, making garlands and also decoration purposes.

The demand for new cultivars is always increasing. With the availability of new cultivars, it is highly essential to have information on magnitude and nature of variability in the available genotypes with respect to yield to select a variety which can be used for commercial cultivation. The genetic variability indicates the accessibility of a given character for its improvement while the estimates of heritability along with genetic advance help in drawing a valuable conclusion for effective selections based on phenotypic performances.

Yield is highly influenced by environment thus, the correlation studies between yield and other economic traits are of immense help in selecting suitable plant type for crop improvement as well as commercial cultivation. Under complex situations, correlation study alone is insufficient thus in such situation, path analysis furnishes a method for separating out the direct and indirect effect so as to measure the relative importance of causal factors involved. Therefore, information on the nature and magnitude of genetic variability, the heritability of traits, their inter-relationship as well as their direct and indirect effects on flower yield are of immense importance to select some varieties suitable for commercial cultivation having greater yield potential.

Therefore the present investigation entitled “**Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under the coastal plain zone of Odisha**” was carried out with following objectives: -

- (i) To study the extent of genetic variability in respect of flower production in African marigold.
- (ii) To study the extent of character association in relation to flower yield and its component traits.
- (iii) Evaluation and selection of African marigold genotypes suitable for coastal plain zone of Odisha.

REVIEW OF LITERATURE

Association of flower yield and its component characters is essential to select better varieties with improved yield. The magnitude of genetic variability present in the plant population decides the efficiency of selection. Correlation coefficient is the significant selection parameter in plant breeding. It is used to find out the strength and direction of the relation between two or more characters. It measures the relationship between various characters and decides the character on which, selection can be based on genetic improvement thus improving the yield. The Path coefficient analysis is a standardized partial regression, which may be useful in choosing the characters that have direct and indirect effects on yield. Heritability serves as a useful parameter in predicting genetic advance and response of selection. It also indicates the accuracy with which a genotype can be recognized by its phenotypic expression. Thus, the magnitude of variation and the estimates of heritability and genetic advance are the important parameters on which the selection procedure lies.

The present investigation was carried out to study the “Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under coastal plain zone of Odisha”. The literature in relation to the proposed work is reviewed under this chapter.

2.1 VARIABILITY STUDY

According to Tikka *et al.*, 1974; Patnaik & Tak, 1974, any breeding programme involves selection of superior at one stage or other and the effectiveness of selection depends upon the existence of genetic variability within or among populations subjected to selection. The amount of variation in the available genetic material and the part played by the environment on the expression of characters is of utmost importance for determining the magnitude of improvement.

Many of the economic important characters in crop plants are quantitative in nature, which is governed by "polygenes". These polygenes are highly influenced by environment. Since environment has got profound influence on quantitative characters, it is difficult to ascertain whether the variability is heritable or non-

heritable. Thus, phenotypic variability is divided into heritable and non-heritable components.

Heritable Variation- It results from the additive or average effect of gene and is called as Additive genetic variance (VA). It also results from intra-allelic interaction and is called as Dominance variance (VD)

Non-Heritable Variation- Inter-allelic interaction or Epistatic variance (VI) results from the interaction of non-allelic genes. Environmental variance (VE) results from non-genetic factors such as climatic changes, error in sampling and difference due to cultural practices.

According to Chaudhury and Prasad (1968), Genetic variability being an inherent variation responds to selection and is heritable in the absence of dominance and dominance X dominance interaction.

According to Weber and Moorthy (1952), the genetic variance is the effect of additive gene action while genotypic variance includes genetic variance and also the variance largely due to dominance and epistasis.

2.2 COEFFICIENT OF VARIATION

Coefficient of variation is defined as a measure of variation and is independent of the unit of measurement which is used for comparison between different populations. The coefficient of variation is partitioned into genotypic coefficient of variation and phenotypic coefficient of variation. Genotypic coefficient of variation is the genotypic standard deviation expressed as the percentage of mean and phenotypic coefficient of variation is expressed as a percentage of the mean of phenotypic standard deviation.

A negligible influence of environment on the character is indicated by a slight difference between phenotypic and genotypic standard deviation as suggested by Chaudhury *et al.*, (1973).

2.3 HERITABILITY STUDIES

Heritability is the proportion of the total phenotypic variance that is due to genetic causes. More specifically heritability on consideration of the response to

selection is used as narrow sense heritability and broad sense heritability. Narrow sense heritability is measured as the ratio of additive genetic variance (VA) to the total phenotypic variance (Wright, 1921). The broad sense heritability is the ratio of total genotypic variance (VG) to the observed phenotypic variance (VP).

Symbolically represented as

$$h^2 \text{ (narrow sense)} = VA / (VG + VE) = VA / VP$$

$$h^2 \text{ (broad sense)} = VG / (VG + VE) = VG / VP$$

Liang and Walter (1968) defined heritability as the transmission of characters from parent to offspring. This statement was supported by Rangaswamy and Sundaram (1973). Heritability indicates the effectiveness with which selection of genotype can be based on phenotypic performance (Johnson *et al.*, 1955). The main use of heritability in a narrow sense for plant breeder is to estimate expected improvement due to selection or genetic advance (Falconer, 1960).

According to Johnson *et al.*, (1955) Heritability estimates increased when used in conjunction with selection differential and the genetic advance is completely predicted as the product of heritability ratio and the selection differential.

According to Weber and Moorthy (1952), the heritability of quantitative inherited attributes and their association with genetic and environmental variances and co-variances may be useful for improving the efficiency of selection. Burton (1952) and Burton and Devane (1953) suggested that genotypic coefficient of variance and heritability gave the best picture of the amount of advance to be expected from the selection. Randhawa *et al.*, (1975) suggested that if the heritability of a character is high, the opportunity is real, good for selecting a genetically good individual. The low value of heritability indicates a high degree of non-heritable variability.

Robinson (1963) reported that heritability estimates in cultivated plants can be grouped under the following categories, Low heritability 5% to 10% e.g. yield, Moderate heritability 10% to 30% e.g. components of yield, High heritability 30% to 60% e.g. maturity characters, chemical composition etc.

Many various non-genetic factors such as plot size, planting density, number of replication, climatic and soil fertility conditions affecting plant growth also affect the heritability estimates (Frey and Homer, 1957).

Heritability thus indicates the accuracy with which a genotype can be recognized by its phenotypic expression.

2.4 GENETIC ADVANCE

The genetic coefficient of variation along with a heritability estimate would seem to give the best picture of the amount of advance to be expected from selection (Burton, 1952). According to Escuro *et al.* (1963) Genetic advance indicates the potential of selection at a particular level of selection intensity. The expected genetic advance from selection when expressed as a percent of the mean is the product of the selection differential measured in terms of phenotypic standard deviation, the genotypic coefficient of variation and the square root of heritability ratio.

2.5 CHARACTER ASSOCIATION (CORRELATION STUDIES) IN MARIGOLD

Yield being the most important economic character, is a complex one depending on various components. So, it is important to know the nature of association for the proper selection procedure. The nature of the association between two components may be positive or negative. When two characters have positively associated the selection for one component will result in the selection of the other while there is an adverse effect on the selection of character when there is a negative correlation.

Evaluation of character association directly from phenotypic value is defined as phenotypic correlation. The phenotypic association is further partitioned into genetic, environment or both. The genetic correlation is a more reliable guide in selection than phenotypic correlation. Two characters are influenced by the difference in environmental conditions. The genetic cause of character association is Pleiotropy and Linkage. Pleiotropy refers to the property or certain genes influencing two or more character. The pleiotropic action of genes causing genetic correlation may be

positive or negative and cannot be modified by recombination. Genetic correlations resulting from linkage are transient and can be modified by recombination.

The correlation coefficient (r) is the measure of the degree of association between two characters working with at the same time (Hays *et al.*, 1955). The degree of association of yield with its components and other inter-relationship are of great importance for making an effective selection. If a high correlation exists between lowly heritable characters like yield and highly heritable character, then selection will be done basing on the later for improvement. If negative correlation exists between components of yield, then the selection is to be done for an intermediate combination for improvement in yield.

2.6 PATH COEFFICIENT ANALYSIS IN MARIGOLD

Linear correlations between yield and various structural or growth components used present a confusing picture because of the interrelationship among the components themselves. Therefore, standard partial correlation or regression (path coefficients) affords much more realistic picture. The concept of path coefficient analysis developed by Wright (1921) was first used for plant selection by Dewey and Lu (1959).

Karuppaiah *et al.* (2004) evaluated 34 genotypes of African marigold. Results of correlation analysis indicated that the flower yield per plant was found to be significantly and positively correlated with the number of branches per plant, flower size, flower weight, number of flowers per plant. Days to first flowering had a negative association with flower yield per plant. Path analysis has shown that number of flowers per plant showed high positive direct effects. Medium level of direct effect was recorded by flower diameter.

Singh and Misra (2008) evaluated nine parents of marigold and its thirty-six F₁s were evaluated to ascertain genetic parameters of variability, heritability, and genetic advance. In all the three different studies, the coefficient of variation was maximum for seed yield per plant. Under pooled data analysis, total chlorophyll content of leaf, number of leaves per plant, leaf biomass, seed germination percentage, days taken to seed ripening and seed yield per plant were found with

lower heritability estimates. High heritability with high genetic advance was found with the number of flowers per plant, number of petals per flower, flower yield per plant and seed yield per plant.

Karuppaiah and Kumar (2010) carried out an investigation with thirty-four genotypes of African marigold. Results of correlation analysis indicated that the flower yield per plant was found to be significantly and positively correlated with the number of branches per plant, flower size, flower weight, number of flowers per plant and xanthophylls content. Days to first flowering showed a negative association with flower yield per plant. Path analysis has shown that number of flowers per plant and xanthophylls content showed high positive direct effects. Medium level of direct effect was recorded by flower diameter. Other characters recorded low or very low direct effects.

Kavitha and Anburani (2010) studied the genetic variability present in thirty germplasm of marigold. The coefficients of variation both at genotypic and phenotypic levels were highest for the number of flowers per plant, while the minimum for dry matter production. Heritability estimates for all the characters were generally very high. High heritability along with high genetic advance as percent of the mean was observed for the number of flowers per plant. Flower yield per plant and number of laterals per plant was due to additive gene effects thus suggesting that selection for these characters would be very effective.

Karuppaiah and Kumar (2011) carried out an investigation with thirty-four genotypes of African marigold to assess the variability, heritability, and genetic advance to identify superior genotypes for further crop breeding programmes. High GCV was observed for the number of flower heads per plant followed by the number of branches per plant, flower yield per plant, flower head size and flower head weight. High heritability estimates of more than 95% were observed for plant height, stem girth, number of branches per plant, days to first flowering, flower head diameter, flower head size, number of flowers per plant, flower yield per plant. When heritability and genetic advance as percent of the mean were considered together, the characters like the number of flowers per plant and flower head weight recorded the highest values.

Panwar *et al.* (2013) evaluated twenty-two genotypes of African marigold for sixteen growth and flowering-related traits to study their genetic parameters such as variability, heritability, GCV and PCV. The high GCV and PCV were observed for flower yield per plant, fresh weight per flower and stalk length whereas the lowest value for both GCV 13 and PCV were obtained for the number of seeds per head followed by days to flowering and harvest index. High heritability (>70%) were recorded for stalk length, stem diameter, flower diameter, fresh weight per flower, dry weight per flower, flower yield per plant and 1000 seed weight. High genetic advance as percent of the mean was observed for flower yield per plant followed by fresh weight per flower and stalk length.

Kumar *et al.* (2014) evaluated ten genotypes of French marigold (*Tagetes patula*) to study the variability parameters and character association for twelve characters. Analysis of variance showed highly significant differences for all the twelve characters. In general, estimates of the phenotypic coefficient of variation (PCV) were found to be higher than their corresponding genotypic coefficient of variation (GCV). High broad sense heritability coupled with high genetic advance was reported for the number of flowers per plant and flower yield per plant, showing additive gene effects and shows the effectiveness of the selection of these characters. The yield of flowers per plant exhibited highly significant and positive correlation with the number of primary branches, number of secondary branches, number of flowers per plant and flower weight. Hence, these characters should be given due consideration during selection for yield improvement in French marigold.

