

Genetic Variability, Correlation and Path Analysis in Okra

THESIS

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Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

**In partial fulfilment of the requirements for
the Degree of**

MASTER OF SCIENCE

In

**AGRICULTURE
HORTICULTURE (VEGETABLE SCIENCE)**

By

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2016

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All the assistance and help received during the course of the investigation have been acknowledged by him.

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Place : Jabalpur

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Contents

No.	Title	Page No.
1.	Introduction	1-3
2.	Review of Literature	4-22
3.	Material and Methods	23-39
4.	Results	40-64
5.	Discussion	65-73
6.	Summary, Conclusion and Suggestions for further work	74-78
	Bibliography	79-84
	Appendices	I-II
	Vita	

LIST OF TABLES

No.	Title	Page No.
3.1	Meteorological information (week wise) during entire crop season of the year 2015-16 at Jabalpur.	24
3.2	Details of genotypes used in study.	25
4.2 (a)	Mean performance of morphological characters of okra	45
4.2 (b)	Mean performance of morphological parameters of okra	47
4.2 (c)	Mean performance of phenological parameters of okra	48
4.2 (d)	Mean performance of fruit characters of okra	50
4.2 (e)	Mean performance of yields of okra	52
4.3	Genetic parameters in okra.	53
4.4	Estimates of genotypic and phenotypic correlation coefficient among yield and its contributing characters	58
4.5	Path coefficients showing direct and indirect effects of different characters on fruit yield per plant (g) in okra	61
4.6	Phenotypic path coefficients showing direct and indirect effects of different characters on fruit yield per plant (g) in okra	62
4.7	Mean Performance of per cent incidence of YVMV in okra and fruit colour of okra	64

LIST OF FIGURES

No.	Title	Page No. (In between)
1.	Weekly meteorological data during the cropping season (2015-2016).	24-25
2.	Layout plan of the experimental field.	28

LIST OF PLATES

No.	Title	Page No. (in between)
1.	Fruits of different genotypes of okra	56-57
2.	Fruits of different genotypes of okra	64-65

LIST OF SYMBOLS

Abbreviation	Stand for
@	At the rate
&	And
ANOVA	Analysis of Variance
Cm	Centimeter
C.D.	Critical difference
d.f.	Degrees of Freedom
DAH	Days after harvesting
et al.	And others or co-workers
M	Meter
Fig.	Figure
GA	Genetic Advance
GCV	Genotypic coefficient of variation
G	Gram
ha.	Hectare
Kg	Kilogram
Max.	Maximum
Min.	Minimum
M.S.S.	Mean Sum of Squares
MT	Metric ton
No.	Number
PCV	Phenotypic coefficient of variation
SEm±	Standard error of means
YVMV	Yellow Vein Mosaic Virus
%	Percentage

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is an annual vegetable crop propagated by seeds in Tropical and Subtropical region of the world like India, Africa, Turkey and other neighbouring countries. Okra has captured a prominent position among vegetables. Okra is more remunerative than leafy vegetables. In India, okra is one of the most important vegetable crops grown for its tender green fruits during summer and rainy seasons.

Okra is a polyploidy, belongs to the family Malvaceae and a self pollinated crop. Occurrence of out crossing to an extent of 4 – 19 percent with the maximum of 42.2 per cent is noticed with the insect assisted pollination. Tender green fruits are cooked in curry and soup, while crop has not adapted in India as leafy vegetable as in for East countries. According to Vavilov, it was probably domesticated in the Ethiopian region but according to Murdock it is in West Africa.

Okra is known by many local names in different parts of the world. It is called lady's finger in England, Gumbo in U.S.A. and Bhindi in India. Edible fresh and tender fruits contain 88% moisture and large number of chemical components including Vit. A 88 IU, B 63 IU and C 13 mg/100 gm. Immature okra fruits contain 3100 calorie energy, 1.8g protein, 90 mg calcium and 1.0 mg iron (Aykroyd, 1941). The Seeds of okra (Pusa makhmali) had the highest oil content 17.3% which is a nutritious ingredient of cattle feed. It has Ayurvedic medicinal properties. Its leaves are used for preparing a medicament to reduce inflammation. It is an excellent source of Iodine for control of goiter (Chadha, 2001).