Bharathi *et al.* (2014) determined the association between different quantitative traits of twenty-eight genotypes of African marigold. The positive and significant correlation was recorded for flower yield per plant with plant height (0.64), stem girth (0.60), number of flowers per plant (0.53), flower size (0.70), single flower weight (0.69) and number of petals per flower (0.52). The results of path analysis indicated that total duration (0.77), number of flowers per plant (0.56), flower size (0.51), single flower weight (0.38) and number of harvest per plant (0.21) had a maximum direct effect.

Yuvraj and Dhatt (2014) studied variability, heritability, genetic advance in twenty-three marigold genotypes for plant growth and flower yield. The highest value of PCV and GCV was observed for the number of flower per plant (117.95 and 116.50, respectively). High heritability was observed for days to bud initiation (98.48) followed by days to first flower opening (98.36), the number of flowers per plant (97.55), plant height (96.44), flower diameter (94.08), flower yield per plant (90.66). The estimates of genetic advance were comparatively maximum for the number of flowers per plant (237.02%) followed by flower yield (105.37% per plant and 104.66% per square meter).

Vishnupriy *et al.* (2015) studied the genetic parameters such as heritability, genotypic and phenotypic coefficient of variation for ten characters of F₂ progenies in two cross combinations viz., Coimbatore Local Orange X Siracole and Siracole X Coimbatore Local Orange of marigold. PCV was higher than the GCV. High PCV and GCV were observed for the number of primary branches, the number of secondary branches, single flower weight, flower compactness and total flower weight. High heritability was observed for days taken for flower bud appearance, total crop duration and number of flowers per plant. High heritability along with high genetic advance as percent mean were recorded in both the crosses for days taken for flower bud appearance and number of flowers per plant whereas moderate to high heritability and genetic advance as percent mean for other characters in both crosses. As the high heritability and genetic advance as percent mean are due to an additive type of gene action selection will be effective for all the characters in both crosses.

2.7 VARIABILITY STUDIES IN MARIGOLD

Singh *et al.* (2003) evaluated African marigold cultivars under semi-arid conditions of Rajasthan and found 'Excel Mixed' the best cultivar in terms of earliest to flowering (36.33 days) and longest flowering duration (65.3 days), whereas, the maximum number of flowers per plant (44.30) was observed in African Double Perfection. The maximum (7.87 cm) flower diameter was recorded in Giant Mixed. The maximum plant height (71.83 cm) was recorded in Excel Mixed followed by Marigold Tall Mixed (71.30 cm) and the minimum in Deep Orange (56.83 cm). The Marigold Tall Mixed was also reported with the maximum plant spread and African

Double Perfection followed by Excel Mixed with the highest number of branches. Among French marigold cultivars, French Spanish Brocade attained the maximum plant height, while Orange Gate followed by Naughty Marienta the maximum plant spread.

Khanvilkar *et al.* (2003) observed that 'Yellow Supreme' recorded earliest to flower (42 days), while 'Orange Boom' required the maximum days to flower (54.13). The maximum diameter of flower (7.12 cm) and average fresh weight of flowers (8.10 g) were recorded in 'African Giant Mixed'.

Singh *et al.*, (2004) found that *Tagetes patula* genotype 'TPG3' was most suitable for early bud initiation (19.33 days) and maximum dry weight of flower (0.610 g) and 'TPG12' and 'TPG7' for flowering duration (131.00 days) and number of flowers per plant (158.67), respectively. They also recorded significantly the maximum number of primary branches per plant (14.67) in TPG 1 among 13 genotypes of *Tagetes patula*, whereas, the maximum stem diameter (1.57 cm) and plant spread (42.90 cm) was recorded in TPG 10 and TPG 13, respectively.

Naik *et al.* (2005) conducted a stability analysis and the results of the stability analysis over three environments i.e. Kharif 2001-02, Rabi 2001-02 and Kharif 2002-03 revealed that the genotype, African Marigold Orange (AMO) recorded significantly higher flower yield (16.47 t/ha) per hectare with a B: C ratio of 3.28 as compared to the local check (Orange Double).

Rao *et al.* (2005) reported the maximum plant height (84 cm) per plant in 'Orange Double' and the maximum plant spread (46.0 cm) and the number of branches per plant (20.00) in 'Hyderabad Local Selection 1'. The cultivar Orange Double gave the highest fresh flower yield. Early flowering was observed in this cultivar followed by Pusa Narangi Gaiinda. Duration of flowering was also observed to be higher in Orange Double cultivar followed by Pusa Basanti Gaiinda. The highest flower yield of Orange Double cultivar might be due to the highest fresh weight and flower diameter of the single flower.

Singh and Singh (2006) evaluated the performance of twenty-nine genotypes of African marigold (*Tagetes erecta* L.) and reported significant variation in

germplasm for all the growth and flowering parameters. The germplasm TEG16 exhibited the best performance on the number of primary branches/plant, number of flowers/plant and dry weight of leaf. However, germplasm TEG17 resulted in maximum flower longevity and dry weight of flower, whereas maximum duration of flowering was recorded with TEG13. Germplasm TEG23 exerted the poorest performance on various growths and flowering attributes.

Singh and Mishra (2008) assessed the diversity of forty-five genotypes of marigold (*Tagetes* spp.) and concluded that the Cross 'Sutton Orange' x 'Crackerjack Mix' recorded maximum plant height (127.80 cm), whereas parent 'French Dwarf' attained maximum plant spread and maximum secondary branches plant⁻¹ (76.61 cm and 107.40). 'Pusa Narangi Gaiinda' x 'Late Summer' attained the maximum flower diameter (13.00), flower yield per ha (182.13). Cross 'Seraceul' x 'Late Summer' exhibited the maximum duration for flowering (134.00 days) in the first year and cross 'Pusa Narangi Gaiinda' x 'French Dwarf' attained the longest flowering duration (132.33 days) in the second year.

Singh and Misra (2009) assessed 45 genotypes of marigold and recorded that a cross of 'Pusa Narangi Gaiinda' x 'Late Summer' attained the maximum flower diameter.

Narsude *et al.* (2010) reported that the genotype Pakharsangavi Local had a maximum plant height (114.64 cm) and stem girth (5.37 cm) Maximum spread of plant (64.48 cm) was observed in genotype Tuljapur Local-2, number of flowers per plant, yield per plant and yield per hectare, the genotype Tuljapur Local – 1 showed significantly superior performance The genotype Marigold Orange Bunch required maximum days (109.67) to last picking and duration of flowering (56.33 days).

Pal and Kumar (2010) concluded that the genotype Pusa Basanti Gaiinda exhibited maximum mean performance for plant height at peak flowering period (80.00 cm), while the minimum was exhibited by Indame Orange (30.90 cm). High heritability along with high genetic advance was observed in Pusa Basanti Gaiinda for fresh weight of flowers per plant (268.83), number of flowers per plant (33.43), plant height at peak flowering period (29.52), days commencement to flowering (20.93) and plant spread at peak flowering period (20.11). However, moderate to low genetic

advance along with high heritability was observed for flowering duration (19.67), no. of secondary branches per plant (19.14), no. of primary branches per plant (5.91), flower stalk length (3.50), flower diameter (2.54) and 1000 seed weight (1.81).

Singh and Singh (2010) evaluated 44 genotypes of marigold viz., 29 of *Tagetes erecta* (TEG 1 to TEG 29), 13 of *Tagetes patula* (TPG 1 to TPG 13) and 2 of *Tagetes minuta* (TMG 1 and TMG 2) and observed the maximum number of primary branches per plant (53.67) and stem diameter (1.93 cm) in 'TMG 1', while the genotype 'TMG 2' performed better in terms of plant height. The maximum plant spread (79.10 cm) was found in 'TEG 21' followed by 'TEG 22' (70.30 cm).

Raghuvanshi and Sharma (2011) evaluated French marigold cultivars and concluded that the cultivar 'Safari Queen' recorded maximum plant height (35.80 cm) and flower yield per square meter (8.27 kg). Plant spread (30.37 cm) was recorded maximum in cv. 'Harmony Boy'. The cultivar 'Bonanza Bolero' recorded maximum values for flower diameter (5.26 cm).

Ingle *et al.* (2011) evaluated twenty-eight genotypes of African marigold and found significant variation among the genotypes for all the growth parameters. The maximum plant height (121.85 cm) was found in 'AMC-10' and the minimum (58.75 cm) in 'Namdhari Cracker Jack Mix'. In 'AMC-7' the maximum stem girth (18.02 mm) and plant spread (55.80 cm²) was found.

Beniwal and Dahiya (2012) evaluated 38 genotypes of marigold and observed that five genotypes of African marigold (MGH 133-1, 133-1-1, 160-8-2, 160-8 and 160-9-1) showed promising results in respect to the number of flowers per plant (10-64), flower size (5.0-12.27 cm), fresh weight of flower (5.2-22.0 g), days to first flower (72-138) and flowering duration (18-42 days).

Munikrishnappa *et al.* (2013) conducted an experiment to evaluate suitable varieties for growth and flower yield of China aster. The maximum flower yield (37.91 t per ha) was recorded in Phule Ganesh White and it was lowest Mixed Variety Local (9.97 ton). The number of cut flower production was maximum (55.43) in variety Phule Ganesh Violet and the lowest number of cut flower per plant was produced in Shashank (40.92). The maximum number of cut flowers (40.76 lakh per

ha) was recorded in Phule Ganesh Violet and the minimum number of cut flower (31.64 lakh per ha) was recorded in variety Kamini.

Bharathi and Jawaharlal (2014) evaluated twenty-eight genotypes of African marigold (*Tagetes erecta* L.) for growth and flowering traits. The earliest day taken for flower bud appearance was found in Bangalore Local Tall (29.47 days) and earliest flower bud opening was observed in Double Orange (46.00 days). The highest plant height was recorded in Dharmapuri local (113.27 cm) and the highest number of primary and secondary branches per plant was observed in BM-1 (22.40 and 41.47 respectively). The highest flower yield per plant was recorded in Coimbatore Local Orange (1.48kg).

Choudhary *et al.* (2014) evaluated thirty genotypes of marigold. The genotype Hisar Jaffri-2 exhibited the best performance in terms plant spread (77.72 cm), numbers of secondary branches per plant (150.97), duration of flowering (76.53 days) and flower yield per plot (20.99 kg). The maximum diameter of flower (8.21cm) was recorded in MGH-09-276, while it was minimum (4.01 cm) in Hisar Jaffri-2. The genotype MGH-148-3-3 recorded maximum stem diameter (2.14 cm), whereas it was minimum (0.61 cm) in Hisar Beauty.

Kumar *et al.* (2015) evaluated varieties of chrysanthemum varieties for loose flower production Variety Decorative White (T3) was found to be effective on vegetative growth parameters and recorded maximum Plant height (60.9 cm), Plant spread (40 cm), number of branches per plant (16). Significantly earlier appearance of bud (43), maximum average flower weight (8.6g), average 100 flower weight (320g), size of flower (8.5 cm) recorded under T2 (Pompon Rosy Pink). Maximum flower diameter (7.60 cm) and floret size (2.1cm) recorded under T9 (Suneel) whereas, the maximum number of florets per flower (860) recorded under T4 (Decorative Reddish Yellow).

Shivakumar *et al.* (2015) found that the genotype Nilakkotai Local Orange exhibited the best performance on plant height, number of primary and secondary branches per plant, stem girth, flower diameter, flower weight and number of flower per plant. However, genotype Coimbatore Local Yellow resulted in maximum leaf area and leaf area index, whereas maximum total chlorophyll content was recorded

with Darmapuri Local. Genotype Dwarf Yellow exhibited the poorest performance on various growth and flowering attributes.

Gulia *et al.* (2017) evaluated 10 genotypes of African and French marigold and concluded that maximum plant height was recorded in MGH 160-9-2 African genotype and maximum plant spread (69.87 cm) was observed in MGH 8-2 French genotype, while maximum number of primary branches (37.83) was observed in MGH 109-1-2 genotype. Among flowering and yield parameters, flower size (9.03 cm), fresh weight (12.69 g), flower yield per plant (568.5 g), flower yield per plot (9.09 kg) and flower yield per acre (14.21 t) were recorded maximum in MGH 160-9-2 and significantly superior over other genotypes, while maximum number of flowers per plant (122.92) was recorded in MGH 109-1-2 genotype.