In India, among fresh vegetables, 60 per cent share of export goes to okra. Okra is widely cultivated in plains of the India with acreage of 518.0 thousand ha. and production 6259.0 thousand mt. (NHB 2013-14). In Madhya Pradesh okra is grown in 26.2 thousand ha area with production of 305.1 thousand mt. and 11.5 tonnes productivity (NHB 2013-2014).

It is a hardy crop and can grow with considerable success on a wide range of soils and under variable environmental conditions. In India it is grown

twice in a year for getting regular supply. In the country, a large number of okra varieties are grown, the variation occurs with regards to quantitative and qualitative traits. The plant height, number of primary branches per plant, number of fruits per plant, size of fruit i.e. length as well as weight of fruits are the yield contributing characters while, colour of fruit and fiber content determine the quality of fruit.

A logical way to start any breeding programme is to survey the variation in the available material. It is said that genetic variability is the “sine quanon” of any such programme. Selection is said to be effective in a population having large heritable variability. The genetic variability and its components are the genetic fractions of observed variability that provides measures of transmissibility of the variation and response to selection. The knowledge of pattern of inheritance of various characters are important consideration while, determining the most approximate breeding procedures applicable to any particular crop. The breeder’s choice of the material for any improvement work consequently depends on the amount of genetic variability present. The phenotype is often not true indicator of its genotype. The phenotypic variability is the result of the effect of environment and genotype interaction.

Attempts have been made to determine the magnitude of heritable and non-heritable components and genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance as percentage of mean in some of the quantitative characters of okra.

These studies along with the association analysis will be more useful in the estimation of inter-relationship among the yield contributing components. It is essential to have detail information on the association among different yield components and their relative contribution to yield. Association analysis of quantitative attributes would help in choosing component characters that are positively correlated. In addition, an understanding of association between the component characters is essential to judge their rational importance. Path coefficient analysis is also very useful in formulating breeding strategy to develop elite genotypes through selection in advanced generations. Thus, the nature and magnitude of variability present in the gene pool for different

characters and relationship with each other determine the success of genetic improvement of a character. Since the pattern of inheritance of quantitative characters is highly complex, therefore the present investigation was undertaken to study the association among different components and their direct and indirect contribution to fruit yield in okra.

In view of the above facts, the present studies in okra entitled “genetic variability, correlation and Path analysis in okra (*Abelmoschus esculentus* (L.) Moench).” has been carried out with the following objectives:

Objectives of investigation:

- 1.) To estimate the various parameters of genetic variability in okra.
- 2.) To find out the Inter-relationship among yield and its components at phenotypic and genotypic levels.
- 3.) To assess the direct and indirect effects of yield contributing characters on fruit yield.

REVIEW OF LITERATURE

The success of any plant improvement programme mainly depends on the right selection of material and its skillful management. It is only possible when we possess knowledge of previous work done in the concerned field. In okra substantial contribution has been made to the literature regarding its

genetics and breeding in the recent years. The literature pertaining to the various aspects of the present study has been reviewed under the following heads:

- 2.1 Genetic variability
- 2.2 Heritability and genetic advance
- 2.3 Correlation coefficient analysis
- 2.4 Path analysis

2.1 Genetic variability

It is a known fact that genotypes within the species exhibit variation in different metric traits and components of yield. The genetic variation can only be useful for crop improvement with the help of partitioning variances. Plant breeders are able to determine the relative importance of genetic and environmental variances.

Hazra and Basu (2000) revealed that there was a wide range of variations for plant height (80.8 cm), leaves per plant (28.9), nodes per plant (14.9), days to first flower (49.9), fruit weight (15 g), fruits per plant (10), seeds per fruit (53.3), fruit yield per plant (155.7g), moderate variations for primary branches per plant (2.9) and fruit length (12.9 cm) and lesser variations for node at first flower (4.8) and ridges per fruit (5.1). Primary branches per plant, which showed a moderate range of variation, recorded the highest genotypic coefficient of variation (GCV; 35.5%). However, plant height (14.3%), leaves per plant (16.6), fruit weight (20%), fruits per plant (16.9%), seeds per fruit (23%), and fruit yield per plant (17.7%) recorded a moderate GCV.

Prakash et al. (2001) reported that Arka Abhay was the best for high seed yield per plant (62.89g), capsule length (12.64cm) and capsule weight (15.66g) whereas Parbhani Kranti registered as a superior parent for number of capsules per plant (16.60) and days to first flowers (44.90). Among the F₁ hybrids, PK X Arka Abhay showed high capsule weight (20.20g).

Hamed et al. (2003) reported that Balady green recorded the highest number of days to first flower (71.78) and number of nodes of first flower (11.31). Gold coast had the highest number of pods per main stem (8.41),

plant height (131.95cm) and yield per plant (90.50g). MNH 1999 had the highest number of branches per plant (12.59), number of early pods per plant (7.78) and total number of pods per plant (20.93).

Duzyaman et al. (2003) reported that the numerous okra genotypes of American, African, Indian, European & Turkish origin were examined for their pod properties and nutritive values. Pod thickness was considerably high in the genetic material from Africa with up to 2.84cm in diameter in the case of line 1051 from Togo. However, pods of the improved cultivars from the USA and India had a more attractive appearance with diameters varying between 1.15 and 1.50 cm.

Bendale et al. (2003) showed a wide range of genetic variability for yield and yield-contributing characters first flowering node, days to first harvest, pod length, pod weight, plant height, nodes per plant, internodal length, number of branches per plant, fruiting period, number of pods per plant and yield per plant. The phenotypic variance (PCV) for all the 15 characters was higher than the genotypic variance (GCV). The number of branches per plant, yield per plant and number of pods per plant showed high GCV and PCV estimates. All the characters recorded medium to high and high heritability.

Zulfeghar and Patil (2004) reported that the Arka Anamika recorded the lowest disease incidence (0.80%) and the highest yield (23.00t/ha), while the susceptible control Pusa Sawani recorded the highest disease incidence (74.99%) and the lowest yield (7.90t/ha). None of the genotypes was immune to the disease. Arka Anamika, Hybrid 8 and Hybrid 10 were resistant, while, Soumya F₁ and Reshma were moderately resistant.

Verma et al. (2004) reported the highly significant differences between genotypes for all the characters. While, higher (168.33 g/plant) fruit yield was observed in JAE-12 followed by JAE-4 (165.66g/plant) whereas, the lowest fruit yield was noted in JAE-15 (41.33 g/plant. Maximum range of mean value was observed for yield per plant and minimum for branches per plant. High degree of variability was observed for branches per plant and yield per plant.

High estimate of heritability and genetic advance were observed for seeds per fruit and plant height.

Kumar and Kuwar (2005) reported that the genotype Punjab-8 had the tallest plant (89.8cm) and produced significantly high number of primary branches (2.53) as compared to other genotypes. The Maximum number of fruits per plant (11.6) was recorded in Arka Abhay and Punjab Padmini.

Singh and Singh (2006) reported that the considerable amount of genetic variation was exhibited by number of branches per plant, fruit yield per plant, tapering length, plant height and fruit length. The closer magnitude of genotypic and phenotypic coefficients of variation indicated that a greater magnitude was played by genotype rather than environment.

Manivannan et al. (2007) revealed that the analysis of variances significant differences among parents and crosses for all the characters except fruit diameter. The highest coefficient of variation (PCV 24.63 and GCV 23.95) was observed for 100-seed weight.

Naidu et al. (2007) reported that the highly significant differences between genotypes were recorded for all the characters. While, higher fruit yield (221.0g/plant) was observed in JAE-14 followed by JAE-18 (199.5g/plant) whereas, the lowest fruit yield was noted in JAE-4 (98 g/plant). The Maximum range of mean value was observed for yield per plant and the minimum for number of ridges per fruit. High degree of variability was observed for plant height, number of fruits per plant, fruit weight and fruit yield per plant.

Udengwu (2008) reported in okra that with deep green skin colour are considered more mucilaginous than others and okra consumers show appreciable preference for them. The results confirmed that fruit skin colour in okra is monogenically controlled and the recessive genes involved form a multiple allelic series. The genotypes of the genes involved are suggested as well as their dominance hierarchy.

Jindal et al. (2009) revealed that the mean sum of squares for genotypes were highly significant for all the characters indicating presence of genetic variability among the genotypes.

Saifullah and Rabbani (2009) reported that the significant variations among the genotypes were observed for different characters studied. The GCV and the PCV were very close in most of the characters which indicated less environmental influence on the expression of those characters.

Kumar and Salimath (2010) studied in an experiment undertaken to study phenotypic and genotypic coefficients of variation, heritability and genetic advance in three double crosses and four single crosses F_2 population of okra. The analysis of variance revealed highly significant differences for the populations under study for the characters. The estimates of phenotypic and genotypic coefficients of variation were moderate to high for all the characters except days to first flowering, stem diameter (in double cross), fruit length and 100 seed weight.