MATERIALS AND METHODS

The present chapter deals with information regarding the materials used and techniques employed during the course of the investigation entitled “Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under coastal plain zone of Odisha”.

The present investigation was conducted during October 2017 to March 2018 at the Biotechnology-cum-Tissue Culture Center (BTCC), Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar, Odisha.

3.1 GEOGRAPHICAL LOCATION

Bhubaneswar, the place of investigation is located 63 km away from the Bay of Bengal at an altitude of 25.5 m above the mean sea level. Geographically it is located at 20.25°N North latitude and 85.52°E East latitude.

3.2 CLIMATE

The experimental site, the 18th agro-climatic region of the country i.e. eastern coastal plain is termed as sub-humid which is characterized by the warm and moist climate with hot and humid summer followed by mild winter. The average annual rainfall of Bhubaneswar is 1522mm. Most of the rainfall (about 85%) occurs from June to September and the rest is received within October to May. The average maximum temperature ranges from 35-40°C during May to June while the minimum temperature varies from 13-15°C during December to January. The relative humidity varies between 50% in summer to 90% in the rainy season. The detail of the weather condition during the period of investigation from October to March 2017-2018 have been presented in the table 3.1.

Table 3.1 **Meteorological data of Bhubaneswar from October 2017 to March 2018**

Year	Month	Temp max (0C)	Temp min (0C)	Rainfall (mm)	RH1 (%)	RH2 (%)	BSH (h)	Evaporation (mm)
2017	Oct	32.2	24.3	204.5	93	69	6.0	3.3
2017	Nov	29.6	18.7	55.2	89	56	7.1	3.3
2017	Dec	28.2	14.4	36.3	92	48	7.0	3.4
2018	Jan	28.0	12.0	0.0	92	35	7.3	3.7
2018	Feb	33.7	15.9	0.0	91	29	8.4	4.2
2018	Mar	36.9	22.2	0.0	92	33	6.6	5.4

3.3 SOIL CHARACTERISTICS OF THE EXPERIMENTAL SITE

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

Table 3.2 **Physio-chemical properties of the soil**

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

3.4 CROPPING HISTORY OF THE EXPERIMENTAL AREA

The experimental area was previously planted with marigold.

3.5 EXPERIMENTAL MATERIALS

Eight genotypes were selected for the experiment. The treatment details are given in table 3.3

Table 3.3 **Genotypes under study**

TREATMENTS	GENOTYPES
T1	Bidhan Marigold 1 (BM-1)
T2	Bidhan Marigold 2 (BM-2)
T3	Bidhan Marigold 3 (BM-3)
T4	Arka Bangara
T5	Arka Agni
T6	Arka Alankar
T7	Pusa Narangi Gaiinda
T8	Pusa Basanti Gaiinda

3.6 COLLECTION OF PLANTING MATERIAL

Generally, African marigold is propagated from stem cuttings with an exception of few varieties are from seeds. The rooted stem cuttings of the varieties of BM-1, BM-2, BM-3, Arka Bangara, Arka Agni, Arka Alankar were taken from the mother plant block of AICRP on Floriculture during the month of last week of August. The herbaceous shoot cuttings of 8-10 cm long were planted in the seed pan for rooting using sterilized sand medium. Before planting the basal portion of the cuttings were treated with rootex powder for better and uniform rooting. Light watering was given. Generally, it takes 15 days for rooting. The rooted cuttings were then transferred to polybags and kept for about 20 days before planting in the field. For the varieties Pusa Narangi Gaiinda and Pusa Basanti Gaiinda, seeds were procured from IARI.

3.7 EXPERIMENTAL DETAILS

The experiment was conducted to evaluate and select African marigold genotypes suitable for commercial cultivation in Odisha. All the treatments were randomized separately in each replication. Irrigation and drainage channels were laid out for efficient intercultural operations.

The experimental details are as follows:

Experiment design followed	- Randomized Block Design (RBD)
Number of Treatments	- 8 genotypes
Number of Replication	- 3
Spacing	- 40 cm x 40 cm
Plot size	- 2m x 2.4m
Plants / Treatment	- 30
Plants / Replication	- 240

3.8 EXECUTION OF THE EXPERIMENT

3.8.1 RAISING OF PLANTING MATERIALS:

8-10 cm long herbaceous shoot cuttings were planted in the seed pan for rooting using sterilized sand medium. Before planting the basal portion of the cuttings were treated with rootex powder for better and uniform rooting. The rooted stem cuttings of the varieties of BM-1, BM-2, BM-3, Arka Bangara, Arka Agni, Arka Alankar were kept in polybags for 20 days before planting. The seeds of Pusa Narangi Gaiinda and Pusa Basanti Gaiinda were procured from IARI and sown in seed pans. Seedlings of 2-3 week old were transferred to polythene bags. Well established plants in polybags were planted in the field to avoid mortality.

3.8.2 PREPARATION OF THE EXPERIMENTAL SITE:

Marigold requires well-prepared soil for proper growth and development. The soil should be well drained. The experimental field was ploughed thoroughly and unwanted objects such as crop residues, grasses, weeds, and foreign materials, etc. were removed. Well-decomposed FYM @ 20 t/ha and neem cake were incorporated in soil during land preparation. The beds/plots were laid out with help of measuring tape, rope and bamboo pegs.

3.8.3 TRANSPLANTING OF SEEDLINGS

The treatments were laid out in the randomized block design with three replications. Well established plants in polybags were transplanted on 28th October 2017. The spacing between row-to-row and plant-to-plant was kept 40 cm x 40 cm. A light irrigation was given prior to planting and also immediately after transplanting for better plant establishment.

3.8.4 MANURES AND FERTILIZERS

Well decomposed FYM @ 2 kg per sq. m was applied at the time of land preparation. The fertilizer dose of N: P₂O₅: K₂O @ 200:200:200 kg/ha was applied in the experiment plot.

Half the quantity of nitrogen and full dose of phosphorus and potash were applied at the time of transplanting, while the remaining dose of nitrogen was applied one month after transplanting. Nitrogen was applied in the form of urea, phosphorous in the form of single super phosphate (SSP) and potassium in the form of muriate of potash (MOP).

3.8.5 AFTERCARE OF THE EXPERIMENTAL PLOT

3.8.5.1 GAP FILLING

Gap filling was done one week after transplanting. The dead plants were replaced with plants in polybags to maintain the required plant population in each treatment.

3.8.5.2 IRRIGATION

The pre-planting irrigation was provided in the morning of the day of planting and again irrigation was given just after transplanting. The watering of plots was done at alternate days for a week after transplanting for field establishment of seedlings. In later stages, irrigation was provided at an interval of 5-6 days depending on soil moisture conditions.

3.8.5.3 PINCHING

The seedlings were pinched one month after transplanting to increase the lateral spread of the plants.

3.8.5.4 WEEDING

Weeds compete with crop plants for nutrients, moisture, space, and light. Thus, for better growth and development of crop plants, plot was kept weed-free by hand weeding and hoeing at regular intervals.

3.8.5.5 PLANT PROTECTION

Prophylactic measures were adopted timely and uniformly as and when required to protect the crop against insect-pests and diseases

3.8.5.6 PLANT TAGGING

Five plants were selected randomly in each treatment plot excluding the border rows and tagged for recording data on various characters to be studied.

3.9 HARVESTING

Harvesting was done after the complete opening of the flowers and it started from the date when the first flower attained fully open stage and thereafter at alternate days. The tagged plants were harvested and the numbers of flowers harvested from individual plants were recorded separately.

3.10 COLLECTION OF EXPERIMENTAL DATA

3.10.1 SAMPLING PROCEDURE

For studying various characters, five plants of each genotype in a replication were selected leaving the border rows, at random which were tagged for recording observations.

3.10.2 OBSERVATIONS ON VEGETATIVE CHARACTERS

3.10.2.1 PLANT HEIGHT (cm)

The plant heights of five tagged plants from each treatment were measured from the ground level to the tip of the plant with the help of meter scale.

3.10.2.2 PLANT SPREAD (cm)

The plant spread was measured in the five tagged plants from each treatment with the help of meter scale in the North-South and East-West direction.

3.10.2.3 NUMBER OF PRIMARY BRANCHES PER PLANT

All the branches from the main stem of the five tagged plants in each treatment were counted.

3.10.2.4 NUMBER OF SECONDARY BRANCHES PER PLANT

The numbers of secondary branches arising from the primary branches per plant of the five tagged plants from each treatment were counted.

3.10.2.5 STEM DIAMETER (mm)

The stem diameter of the five selected plants was measured using slide callipers.

3.10.3 OBSERVATIONS ON FLOWER CHARACTERS

3.10.3.1 DAYS TAKEN FOR FLOWER BUD APPEARANCE

The date on which about 50% of plants in a plot showed flower buds was recorded and the number of days was counted from the date of planting.

3.10.3.2 DAYS TAKEN FOR FLOWER BUD OPENING

The number of days was calculated from the date of flower bud appearance to the date of opening of the flower bud to give the number of days taken for flower bud opening.

3.10.3.3 SHELF LIFE OF FLOWERS (days)

Twenty flowers from the tagged plants were kept at room temperature after harvest to study the shelf life. Prior to that, the average weight of the twenty flowers was recorded. The observations were taken on the number of days the flower retains freshness.

3.10.4 OBSERVATIONS ON YIELD ATTRIBUTING TRAITS

3.10.4.1 FLOWER DIAMETER (cm)

The maximum diameter of five flowers at fully open stage from five selected plants was measured using slide callipers and then mean of the flower size value was calculated.

3.10.4.2 FLOWER WEIGHT (g)

The weight of ten fresh flowers from the five selected plants of each treatment was recorded with the help of weighing machine and the mean was calculated.

3.10.4.3 NUMBER OF FLOWERS PER PLANT

At each harvest, the numbers of flowers harvested from the five selected plants were counted to get the number of flowers per plant.

3.10.4.4 WEIGHT (YIELD) OF FLOWERS PER PLANT (kg)

It was calculated by multiplying the mean value of the weight of flower with the mean value of the number of flowers per plant of the five selected plants of each treatment.

3.10.4.5 DURATION OF FLOWERING (days)

It was recorded by counting the number of days of first flowering to harvesting of the last flower.

3.10.5 OBSERVATIONS ON QUALITY PARAMETERS

3.10.5.1 FLOWER TYPE

Visual assessment of the type of flowers of the genotypes was done.

3.10.5.2 FLOWER COLOUR

The colour of flowers of different genotypes was determined by the help of RHS colour chart.

3.10.5.3 FLOWER COMPACTNESS

The compactness of flowers was determined by manually pressing the flowers with palm.

3.11 STATISTICAL ANALYSIS

The data collected from various observations recorded in the field were subjected to statistical analysis by standard analysis of variance technique (Gomez and Gomez, 1984).

3.11.1 Analysis of Variance

The analysis was carried out for each trial following the procedures of randomized block design analysis (Gomez and Gomez, 1983. Panse and Sukhatme, 1954). Analysis of variance was done on the basis of the following model

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

Where,

Y_{ij} = Phenotypic observation in the i^{th} genotype and the j^{th} replication

m = General mean

g_i = Effect of the i^{th} genotype/treatment

r_j = Effect of j^{th} replication

e_{ij} = random error associated with i^{th} genotype in j^{th} replication

Table 3.4 Analysis of variance and expected mean sum of square

Source	Df	MSS	Expected mean sum of square
Replication	(r-1)	M _R	$\sigma_e^2 + g\sigma_r^2$
Genotype	(g-1)	M _G	$\sigma_e^2 + r\sigma_g^2$
Error	(r-1)(g-1)	M _E	σ_e^2

3.11.2 Mean, range, standard error, and critical differences

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

$$\text{Standard error mean (SEM)} = \sqrt{\frac{2EMS}{r}}$$

Critical difference (C.D.)

$$= \sqrt{\frac{2EMS}{r}} \times t \text{ value at error d.f. at 5\% and 1\% level of significance}$$

Where, r = number of replications

EMS = Error mean sum of square

3.11.3 Co-efficient of variation

For comparing the variability of two or more than two characters, coefficient of variation were calculated by using the formula given below:

$$\text{C.V.} = \frac{SD}{\bar{X}} \times 100 = \frac{1}{\bar{X}} \sqrt{EMS} \times 100$$

Where,

S.D. = standard deviation which is the square root of mean square due to error (EMS)

X = Experimental mean

From the structure of the analysis of variance

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

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

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

The genotypic coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV) was calculated by the formula given by Burton (1952).