Somashekhar et al. (2011) reported that the wider range of variation as evidence by high PCV and GCV values for number of branches per plant, number of fruits per plant, average fruit weight (g), fruit length, and fruit yield per plant (g).

Opping-Sekyere et al. (2011) revealed that the variation in petal colour, pubescence of the leaf and stem, fruit shape, anthocyanin pigmentation and number of days to 50% flowering.

Kumar et al. (2011) found that the analysis of variance (mean sum of squares) revealed significant differences among genotypes for all the characters under study. The results based on GCV and PCV indicated considerable genetic variability among the genotypes for height at first fruiting node, number of node at first pod appearance, plant height, number of nodes per plant, number of pods per plant and pod yield per plant.

Senapati et al. (2011) reported that the analysis of variance exhibits a wide spectrum of variability among the characters of the hybrids. The largest variability was recorded in fruit yield (58.163-125.077 q/ha) followed by plant height (138.800-182.267 cm). In general, phenotypic coefficients of variation (PCV) were greater than the genotypic coefficients of variation (GCV) in all quantitative traits due to environmental influence.

Chaukhande et al. (2011) revealed that the highest genotypic coefficient of variation as well as phenotypic coefficient of variation was observed for incidence of yellow vein mosaic virus. The maximum difference between GCV and PCV was noted for inter nodal length.

Nagre et al. (2011) reported that the highest genotypic coefficient of variation as well as phenotypic coefficient of variation were observed for leaf area followed by number of nodes per plant, length of fruit, number of leaves per plant, yield per plant, and internodal length.

Singh and Jain (2012) investigated that the significant differences were recorded for all the characters except stem girth. The plant height was ranged between 90.9-134.0 cm. It was the highest in SOHO-2 and the lowest in HIHBO-90., more number of branches per plant was recorded in SOHO-2 and DVR-1 (5.1) and the minimum in RHROH-1 (3.7). DVR-1 was found early among all the cultivars. The number of pods per plant was ranged from 9.2 (Arka Anamika) to 22.2 (SOH-5), the weight of pods per plant ranged from 175.0 g to 327 g. It was greater in SOH-5 and the lowest in HIHBO-83 as compared to checks. The longest pods were harvested from RHROH-1 (16.8 cm) and the smallest from Arka Abhay (13.3 cm), thick pods were recorded in HIHBO-90 (5.87 cm), and thin pods in Vijaya (4.35 cm), the minimum infestation of fruit borer was observed in DVR-2 (10.8%) and it was higher in HIHBO-83 (29.6%), Hybrid/cultivars namely DVR-1, DVR-2, RHROH-1, HIHBO-68, and HIHBO-90 were found free from YVMV up to 90 days after seed sowing. The highest infection of YVMV was recorded in HIHBO-90 (17.3%) followed by Vijaya (16.0%) and SOH O-2 (14.7%) than check cvs. Parbhani Kranti (6.3%) and Arka Anamika (5.60%), at 90 days after seed sowing. The hybrid cultivars viz. DVR-2, SOH-5 and HIHBO-83 were topper in fruit yield. They produced 189.97, 183.70 and 147.65% higher pod yield over Arka Anamika and 30.28, 27.46 and 11.27% over Parbhani Kranti, respectively.

Nwangburuka et al. (2012) reported that the twenty-nine okra accessions from different agro-ecological regions in Nigeria were grown during the rainy and dry seasons, between 2006 and 2007 at Abeokuta (derived savanah) and Ilishan (rainforest). There was high genotypic

coefficient of variability in traits such as plant height (26.2), fresh pod length (23.9), fresh pod width (23.9), mature pod length (28.6), branching per plant (29.3) and pod weight per plant (33.9).

Patel et al. (2014) found that estimates of mean sum of squares due to genotypes were highly significant for all the characters, indicating the presence of genetic diversity in the existing material. The variation was the highest for fruit yield per plant, followed by fruit yield per hectare, plant height at 120 DAS, plant height at 90 DAS, plant height at 60 DAS and fruiting span.