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

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

3.11.4 Heritability (broad sense)

Heritability is calculated by the formula suggested by Lush (1949) and Burton and Devance (1953) and expressed in percentage according to Weber and Moorthy (1952).

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

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

3.11.5 Expected genetic advance

The genetic advance was calculated using the formula suggested by Johnson *et al* (1955).

$$\text{GA} = K. h^2 \sigma_p$$

Where,

K = Selection differential in standard units (which is 2.06 per 5% selection intensity).

h^2 = Heritability in broad sense

σ_p = Phenotypic standard deviation

GA expressed as a percentage of mean = $\frac{GA}{Mean} \times 100$

3.11.6 Estimation of correlation coefficient

Simple correlation coefficient was computed at phenotypic and genotypic levels between pairs of 14 characters that contribute to total flower yield using the following formula.

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

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

Where,

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

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

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

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

The estimated values were compared with the table value at (n - 2) and at degrees of freedom at 5% and 1% levels of significance in the order of test the significance of correlation coefficient at phenotypic and genotypic level.

3.11.7 Path coefficient analysis

Path coefficient analysis determines the cause and effect relationship among the various correlated characters. Path coefficient was standardized by partial

regression coefficients which individually provide a measure of the direct effect of the causal factors on the effect variable.

In the present experiment, weight (yield) of flowers per plant was taken as the effect with other characters like plant height, plant spread, number of primary branches, number of secondary branches, stem diameter, flower diameter, flower weight, number of flowers per plant and duration of flowering related to this as the causal factor.

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

$$\begin{aligned} r_{112} &= r_{11}p_{112} + r_{12}p_{112} + r_{13}p_{112} + \dots + r_{111}p_{1112} \\ r_{212} &= r_{21}p_{112} + r_{22}p_{112} + r_{23}p_{112} + \dots + r_{211}p_{1112} \\ r_{312} &= r_{31}p_{112} + r_{32}p_{112} + r_{33}p_{112} + \dots + r_{311}p_{1112} \\ r_{1112} &= r_{111}p_{112} + r_{112}p_{212} + r_{113}p_{312} + \dots + p_{1112} \end{aligned}$$

Where,

r_{ij} is the coefficient of correlation between i^{th} and j^{th} characters

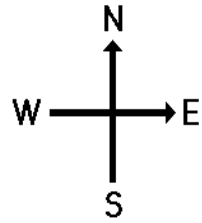
p_{qi} is the path coefficient (direct effect of i^{th} character total yield per plant (1, 2).

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

$$\begin{aligned} I &= p_{12,R}^2 + \sum p_{iy}r_{iy} \\ R^2 &= \sum p_{iy}r_{iy} \\ &= p_{112}r_{112} + p_{212}r_{212} + p_{312}r_{312} + \dots + p_{1112}r_{1112} \\ P_{12,R} &= \sqrt{1 - R^2} \end{aligned}$$

The path analysis at the genotypic level with the same cause and effect relationship was computed using the genotypic correlations as stated earlier.

Fig 3.1 LAYOUT OF THE EXPERIMENTAL FIELD



R1T8		R1T7		R1T6		R1T5		R1 T4		R1T3		R1T2		R1T1
R2T8		R2T3		R2T4		R2 T1		R2T2		R2T6		R2T7		R2T5
R3T8		R3T1		R3T5		R3T3		R3T6		R3T7		R3T4		R3T2

Fig 3.2 PLOT AT FULL BLOOM STAGE



Fig 3.3 Pictures of plant and flowers of different genotypes under study

BM-1



BM-2



BM-3



ArkaBangara



Arka Agni



ArkaAlankar



Pusanarangigainda



PusaBasantigainda



Fig 3.4 Comparative view of the flowers



RESULTS

The present experiment “Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under coastal plain zone of Odisha.” was conducted at experimental site of the Biotechnology-cum-Tissue Culture Center (BTCC), Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar, Odisha during October 2017 to March 2018. The experiment was laid out with 8 genotypes of African marigold with 3 replications in Randomized block design.

4.1 Analysis of Variance

Between 14 characters (plant height, plant spread (both north-south and east-west), number of primary branches, number of secondary branches, stem diameter, days taken for flower bud appearance, days taken for flower bud opening, flower diameter, flower weight, number of flowers per plant, duration of flowering, shelf life of flowers and weight(yield) of flowers per plant) observed in 8 genotypes, the variance (mean square values) are presented in the Table 4.1. The presence of significant difference among the 8 varieties were observed for 12 characters while 2 characters showed insignificant difference.

4.2 Mean performance of different characters

The estimate of mean performance of different characters is presented in Table 4.2 and range is presented in Table 4.3. The maximum mean range of 114.80-185.33 was recorded for the character number of flowers per plant, while the minimum of 0.71-1.60 was for the character weight (yield) of flowers per plant.

Plant height

For the character plant height, the range observed was 55.70-73.77 cm. The highest plant height was recorded in Pusa Narangi Gaiinda (73.77 cm) and the lowest in Pusa Basanti Gaiinda (55.70 cm). Pusa Narangi Gaiinda was followed by Arka Alankar (69.46 cm), Arka Bangara (69.41 cm), Arka Agni (67.45 cm), BM-1 (63.16 cm), BM-2 (62.43 cm) and BM-3 (60.24 cm)

Plant spread (north-south)

The observed range for the character plant spread (north-south) was 44.99-52.07 cm. The highest spread was observed in Pusa Narangi Gaiinda (52.07 cm) followed by BM-1 (48.17 cm), Arka Alankar (47.43 cm), Arka Agni (46.67 cm), BM-3 (46.23 cm) , Pusa Basanti Gaiinda (45.79 cm) , Arka Bangara (45.09 cm) and the lowest spread was observed in BM-2 (44.99 cm).

Plant spread (east-west)

Variation for the character plant spread (east-west) was observed in the range of 44.91-54.38 cm. The highest spread was observed in Pusa Narangi Gaiinda (54.38 cm), followed by BM-2 (48.95 cm), BM-1 (48.81 cm), BM-3 (47.73 cm), Arka Agni (46.17 cm), Arka Bangara (45.86 cm), Pusa Basanti Gaiinda (45.26 cm) and the lowest in Arka Alankar (44.91 cm).

Number of primary branches

The observed range for the character number of primary branches was 6.87-17.93. The highest number of primary branches was in Pusa Narangi Gaiinda (17.93) followed by BM-3 (17.27), BM-1 (15.06), Pusa Basanti Gaiinda (13.67), BM-2 (12.80), Arka Bangara (10.80), Arka Agni (19.40) and the lowest number of primary branches was found in Arka Alankar (6.87).

Number of secondary branches

For the character number of secondary branches, the range observed was 30.60-83.60. The highest number of secondary branches was found in Pusa Narangi Gaiinda (83.60) followed by BM-3 (83.47), Arka Alankar (55.80), Pusa Basanti Gaiinda (48.47), BM-1 (47.20), BM-2 (35.47), Arka Bangara (33.13) and the lowest value was found in Arka Agni (30.60).

Stem diameter

Variation for the character stem diameter was observed in the range of 15.55-20.15 mm. The highest stem diameter was observed in Pusa Narangi Gaiinda (20.15 mm) followed by Arka Alankar (19.18 mm), Arka Agni (18.62 mm), BM-2 (17.65

mm), Arka Bangara (17.39 mm), Pusa Basanti Gaiinda (17.01 mm), BM-3 (16.85 mm) and the lowest value was found in BM-1 (15.55 mm).

Days taken to flower bud appearance

The range for the number of days taken to flower bud appearance was 54.33-78.67 days. Early bud appeared in the variety Arka Bangara (54.33 days) followed by Arka Alankar (58.67 days), Arka Agni (60 days), BM-2 (63.67 days), BM-1 (65.33 days), BM-3 (70 days), Pusa Narangi Gaiinda (75 days) and the highest days taken for flower bud appearance was in Pusa Basanti Gaiinda (78.67 days).

Days taken to flower bud opening

The range for the number of days taken to flower bud opening was 42.67-61 days. Early flower opening was observed in Arka Bangara (42.67 days) followed by Arka Alankar (46 days), Arka Agni (48.33 days), BM-1 (49.33 days), BM-2 (49.67 days), BM-3 (54.33 days), Pusa Narangi Gaiinda (56.67 days) and late flower opening was seen in Pusa Basanti Gaiinda (61 days).

Flower diameter

For the character flower diameter, the range observed was 6.21-7.65 cm. Largest flower with high flower diameter was in the variety Arka Bangara (7.65 cm) followed by BM-2 (7.35 cm), BM-1 (6.78 cm), Arka Agni (6.72 cm), Pusa Narangi Gaiinda (6.47 cm), Pusa Basanti Gaiinda (6.43 cm), Arka Alankar (6.23 cm) and the smallest flower with less flower diameter was in the variety BM-3 (6.21 cm).

Flower weight

Variation for the character flower weight was observed in the range of 5.68-8.64 g. Highest individual flower weight was found in the variety Arka Agni (8.64 g) followed by the variety Arka Bangara (6.84 g), BM-2 (6.51 g), Arka Alankar (6.46 g), BM-1 (6.22 g), Pusa Narangi Gaiinda (6.15 g), Pusa Basanti Gaiinda (6.14 g) and the lowest flower weight was found in the variety BM-3 (5.68 g).

Number of flowers per plant

The observed range for the character number of flowers per plant was 114.8-185.33. Highest number of flower were obtained in the variety Arka Agni (185.33) followed by the varieties BM-2 (168.33), BM-3 (153.67), BM-1 (134), Arka Bangara (133.27), Arka Alankar (131.47), Pusa Narangi Gaiinda (122.87) and the lowest number of flowers was in the variety Pusa Basanti Gaiinda (114.8).

Duration of flowering

A range of 72.67-90.33 days was observed for the flowering duration. The longest duration was observed in the variety Arka Bangara (90.33 days) followed by BM-2 (88.33 days), Arka Alankar (87.33 days), Arka Agni (85.33 days), BM-1 (84.33 days), BM-3 (81 days), Pusa Basanti Gaiinda (76.67 days) and the shortest flowering duration was observed for the variety Pusa Narangi Gaiinda (72.67 days).

Shelf life of flowers

The shelf life of flowers ranged from 1.67-6.33 days in the experiment. Longest shelf life was for the flowers of the variety BM-2 (6.33 days) followed by BM-3 (4.67 days), Arka Bangara (4.33 days), BM-1 (3.67 days), Arka Alankar (3.33 days), Arka Agni (2.67 days), Pusa Narangi Gaiinda (2.33 days) and the lowest shelf life was observed for the variety Pusa Basanti Gaiinda (1.67 days).

Weight (yield) of flowers per plant

Variation was observed in the range of 0.71-1.60 kg for the character weight of flowers per plant. Highest value for this character was for the variety Arka Agni (1.60 kg) followed by the varieties BM-2 (1.09 kg), Arka Bangara (0.91 kg), BM-3 (0.87 kg), Arka Alankar (0.85 kg), BM-1 (0.83 kg), Pusa Narangi Gaiinda (0.75 kg) and the lowest weight of flowers per plant was observed in the variety Pusa Basanti Gaiinda (0.71 kg).

4.3 Mean, range, and coefficient of variation

The coefficient of variation (CV) estimate is presented in Table 4.2. It ranged from 1.75-15.35.

The highest variation was observed for shelf life of flowers(15.35) followed by number of primary branches (10.64), plant spread(E-W) (8.52), plant spread(N-S) (7.02), stem diameter (5.04), number of secondary branches (4.37), weight of flowers per plant (4.09), number of flowers per plant(3.64), plant height(3.36),flower diameter (2.56), days taken to flower bud opening (2.55), days to flower bud appearance (2.18), flower weight (2.04) and the lowest variation observed is for duration of flowering (1.75).

Thus low variation ($CV \leq 5\%$) was observed for the characters number of secondary branches, the weight of flowers per plant, number of flowers per plant, plant height, flower diameter, days taken to flower bud opening, days to flower bud appearance, flower weight and duration of flowering. Moderate variability ($5 < CV < 10\%$) was observed for stem diameter, plant spread (N-S), plant spread (E-W). High variability ($CV \geq 10\%$) was observed for the characters number of primary branches and shelf life of flowers.

4.4 Estimates of genetic parameters

For the estimation of genetic parameters, the phenotypic coefficient of variation (PCV), the genotypic coefficient of variation (GCV), broad sense heritability and genetic advance are presented in Table 4.4

For all the characters observed, it was observed from the Table 4.4 that PCV is always greater than GCV. The PCV was highest for the character shelf life (42.83) followed by number of secondary branches (40.62) and the lowest value was for duration of flowering (7.44). Highest GCV was in number of secondary branches (40.39) followed by the character shelf life of flowers (39.99) and the lowest value was for plant spread (N-S) (2.75).

Heritability

The broad sense heritability was highest for the character number of secondary branches (98.84 %) and the lowest value was for the character plant spread (N-S) (13.30%). Except for stem diameter (69.78%), plant spread (E-W) (19.58%) and plant spread (N-S) (13.30%) all other characters showed high heritability ($>85\%$).

The heritability of other characters are weight(yield) of flowers per plant (98.17%), individual flower weight (97.81%), days to flower bud appearance (97.11%), number of flowers per plant (95.46%), days taken to flower bud opening (95.38%), duration of flowering (94.47%), flower diameter (89.88%), number of primary branches (87.99%), plant height (87.28%), shelf life (87.16%)

Genetic advance

The range for the genetic advance was from 0.58% (weight of flowers per plant) to 48.08% (number of flowers per plant). High genetic advance (>10%) was found in plant height (11.03%), days taken to flower bud opening (11.91%), duration of flowering (12.05%), days to flower bud appearance (16.88%), number of secondary branches (43.19%) and number of flowers per plant (48.08%). Low genetic advance (<10%) was found in number of primary branches (7.22%), shelf life of flowers (2.79%), stem diameter (2.35%), flower weight (1.83%), plant spread(E-W) (1.83%), flower diameter (1%), plant spread(N-S) (0.97%) and weight (yield) of flowers per plant (0.58%).

The genetic advance expressed as a percentage of mean ranges from 2.06% (plant spread N-S) to 82.72% (number of secondary branches). The values of genetic advance for all other characters are shelf life of flowers (76.9%), weight (yield) of flowers per plant (61.13%), number of primary branches (55.65%), number of flowers per plant (33.63%), flower weight (27.76%), days to flower bud appearance (25.68%), days taken to flower bud opening (23.36%), plant height (16.91%), flower diameter (14.88%), duration of flowering (14.48%), stem diameter (13.18%) and plant spread(E-W) (3.83%).

4.4 Character association

In Table 4.5 estimates of the phenotypic correlation coefficient and Table 4.6 gives the estimates of the genotypic correlation coefficient for 14 characters related to weight (yield) of flowers per plant is presented.

Phenotypic correlation

Association of weight (yield) of flowers per plant with component characters

A positive correlation exist between weight (yield) of flowers per plant with plant height (0.138), stem diameter (0.145), flower diameter (0.237), flower weight

(0.903), number of flowers per plant (0.906), duration of flowering (0.408) and shelf life of flowers (0.140).

A negative correlation was found with plant spread (N-S) (-0.163), plant spread (E-W) (-0.128), number of primary branches (-0.429), number of secondary branches (-0.542), days to flower bud appearance (-0.475) and days taken to flower bud opening (-0.382).

Association among component characters

Plant height was found to be positively correlated with plant spread(N-S) (0.476), plant spread(E-W) (0.377), number of secondary branches (0.093), stem diameter (0.626), flower diameter (0.123), flower weight (0.276), number of flowers per plant (0.0032), duration of flowering (0.057) and weight(yield) of flowers per plant (0.138). It was negatively correlated with number of primary branches (-0.192), days to flower bud appearance (-0.423), days to flower bud opening (-0.451) and shelf life of flowers (-0.108).

Plant spread(N-S) have a positive correlation with plant spread(E-W) (0.587), number of primary branches (0.322), number of secondary branches (0.429), stem diameter (0.263), days to flower bud appearance (0.236), days to flower bud opening (0.195). This character was negatively correlated with flower diameter (-0.369), flower weight (-0.101), number of flowers per plant (-0.209), duration of flowering (-0.392) and shelf life of flowers (-0.341).

Plant spread (E-W) was positively correlated with number of primary branches (0.494), number of secondary branches (0.367), stem diameter (0.305), days to flower bud appearance (0.272) and days to flower bud opening (0.218). A negative correlation with flower diameter (-0.0196), flower weight (-0.191), number of flowers per plant (-0.06), duration of flowering (-0.366) and shelf life of flowers (0.0444) was observed.

The number of primary branches exhibits a positive correlation with number of secondary branches (0.639), days to flower bud appearance (0.67) and days to flower bud opening (0.598). A negative correlation with stem diameter (-0.206), flower diameter (-0.198), flower weight (-0.576), number of flowers per plant

(-0.246), duration of flowering (-0.636) and shelf life of flowers (-0.007) was observed.

The numbers of secondary branches have a positive correlation with stem diameter (0.211), days to flower bud appearance (0.584) and days to flower bud opening (0.531). It was negatively correlated with flower diameter (-0.665), flower weight (-0.647), number of flowers per plant (-0.369), duration of flowering (-0.682) and shelf life of flowers (-0.171).

There is a positive correlation between stem diameter with days to flower bud appearance (0.002), days to flower bud opening (0.002), flower weight (0.238), number of flowers per plant (0.250) and weight (yield) of flowers per plant (0.145). A negative correlation exists between stem diameter with flower diameter (-0.213), duration of flowering (-0.227) and shelf life of flower (-0.183).

Days to flower bud appearance exhibited positive correlation with days to flower bud opening (0.970) and a negative correlation with flower diameter (-0.527), flower weight (-0.509), number of flowers per plant (-0.419), duration of flowering (-0.876), shelf life of flowers (-0.418) and weight (yield) of flowers per plant (-0.475).

Days to flower bud opening exhibited a negative correlation with the flower diameter (-0.531), flower weight (-0.422), number of flowers per plant (-0.336), duration of flowering (-0.865), shelf life of flowers (-0.434) and weight of flowers per plant (-0.382).

Flower diameter was positively correlated with flower weight (0.276), number of flowers per plant (0.212), duration of flowering (0.578), shelf life of flowers (0.479) and weight (yield) of flowers per plant (0.237). Flower weight have a positive correlation with number of flowers per plant (0.641), duration of flowering (0.367) and weight (yield) of flowers per plant (0.903) and negative correlation with shelf life of flowers (-0.155).

Number of flowers per plant had a positive correlation with duration of flowering (0.439), shelf life of flowers (0.461) and weight (yield) of flowers per plant (0.906). Duration of flowering has a positive correlation with shelf life of flowers

(0.608) and weight of flowers per plant (0.408). Shelf life of flowers is positively correlated with weight (yield) of flowers per plant (0.140).

Genotypic correlation

Association of weight (yield) of flowers per plant with component characters

A positive correlation exist between weight (yield) of flowers per plant with plant height (0.149), stem diameter (0.163), flower diameter (0.251), flower weight (0.911), number of flowers per plant (0.91), duration of flowering (0.426) and shelf life of flowers (0.138). A negative correlation was found with plant spread (N-S) (-0.504), plant spread (E-W) (-0.343), number of primary branches (-0.44), number of secondary branches (-0.549), days to flower bud appearance (-0.488) and days to flower bud opening (-0.397).

Association among component characters

Plant height was found to be positively correlated with plant spread(N-S) (0.892), plant spread(E-W) (0.504), number of secondary branches (0.113), stem diameter (0.788), flower diameter (0.158), flower weight (0.317), duration of flowering (0.085) and weight (yield) of flowers per plant (0.149).It was negatively correlated with number of primary branches (-0.22), days to flower bud appearance (-0.441), days to flower bud opening (-0.501), number of flowers per plant (-0.008) and shelf life of flowers (-0.083).

Plant spread(N-S) have a positive correlation with plant spread(E-W) (1.352), number of primary branches (0.692), number of secondary branches (1.081), stem diameter (1.07), days to flower bud appearance (0.715) and days to flower bud opening (0.549). This character was negatively correlated with flower diameter (-0.675), flower weight (-0.321), number of flowers per plant (-0.665), duration of flowering (-1.247), shelf life of flowers (-0.818) and weight (yield) of flowers per plant (-0.504).

Plant spread (E-W) was positively correlated with number of primary branches (1.112), number of secondary branches (0.856), stem diameter (0.414), days to flower bud appearance (0.675) and days to flower bud opening (0.53).This character had

negative correlation with flower diameter(-0.088), flower weight(-0.454), number of flowers per plant(-0.191), duration of flowering(-0.901), shelf life of flowers(-0.012) and weight (yield) of flowers per plant (-0.343).

The number of primary branches exhibits a positive correlation with number of secondary branches (0.676), days to flower bud appearance (0.746), days to flower bud opening (0.681) and shelf life of flowers (0.007). It showed negative correlation with stem diameter (-0.218), flower diameter (-0.189), flower weight (-0.603), number of flowers per plant (-0.239), duration of flowering (-0.728) and weight (yield) of flowers per plant (-0.44).

The numbers of secondary branches have a positive correlation with stem diameter (0.288), days to flower bud appearance (0.593) and days to flower bud opening (0.54). It was negatively correlated with flower diameter (-0.702), flower weight (-0.657), number of flowers per plant (-0.381), duration of flowering (-0.717), shelf life of flowers (-0.189) and weight (yield) of flowers per plant (-0.549).

There is a positive correlation between stem diameter with days to flower bud opening (0.0122), flower weight (0.286), number of flowers per plant (0.014) and weight (yield) of flowers per plant (0.163). A negative correlation exists between stem diameter with days to flower bud appearance (-0.023), flower diameter (-0.219), duration of flowering (-0.284) and shelf life of flowers (-0.365).

Days to flower bud appearance exhibited positive correlation with days to flower bud opening (0.999) and a negative correlation with flower diameter (-0.561), flower weight (-0.524), number of flowers per plant (-0.435), duration of flowering (-0.936), shelf life of flowers (-0.466) and weight (yield) of flowers per plant (-0.488).

Days to flower bud opening exhibited a negative correlation with flower diameter (-0.58), flower weight (-0.44), number of flowers per plant (-0.359), duration of flowering (-0.909), shelf life of flowers (-0.486) and weight (yield) of flowers per plant (-0.397).

Flower diameter was positively correlated with flower weight (0.291), number of flowers per plant (0.232), duration of flowering (0.63), shelf life of flowers (0.553) and weight (yield) of flowers per plant (0.251).

Flower weight has a positive correlation with number of flowers per plant (0.66), duration of flowering (0.383) and weight (yield) of flowers per plant (0.911) and negative correlation with shelf life of flowers (-0.16).

The number of flowers per plant had a positive correlation with duration of flowering (0.463), shelf life of flowers (0.468) and weight (yield) of flowers per plant (0.910). Duration of flowering has a positive correlation with shelf life of flowers (0.644) and weight (yield) of flowers per plant (0.426). Shelf life of flowers is positively correlated with weight (yield) of flowers per plant (0.138).

4.5 Path coefficient analysis

To organize the relationship between different dependent and independent variables, Path analysis has been used. Partitioning of correlation coefficient into direct and indirect effects through path coefficient analysis is important to understand the effect of each studied character on the weight (yield) of flowers per plant character. Table 4.7 presents the direct and indirect effect of all the component characters on the weight (yield) of flowers per plant.

The result of path analysis revealed that number of flowers per plant (0.560), flower weight (0.558), number of primary branches (0.026), plant spread (E-W) (0.017) and plant height (0.015) had positive direct effect on weight(yield) of flowers per plant.

Number of flowers per plant in addition to its strong direct positive influence (0.560) on yield also had indirect positive influence via flower weight (0.358), number of secondary branches (0.015), plant spread (N-S) (0.005) and plant height (0.001).

Flower weight also had a strong positive direct influence (0.558) on yield. Besides it has positive indirect influence on yield through number of flowers per plant (0.359), number of secondary branches (0.027), plant spread (N-S) (0.003) and plant height (0.004).