Mihretu et al. (2014) revealed that the analysis of variance showed significant differences ($p < 0.01$) among the accessions for all quantitative characters measured. Estimate of phenotypic and genotypic coefficients of variation also showed the presence of variability among the accessions for the majority of the characters. High heritability (96.76 and 96.50%) coupled with high genetic advance as percent of mean (106.32 and 97.25%) were recorded for internodal length and plant height, respectively.

Mishra et al. (2015) observed the wide variations for fruit weight (12.23g to 23.40g), first flowering nodes (4.90 to 7.77), and fruit yield per plant (192.26g to 433.34g). Similarly, fruit yield per plant had the highest mean of 290.90g followed by plant height (160.62 cm) whereas, the lowest mean was observed for first flowering node.

Sharma and Prasad (2015) investigated that the phenotypic variance and coefficient of variation were higher than their respective genotypic variance and coefficient of variation for all the traits indicated the environmental effects on their expression. The differences between genetic coefficients of variation (GCV) and phenotypic coefficient of variation (PCV) were high for fruit diameter (FD) followed by number of branches per plant (NB), days to 50% flowering (DF), fruit weight (FW) and days to first harvest (FH) indicating the vulnerability of traits to environmental influences reflects the possibilities of varietal improvement.

2.2 Heritability and genetic advance

Heritability (broad sense) is an index of transmitting a character from the parents to the offspring. It is of great importance for both breeders and geneticists. Lush (1940) defined in broad sense heritability as the ratio of the total genotypic variance to the total phenotypic variance which provides a measure of the overall importance of hereditary determination of a trait.

Characters bearing high heritability values could be improved directly through selection since they are less affected by environment. It indicates the effectiveness in which selection of genotypes can be based on phenotypic performance. Heritability could be more desirably utilized in assembly with the selection differential in predicting genetic gain.

2.2.1 Heritability

Hazra and Basu (2000) revealed that the plant height, fruit weight, ridges per fruit and seeds per fruit, were highly heritable (above 80% heritability) while primary branches per plant, leaves per plant, days to first flower, fruit length, fruits per plant and fruit yield per plant were moderately heritable (60-75% heritability). Primary branches per plant, seeds per plant, seeds per fruit and fruit weight had high heritability values with above average to high genetic advance.

Dhankar and Dhankar (2002) reported that the fruit yield, number of fruits per plant and plant height showed high to moderate heritability in both the years.

Sureshababu et al. (2004) found that the high value of genotypic coefficient of variation combined with high heritability for the characters like fruits per plant, yield per plant and number of ribs on the fruit and height of the plant.

Singh and Singh (2006) expressed that the heritability estimates were high for days to first flowering, first fruiting and node length.

Magar and Medrap (2009) reported that Heritability estimates were of high magnitude for fruit length, total fruit yield per plant indicating major role of genotype with less environmental influence

Senapati et al. (2011) investigated that the high heritability estimates

were obtained in YVMV disease incidence (98.02%), fruit yield (93.92%), edible maturity (90.98%) and days to 50% flowering (89.02%) indicating that these characters might be heritable and less influenced by environment.

Chaukhande et al. (2011) revealed that the character plant height exhibited high heritability (broad sense) percentage.

Nagre et al. (2011) reported that the highest estimate of heritability was recorded for leaf area followed by number of leaves per plant, yield per plant, length of fruit, number of nodes per plant, chlorophyll content of leaves and number of fruits per plant.

Nwangburuka et al. (2012) found that the twenty-nine okra accessions from different agro-ecological regions in Nigeria were grown during the rainy and dry seasons, between 2006 and 2007 at Abeokuta (derived savannah) and Ilishan (rainforest). There was high % broad-sense heritability in traits such as plant height (90.7), fresh pod length (98.5), fresh pod width (98.5), mature pod length (98.5), branching per plant (82.3) and pod weight per plant (90.0).

2.2.2 Genetic advance

Dhall et al. (2000) reported that heritability and genetic advance as a percentage of the mean was higher for fruit length, plant height, number of fruits per plant and virus incidence.

Dhankar and Dhankar (2002) found that the fruit yield, number of fruits per plant and plant height showed high to moderate heritability in both the years. The genetic advance was found medium to low for all traits which indicates that there is limited scope for improvement through selection procedures.

Mehta et al. (2006) reported that The GCV, heritability and genetic advance as percentage of mean were higher for fruit yield, average fruit weight, plant height and fruit length, which might be attributed to additive gene action resulting their inheritance

Chaukhande et al. (2011) revealed that the highest genetic advance was recorded for yellow vein mosaic virus while the lowest for fruit diameter.