Number of primary branches had a moderate direct positive effect (0.026) on yield accompanied with indirect positive effect by the characters plant spread (E-W)

(0.008), stem diameter (0.003), flower diameter (0.011) and duration of flowering (0.019).

Plant spread (E-W) had direct (0.017) and indirect positive influence on yield. It had indirect positive influence on yield through number of primary branches (0.013), duration of flowering (0.011), plant height (0.006) and flower diameter (0.001).

Plant height had a direct yet low positive influence (0.015) on yield. It also had indirect positive influence through characters like flower weight (0.154), plant spread (E-W) (0.006) and number of flowers per plant (0.002).

Flower diameter had a low direct negative influence (-0.055) on yield but influenced yield by positive indirect influence of characters like number of secondary branches (0.027), stem diameter (0.003), flower weight (0.154), number of flowers per plant (0.119), plant height (0.002) and plant spread (N-S) (0.01).

Duration of flowering although had a negative direct effect (-0.03) on yield but influenced yield by indirect positive influence through number of flowers per plant (0.246), number of secondary branches (0.028), flower weight (0.205), plant spread (N-S) (0.01), stem diameter (0.003) and plant height (0.001).

Stem diameter had a weak direct negative effect (-0.014) on yield but affected yield in a positive direction via plant height (0.009), plant spread (E-W) (0.005), flower diameter (0.012), flower weight (0.133), number of flowers per plant (0.014) and duration of flowering (0.007).

Number of secondary branches had a negative direct effect (-0.041) on yield and also affected yield in a negative way due to the indirect negative influence via the characters plant spread (N-S) (-0.011), stem diameter (-0.003), flower weight (-0.361) and number of flowers per plant (-0.207). But it also had indirect less positive effect on yield through plant height (0.001), plant spread (E-W) (0.006), number of primary branches (0.017), flower diameter (0.037) and duration of flowering (0.02).

Plant spread (N-S) had a negative direct effect (-0.026) on yield and also affected yield in a negative way due to the indirect negative influence through number

of secondary branches (-0.018), stem diameter (-0.004), flower weight (-0.056) and number of flowers per plant (-0.117). But it also had indirect less positive effect on yield through plant height (0.007), plant spread (E-W) (0.01), number of primary branches (0.008), flower diameter (0.02) and duration of flowering (0.012).

4.6 Qualitative parameter

The observation on quality parameters of marigold is presented in Table.4.8. The flower types of marigold cultivars evaluated were observed visually and it was found that all the cultivars had carnation type flowers. The colour of flower was determined with the help of RHS colour chart and the results are presented in Table 4.8. The flowers of BM-1 and Pusa Basanti Gaiinda are Yellow 9A. The flowers of BM-2, BM-3 and Arka Agni are Orange 25A. The flower colour of BM-3 and Pusa Narangi Gaiinda is Yellow orange 14A. The compactness of flowers was determined manually by pressing with palm. It was observed that the cultivars, BM-1, BM-2 and BM-3 are more compact than other cultivars evaluated.

A graph was plotted by taking two most important economic characters (yield and shelf life) to find out the most promising cultivar for commercial cultivation in Odisha. It was seen from the graph that the cultivar BM-2 is above the intersection point of Grand mean values of yield and shelf life.

Table 4.1 Analysis of Variance (ANOVA) of quantitative characters studied in 8 genotypes of African marigold

Sl.No.	CHARACTERS	MEAN SQUARES		
		Replication	Genotypes	Error
	Df	2	7	14
1.	Plant height	0.922	103.298**	4.787
2.	Plant spread (N-S)	4.613	15.917	10.9001
3.	Plant spread (E-W)	54.627	28.632	16.545
4.	Primary Branches	1.061	43.737**	1.904
5.	Secondary Branches	5.0293	1339.526**	5.203
6.	Stem diameter	0.296	6.383**	0.805
7.	Days to first flower bud appearance	26.293	209.375**	2.0536
8.	Days to first flower bud opening	39.125	106.857**	1.696
9.	Flower diameter	0.0112	0.818**	0.0296
10.	Flower weight	0.00616	2.431**	0.0180
11.	Number of flowers per plant	33.203	1738.723**	27.116
12.	Duration of flowering	0.5	110.833**	2.119
13.	Shelf life	0.5	6.613**	0.309
14.	Weight(yield) of flowers per plant	0.00168	0.246**	0.00151

* Significant at 5% level

**Significant at 1% level

Table 4.2 Mean values of quantitative characters in 8 genotypes of African marigold

GENOTYPES	CHARACTERS													
	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10	CH11	CH12	CH13	CH14
BM-1	63.16	48.17	48.81	15.06	47.20	15.55	65.33	49.33	6.78	6.22	134.00	84.33	3.67	0.83
BM-2	62.43	44.99	48.95	12.80	35.47	17.65	63.67	49.67	7.35	6.51	168.33	88.33	6.33	1.09
BM-3	60.24	46.23	47.73	17.27	83.47	16.85	70.00	54.33	6.21	5.68	153.67	81.00	4.67	0.87
Arka Bangara	69.41	45.09	45.86	10.80	33.13	17.39	54.33	42.67	7.65	6.84	133.27	90.33	4.33	0.91
Arka Agni	67.45	46.67	46.17	9.40	30.60	18.62	60.00	48.33	6.72	8.64	185.33	85.33	2.67	1.60
Arka Alankar	69.46	47.43	44.91	6.87	55.80	19.18	58.67	46.00	6.23	6.46	131.47	87.33	3.33	0.85
Pusa Narangi gainda	73.77	52.07	54.38	17.93	83.60	20.15	75.00	56.67	6.47	6.15	122.87	72.67	2.33	0.75
Pusa Basanti gainda	55.70	45.79	45.26	13.67	48.47	17.01	78.67	61.00	6.43	6.14	114.80	76.67	1.67	0.71
CV	3.36	7.02	8.52	10.64	4.37	5.04	2.18	2.55	2.56	2.04	3.64	1.75	15.35	4.09
CD	3.82	NS	NS	2.410	3.985	1.568	2.504	2.275	0.3	0.235	9.097	2.543	0.972	0.068

CH1- Plant height (cm)

CH2 -Plant spread (N-S) (cm)

CH3- Plant spread (E-W) (cm)

CH4 -Number of primary branches

CH5- Number of secondary branches

CH6- Stem diameter (mm)

CH7-Days to flower bud appearance

CH8-Days to flower bud opening

CH9- Flower diameter (cm)

CH10- Flower weight (g)

CH11-Number of flowers per plant

CH12- Duration of flowering (days)

CH13- Shelf life of flowers (days)

CH14- Weight (yield) of flowers per plant (kg)

Table 4.3 Estimation of mean, range and variance in 8 genotypes of African marigold

Sl. No.	Characters	Mean	Range	Variance	
				Phenotypic	Genotypic
1.	Plant height(cm)	65.203	55.70-73.77	37.62	32.84
2.	Plant spread(N-S) (cm)	47.056	44.99-52.07	12.57	1.67
3.	Plant spread(E-W) (cm)	47.758	44.91-54.38	20.57	4.03
4.	Number of primary branches	12.967	6.87-17.93	15.85	13.94
5.	Number of secondary branches	52.217	33.13-83.60	449.98	444.78
6.	Stem diameter (mm)	17.802	15.55-20.15	2.66	1.86
7.	Days to flower bud appearance	65.708	63.67-78.67	71.16	69.11
8.	Days to flower bud opening	51.000	42.67-61	36.75	35.05
9.	Flower diameter (cm)	6.730	6.21-7.65	0.29	0.27
10.	Flower weight (g)	6.580	5.68-8.64	0.82	0.80
11.	Number of flowers per plant	142.97	114.80-185.33	597.65	570.53
12.	Duration of flowering (days)	83.250	72.67-90.33	38.36	36.24
13.	Shelf life of flowers (days)	3.625	1.67-6.33	2.41	2.10
14.	Weight(yield) of flowers per plant (kg)	0.952	0.71-1.60	0.083	0.08

Table 4.4 Estimation of variability and genetic advance in 8 genotypes of African marigold

Sl. No.	Characters	Coefficient of variation (%)		Heritability (%)	GA (%)	GA as % of mean
		PCV	GCV			
1.	Plant height(cm)	9.41	8.79	87.28	11.03	16.91
2.	Plant spread(N-S) (cm)	7.54	2.75	13.3	0.97	2.06
3.	Plant spread(E-W) (cm)	9.49	4.20	19.58	1.83	3.83
4.	Number of primary branches	30.70	28.79	87.99	7.22	55.65
5.	Number of secondary branches	40.62	40.39	98.84	43.19	82.72
6.	Stem diameter (mm)	9.17	7.66	69.78	2.35	13.18
7.	Days to flower bud appearance	12.84	12.65	97.11	16.88	25.68
8.	Days to flower bud opening	11.89	11.61	95.38	11.91	23.36
9.	Flower diameter (cm)	8.04	7.62	89.88	1.00	14.88
10.	Flower weight (g)	13.78	13.63	97.81	1.83	27.76
11.	Number of flowers per plant	17.10	16.71	95.46	48.08	33.63
12.	Duration of flowering (days)	7.44	7.23	94.47	12.05	14.48
13.	Shelf life of flowers (days)	42.83	39.99	87.16	2.79	76.9
14.	Weight(yield) of flowers per plant (kg)	30.23	29.95	98.17	0.58	61.13

Table 4.5 **Phenotypic correlation between pairs of different characters studied in African marigold**

	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10	CH11	CH12	CH13	CH14
CH1		.476	.377	-.192	0.093	.626	-.423	-.451	.123	.276	.0032	.057	-.108	.138
CH2			.587	.322	.429	.263	.236	.195	-.369	-.101	-.209	-.392	-.341	-.163
CH3				.494	.367	.305	.272	.218	-.0196	-.191	-.060	-.366	.0444	-.128
CH4					.639	-.206	.670	.598	-.198	-.576	-.246	-.636	-.007	-.429
CH5						.211	.584	.531	-.665	-.647	-.369	-.682	-.171	-.542
CH6							.002	.002	-.213	.238	.0250	-.227	-.183	.145
CH7								.970	-.527	-.509	-.419	-.876	-.418	-.475
CH8									-.531	-.422	-.336	-.865	-.434	-.382
CH9										.276	.212	.578	.479	.237
CH10											.641	.367	-.155	.903
CH11												.439	.461	.906
CH12													.608	.408
CH13														.140
CH14														

CH1- Plant height (cm)

CH2 -Plant spread (N-S) (cm)

CH3- Plant spread (E-W) (cm)

CH4 -Number of primary branches

CH5- Number of secondary branches

CH6- Stem diameter (mm)

CH7-Days to flower bud appearance

CH8-Days to flower bud opening

CH9- Flower diameter (cm)

CH10- Flower weight (g)

CH11-Number of flowers per plant

CH12- Duration of flowering (days)

CH13- Shelf life of flowers (days)

CH14- Weight (yield) of flowers per plant (kg)

Table 4.6 Genotypic correlation between pairs of different characters studied in African marigold

	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10	CH11	CH12	CH13	CH14
CH1		.892	.504	-.220	.113	.788	-.441	-.501	.158	.317	-.008	.085	-.083	.149
CH2			1.352	.692	1.081	1.070	.715	.549	-.675	-.321	-.665	-1.247	-.818	-.504
CH3				1.112	.856	.414	.675	.530	-.088	-.454	-.191	-.901	-.012	-.343
CH4					.676	-.218	.746	.681	-.189	-.603	-.239	-.728	.007	-.440
CH5						.288	.593	.540	-.702	-.657	-.381	-.717	-.189	-.549
CH6							-.023	.0122	-.219	.286	.014	-.284	-.365	.163
CH7								.999	-.561	-.524	-.435	-.936	-.466	-.488
CH8									-.580	-.440	-.359	-.909	-.486	-.397
CH9										.291	.232	.630	.553	.251
CH10											.660	.383	-.160	.911
CH11												.463	.468	.910
CH12													.644	.426
CH13														.138
CH14														

CH1- Plant height (cm)

CH2 -Plant spread (N-S) (cm)

CH3- Plant spread (E-W) (cm)

CH4 -Number of primary branches

CH5- Number of secondary branches

CH6- Stem diameter (mm)

CH7-Days to flower bud appearance

CH8-Days to flower bud opening

CH9- Flower diameter (cm)

CH10- Flower weight (g)

CH11-Number of flowers per plant

CH12- Duration of flowering (days)

CH13- Shelf life of flowers (days)

CH14- Weight (yield) of flowers per plant (kg)

Table 4.7 Estimates of direct (diagonal) and indirect effects of component characters on weight (yield) of flowers per plant in African marigold

Characters	PH	N-S	E-W	PB	SB	SD	FD	FW	NF	DF	Yield
Plant height	<u>0.015</u>	-0.012	0.006	-0.005	-0.004	-0.009	-0.007	0.154	0.002	-0.002	0.138
Plant spread (N-S)	0.007	<u>-0.026</u>	0.010	0.008	-0.018	-0.004	0.020	-0.056	-0.117	0.012	-0.163
Plant spread (E-W)	0.006	-0.016	<u>0.017</u>	0.013	-0.015	-0.004	0.001	-0.106	-0.034	0.011	-0.128
Number of primary branches	-0.003	-0.008	0.008	<u>0.026</u>	-0.026	0.003	0.011	-0.321	-0.138	0.019	-0.429
Number of secondary branches	0.001	-0.011	0.006	0.017	<u>-0.041</u>	-0.003	0.037	-0.361	-0.207	0.020	-0.542
Stem diameter	0.009	-0.007	0.005	-0.005	-0.009	<u>-0.014</u>	0.012	0.133	0.014	0.007	0.145
Flower diameter	0.002	0.010	-0.001	-0.005	0.027	0.003	<u>-0.055</u>	0.154	0.119	-0.017	0.237
Flower weight	0.004	0.003	-0.003	-0.015	0.027	-0.003	-0.015	<u>0.558</u>	0.359	-0.011	0.903
Number of flowers per plant	0.001	0.005	-0.009	-0.006	0.015	-0.001	-0.012	0.358	<u>0.560</u>	-0.013	0.906
Duration of flowering	0.001	0.010	-0.006	-0.017	0.028	0.003	-0.032	0.205	0.246	<u>-0.030</u>	0.408

Residual effect- **0.00072**

PH- Plant height (cm)

N-S -Plant spread (N-S) (cm)

E-W- Plant spread (E-W) (cm)

DF- Duration of flowering (days)

Figures underlined denote the direct effect

PB-Number of primary branches

SB- Number of secondary branches

SD- Stem diameter (mm)

Yield- Genotypic correlation with Weight (yield) of flowers per plant

FD- Flower diameter (cm)

FW- Flower weight (g)

NF- Number of flowers per plant

Table 4.8 Assessment of Qualitative parameters

Genotypes	Flower type	Flower colour (as per RHS colour chart)	Flower compactness
Bidhan Marigold-1 (BM-1)	Carnation type	Yellow 9A	+++
Bidhan Marigold-2 (BM-2)	Carnation type	Orange 25A	+++
Bidhan Marigold-3 (BM-3)	Carnation type	Orange 25A	+++
Arka Bangara	Carnation type	Yellow Orange 14A	+
Arka Agni	Carnation type	Orange 25A	++
Arka Alankar	Carnation type	Yellow Orange 14A	++
Pusa Narangi Gaiinda	Carnation type	Yellow Orange 14A	+
Pusa Basanti Gaiinda	Carnation type	Yellow 9A	++

+++ Highly compact

++ Less compact

+ Loose

DISCUSSION

The existence of genetic variability in the crop is important for any crop improvement programme. An assessment of the magnitude of variability and the extent of its heritability is a very important point to be considered for a successful breeding programme. Information on nature and magnitude of variability in the available genotypes and character association and their correlation is important to know the effect of their direct and indirect relation on the yield to select a proper parent material for crop improvement and also for commercial cultivation. High variability indicates a greater scope for improvement.

Yield is the most important economic character yet the most complex one which is governed by polygenes and is quantitatively inherited.

5.1 Analysis of Variance

A large amount of variation among the genotypes indicates a greater improvement scope in African marigold through the characters plant height, number of primary branches, number of secondary branches, stem diameter, number of days taken for flower bud appearance, number of days taken for flower bud opening, flower diameter, flower weight, number of flowers per plant, duration of flowering, shelf life of flowers and weight (yield) of flowers per plant. Similar findings were by Panwar *et al.*, (2013), Singh and Misra (2008), Raghuvanshi and Sharma (2011), Singh and Kumar (2008) and Namita *et al.*, (2008).

The variation indicates that for specific objectives it is possible to select genotypes for the magnitude and wide spectrum of variation observed in each character.

5.2 Mean performance of genotypes

Tallest plants were produced in Pusa Narangi Gaiinda followed by Arka Alankar while the shortest ones were in Pusa Basanti Gaiinda. Other varieties BM-1, BM-2, BM-3, Arka Bangara, Arka Agni also produced taller plants.

Earliest flower bud appearance and flower bud opening were seen in Arka Bangara followed by Arka Alankar and the late bud appearance and opening was in Pusa Basanti Gaiinda. Large blooms were seen in Arka Bangara followed by BM-2 and the smallest bloom in BM-3. Highest flower weight was found in Arka Agni while the lowest in BM-3. Maximum numbers of flowers were observed in Arka Agni while the lowest number in Pusa Basanti Gaiinda. BM-2 flowers remained fresh for a longer period while the flowers of Pusa Basanti Gaiinda were fresh for the shortest period.

The yield of flowers per plant was maximum in the variety Arka Agni followed by BM-2, whereas Pusa Basanti Gaiinda recorded minimum yield per plant.

The foremost requirement for selection is to know about the presence of genetic variability for the characters in the population at a significant level. The phenotypic mean values used for comparison may not be always correct as it is influenced by environment. Thus, for correct data interpretation, estimation of variance, coefficient of variance etc. are quite necessary. The estimates of genetic parameters such as phenotypic and genotypic variances are computed as method suggested by Burton and Devane (1953).

5.3 Coefficient of Variation (PCV and GCV)

Table 4.4 indicates that PCV is greater than GCV and it means that the environment has an influence on character expression. Similar results were found by Karuppiiah and Kumar (2010), Panwar *et al.*, (2013), Sharma and Raghuvanshi (2011), Pattnaik and Mohanty (2002) and Vishnupriy *et al.*, (2015).

Narrow difference between PCV and GCV revealed that variability existing among different genotypes of marigold was mainly due to genetic makeup and there was less environmental influence on the expression of this trait. Same results had also been recorded by Singh and Misra (2008) in marigold.

The PCV is highest for shelf life of flowers followed by number of secondary branches, number of primary branches, weight of flowers per plant, number of flowers per plant, flower weight, days to flower bud appearance, days taken to flower bud opening, plant spread(E-W), plant height, stem diameter, flower diameter, plant

spread(N-S). Duration of flowering had the lowest PCV value. The GCV is highest for number of secondary branches followed by shelf life of flowers, weight of flowers per plant, number of primary branches, number of flowers per plant, flower weight, days to flower bud appearance, days to flower bud opening, plant height, stem diameter, flower diameter, duration of flowering, plant spread (E-W) and the lowest value was for plant spread (N-S). Yuvraj and Dhatt (2014) also found that number of flowers per plant had a high PCV and GCV.

5.4 Heritability and Genetic advance

High heritability (> 85%) was observed in weight (yield) of flowers per plant, flower weight, days to flower bud appearance, number of flowers per plant, days to flower bud opening, duration of flowering, flower diameter, number of primary branches, plant height and shelf life of flowers. Rest all the characters had a low heritability. Similar findings were by Karuppiiah and Kumar (2010), Yuvraj and Dhatt (2014) and Vishnupriy *et al.*, (2015). Higher the heritability value of a character less will be the environmental influence, thereby indicating a better opportunity for selecting a genetically good individual (Randhawa *et al.*, 1975).

Burton (1952) suggested that genotypic coefficient of variation together with heritability estimates would give the best picture of heritable variation. Heritability along with genetic advance helps in determining the heritable variation with a greater accuracy. Genetic advance indicated the potentiality of selection at a particular level of selection intensity (Escuro *et al.*, 1963). Thus instead of heritability alone, the conjunction of genetic advance with heritability is a reliable index for selection.

High heritability coupled with high genetic advance is seen in plant height, number of secondary branches, days to flower bud appearance, days to flower bud opening, number of flowers per plant and duration of flowering. Vishnupriy *et al.*, (2015) also observed high heritability along with high genetic advance in days for flower bud appearance, days to flower bud opening, number of flowers per plant.

High heritability with moderate genetic advance is seen in the number of primary branches, stem diameter, the shelf life of flowers, flower diameter, flower

weight. Low heritability with a low genetic advance in plant spread (N-S) and weight (yield) of flowers per plant. Low heritability with a moderate genetic advance in plant spread (E-W).

5.5 Character Association

It is essential to have a positive correlation between desirable characters for improvement of characters,. Since the genotypic correlation coefficient is found to be greater than phenotypic correlation coefficient (Table 4.5 and Table 4.6), it indicates a strong inherent association between various characters.

At phenotypic level yield had a positive correlation with plant height, stem diameter, flower diameter, flower weight, number of flowers per plant, duration of flowering and shelf life of flowers. And at the genotypic level, there was a positive correlation with plant height, stem diameter, flower diameter, flower weight, number of flowers per plant, duration of flowering and shelf life of flowers. Findings of Karuppaiah et al. (2006), Singh and Saha (2009) and Kavitha and Anburani (2010) were that yield had a positive correlation with flower weight, number of flowers per plant, duration of flowering. The findings of Bharati *et al.*, (2014) also stated that there existed a positive correlation among flower yield with plant height, stem diameter, flower weight and number of flowers per plant.

All the above positive correlation is helpful in improving the yield of African marigold.

5.6 Direct and indirect effects of characters

Wright (1921) suggested that path coefficient analysis provides a better knowledge as it reveals the direct and indirect causes of association and allows a critical examination of the scientific ways to produce a given correlation and measures the relative importance of each causal characters. The cause and effect relationship with values of correlation (yield) and path coefficient for component characters at phenotypic and genotypic levels are presented in Table 4.7.

The number of flowers per plant, flower weight, number of primary branches, plant spread (E-W) and plant height had positive direct effect on yield.

Number of flowers per plant has the maximum effect on yield due to its strong direct positive influence and also indirect positive influence via flower weight, number of secondary branches, plant spread (N-S) and plant height.

Flower weight also had a strong influence on yield by the positive direct influence and also indirect positive influence through number of flowers per plant, number of secondary branches, plant spread (N-S) and plant height.

Duration of flowering had a negative direct effect on yield but influenced yield in a high positive direction due to the indirect positive effect by number of flowers per plant, number of secondary branches, flower weight, plant spread (N-S), stem diameter and plant height.

The direct effect of flower diameter on yield was negative but overall it affected yield positively by the influence of number of secondary branches, stem diameter, flower weight, number of flowers per plant, plant height and plant spread (N-S).

Similarly, the direct effect of stem diameter on yield is negative but there is a positive influence by the indirect influence by plant height, plant spread (E-W), flower diameter, flower weight, number of flowers per plant and duration of flowering.

Plant height affected yield positively by direct positive influence and also indirect positive effect through characters like flower weight, plant spread (E-W) and number of flowers per plant. Thus the yield enhancing characters are number of flowers per plant, flower weight, duration of flowering, flower diameter and stem diameter.

Number of primary branches had a moderate direct positive effect on yield accompanied with indirect positive effect through plant spread (E-W), stem diameter, flower diameter and duration of flowering but influenced yield negatively. This may be due to the indirect negative effect through plant height, plant spread (N-S), stem diameter, flower weight and number of flowers per plant.

Number of secondary branches highly influenced yield negatively. This may be due to its negative direct effect and indirect negative influence via the characters plant spread (N-S), stem diameter, flower weight and number of flowers per plant.

Plant spread (E-W) had direct positive influence on yield but resulted in an overall negative influence due to indirect negative effect by the characters plant spread (N-S), stem diameter, number of secondary branches, flower weight and number of flowers per plant. Plant spread (N-S) had a negative direct effect on yield and also affected yield in a negative way due to the indirect negative influence through number of secondary branches, stem diameter, flower weight and number of flowers per plant.

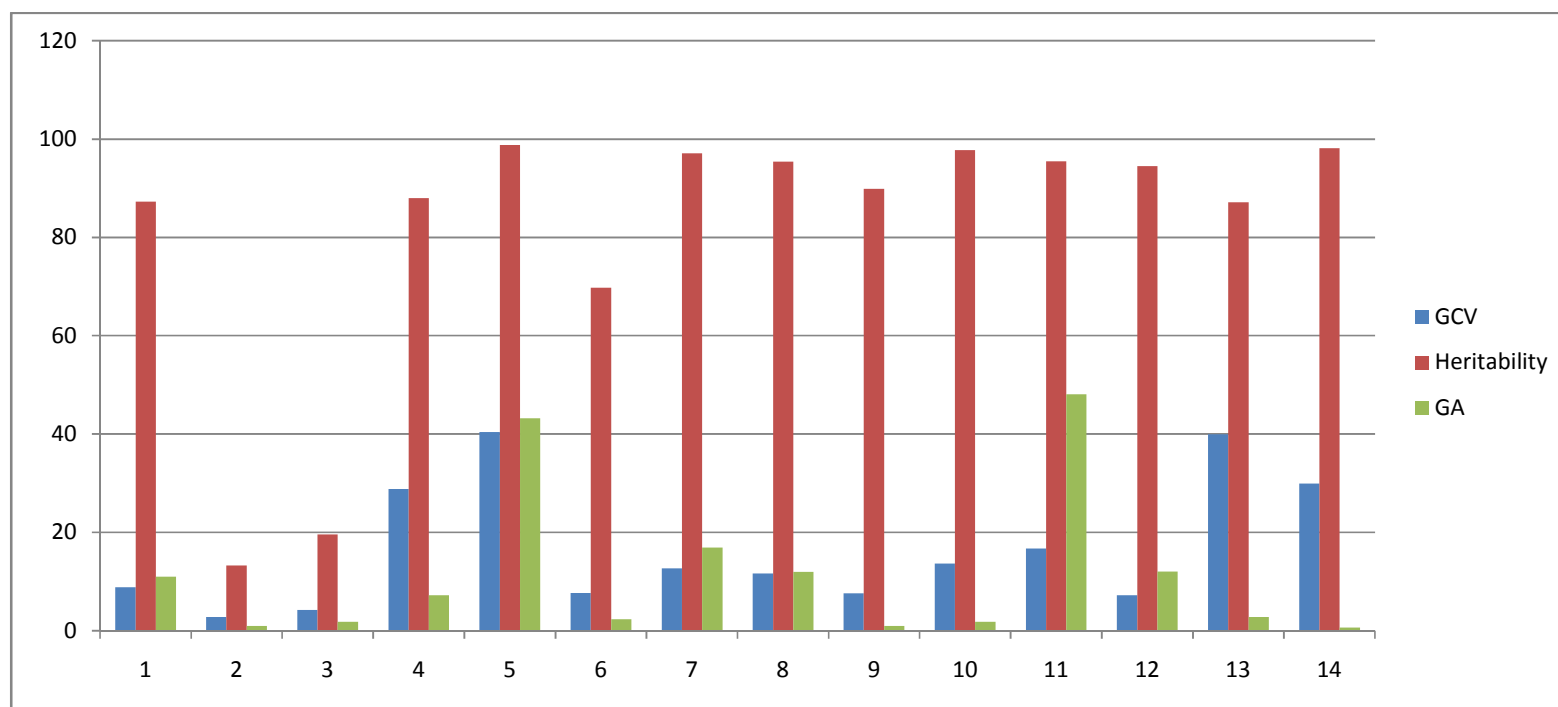
According to Bharati *et al.*, (2014) total duration, number of flowers, flower weight and flower diameter had the maximum direct effect on yield.

5.7 Qualitative parameters

The findings of the qualitative parameters states that all the genotypes had carnation type flowers. The flowers can be broadly divided into two groups basing on flower colour. The cultivars like, BM-2, BM-3, Arka Agni and Pusa Narangi Gaiinda belong to orange group, whereas other marigold cultivars evaluated belong to yellow group. It was observed that the cultivars, BM-1, BM-2 and BM-3 are more compact than other cultivars evaluated.

The graph plotted by taking yield and shelf life depicts that the cultivars BM-2 is above the intersection point of the grand mean values of yield and shelf life. Hence, the cultivar BM-2 is considered as the most suitable variety for commercial cultivation in coastal plain zone of Odisha.

Fig 5.1 Graph between GCV, Heritability and GA for 14 characters in 8 genotypes of African marigold



CH1- Plant height (cm)

CH2 -Plant spread (N-S) (cm)

CH3- Plant spread (E-W) (cm)

CH4 -Number of primary branches

CH5- Number of secondary branches

CH6- Stem diameter (mm)

CH7-Days to flower bud appearance

CH8-Days to flower bud opening

CH9- Flower diameter (cm)

CH10- Flower weight (g)

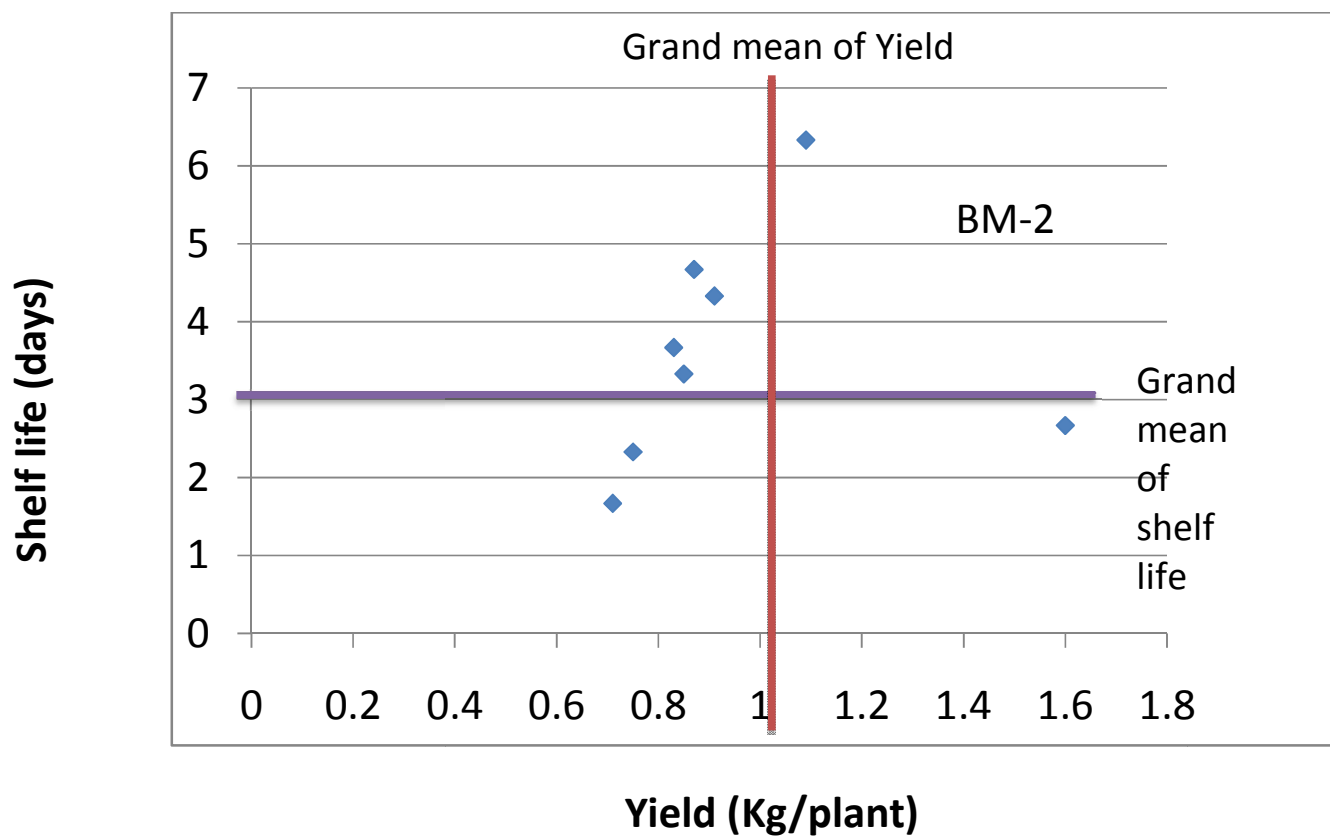
CH11-Number of flowers per plant

CH12- Duration of flowering (days)

CH13- Shelf life of flowers (days)

CH14- Weight (yield) of flowers per plant (kg)

Fig 5.2 Graph between Yield and Shelf life



SUMMARY AND CONCLUSION

The present investigation entitled “Evaluation and selection of African Marigold (*Tagetes erecta* L.) genotypes suitable for commercial cultivation under the coastal plain zone of Odisha” was conducted during October 2017 to March 2018 at the Biotechnology-cum-Tissue Culture Center (BTCC), Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar, Odisha. The experiment was laid out with 8 treatments and 3 replications in RBD. The objective were to evaluate the quantitative and qualitative attributes of 8 African marigold genotypes, study the extent of genetic variability and character association and also select a variety which would be suitable for commercial cultivation in the coastal ecosystem of Odisha.

Observations were recorded for 3 qualitative and 15 quantitative characters such as plant height, plant spread (N-S), plant spread (E-W), number of primary branches, number of secondary branches, stem diameter, days for flower bud appearance, days taken for flower bud opening, flower diameter, flower weight, number of flowers per plant, duration of flowering, shelf life of flowers and yield of flowers per plant. Different parameters of data interpretation were the analysis of variance, mean, range, PCV, GCV, heritability, genetic advance, GA as percentage of mean, genotypic correlation coefficient, phenotypic correlation coefficient and path analysis.

The treatment mean square was significant for almost all quantitative characters indicating the existence of variation among genotypes and this indicates scope for improvement. It proves that the 8 genotypes under study have high difference among themselves. These variations would be helpful in selecting a suitable variety for commercial cultivation. For almost all the characters there was a wide difference in mean performance of different genotypes. The variation in range was maximum for the numbers of flowers per plant while it was minimum for weight (yield) of flowers per plant

It was found that PCV is greater than GCV and this indicates the presence of environmental influence. The difference between PCV and GCV is narrow and this

indicates that the environmental influence is less. PCV is highest for the shelf life of flowers and lowest for the duration of flowering. GCV is highest for the number of secondary branches while lowest for plant spread (N-S).

Maximum heritability in broad sense is seen in the number of secondary branches followed by weight (yield) of flowers per plant, flower weight, days to flower bud appearance and number of flowers per plant. The genetic advance was maximum in the number of flowers per plant followed by the number of secondary branches. This indicates that the characters having high heritability with genetic advance would be useful in effective selection of parents during breeding programme in African marigold.

Genotypic correlation coefficient is greater than the phenotypic correlation coefficient. This implies that the character association studied is strongly inherent and was marked by an environmental component with regards to phenotypic expression. The characters that would be helpful in selecting a suitable commercial variety are days to flower bud appearance, days to flower bud opening, flower diameter, flower weight, number of flowers per plant, duration of flowering, shelf life of flowers and weight (yield) of flowers per plant.

Path analysis of different quantitative parameters revealed that number of flowers per plant, flower weight, number of primary branches, plant spread (E-W) and plant height had positive direct effect on yield. Thus, during improvement programme and parent selection more attention should be paid to number of flowers per plant and individual flower weight.

The assessment of qualitative parameters i.e. flower type, flower colour and flower compactness was done to find the variety which is most suitable as loose flowers with a greater acceptability.

Conclusion

Based on the result of present investigation it may be concluded that besides direct selection for yield, indirect selection through flower diameter, flower weight, number of flowers per plant, duration of flowering and shelf life of flowers, should be considered for further improvement of flower yield in marigold while formulating breeding programme.

Qualitative parameters play a major role as compared to the quantitative parameters while selecting a variety for commercial cultivation in any flower crop. The better appearance of any flower crop gives more profit to the farmer than increased yield. An attractive bloom with more shelf life is acceptable by a consumer than a less attractive flower and consumer acceptability increases the profit of a farmer. Highest yield was observed in Arka Agni. Since, quality is the major concern in a flower crop, the variety BM-2 with second highest yield but better appearance, attractive blooms and long shelf life would be preferred by consumers. Thus, BM-2 is recommended for the commercial cultivation in the coastal plain zone of Odisha.

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