Nagre et al. (2011) reported that the highest genetic advance was also observed for the characters leaf area followed by yield per plant, plant height and number of leaves per plant.

Nwangburuka et al. (2012) investigated that the high genetic advance in traits such as plant height (51.5), fresh pod length (48.8), fresh pod width (48.8), mature pod length (52.3), branching per plant (54.8) and pod weight per plant (63.3).

2.2.3 Heritability with genetic advance

Ahamed et al. (2015) revealed that high heritability coupled with high or moderate degree of genetic advance was estimated in plant height (99.82 % and 205.06), number of fruits per plant (99.53% and 203.63%), number of leaves per plant (99.57% and 204.49%), number of seeds per fruit (99.73% and 205.44%), leaf length (98.22% and 198.52%), leaf diameter (98.91% and 203.76%), 100-seed weight (98.12% and 202.13%) and yield per plant (95.76 % and 197.26%). The highest positive correlation were observed between number of fruits per plant and yield per plant ($r = 0.99$) and between number of fruits per plant and 100-seed weight ($r = 0.44$).

Verma et al. (2004) observed that the high estimate of heritability and genetic advance for seeds per fruit and plant height.

Singh and Singh (2006) suggested that the genetic advance and heritability suggested that the characters such as first fruiting node length, number of branches per plant, tapering length and fruit yield per plant were under additive gene effects.

Naidu et al. (2007) observed that high estimate of heritability and genetic advance were obtained in number of nodes to first flower, number of fruits per plant, number of seeds per fruit and fruit yield per plant. These characters are governed by additive gene action.

Manivannan et al. (2007) revealed that the high heritability (94.5%) and the highest genetic advance as percent of mean (1.870) were observed for 100-seed weight.

Saifullah and Rabbani (2009) noted that the high heritability estimates along with considerable genetic advance were noticed in days to first

flowering, plant height, number of primary branches per plant, number of internodes per plant, number of fruits per plant, fruit weight, number of seeds per fruits and fruit yield per plant provided the basis for selection for development of new variety of okra based on phenotypic performance.

Kumar and salimath (2010) observed that the heritability and genetic advance were also high for all the characters indicating the involvement of additive type of gene action in controlling these characters, hence, selection could be effective.

Kumar et al. (2011) found that the heritability coupled with genetic advance indicated considerable genetic variability among the genotypes for height at first fruiting node, number of node at first pod appearance, plant height, number of nodes per plant, number of pods per plant and pod yield per plant.

Senapati et al. (2011) reported that the high heritability estimates coupled with high genetic advance, were obtained for characters such as fruit yield (93.92, 38.89%) and YVMV incidence (98.06, 30.64%).

Umesh et al. (2013) recorded that high to moderate heritability and genetic advance were estimated for the characters viz., yield per plant (g), length of internode, height of plant (cm), days to flowering, number of nodes per plant, while length of internode showed high heritability and high genetic advance but yield per plant showed high heritability and moderate genetic advance and also number of branches showed high heritability and low genetic advance. These two characters viz., yield per plant and length of internode indicated the involvement of non-additive gene action. The heritability for these traits was only due to favorable environmental condition. The characters mentioned above except these two traits had high heritability coupled with high genetic advance and assured that there was preponderance of additive gene action, and selection for these traits was reliable for development of high yielding cultivars of okra.

Patel et al. (2014) reported that high heritability coupled with high genetic advance as percentage of mean for traits like fruit yield per plant and fruit yield per plot suggested that the preponderance of additive

genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions.

Reddy and Sridevi (2014) obtained High estimates of heritability coupled with high genetic advance obtained for fruit yield per plant indicating presence of additive gene effects which indicated the effectiveness of selection for these traits. Presence of high heritability coupled with low genetic advance for average fruit weight, plant height and fruit diameter revealed that straight selection has limited scope for further improving these traits. The results exhibited that four lines were highly resistant to yellow vein mosaic virus, ten lines showed moderate resistant, 26 lines tolerant, 10 lines moderate susceptible, 6 susceptible and one highly susceptible. The highest yield per hectare was found in the DBh-25 (21.98 t/ha) followed by DBh-33 (19.9 t/ha) and DBh-7 (19.54 t/ha).

2.3 Correlation coefficient analysis:

The study of correlation coefficient between various economic traits of crop plant is very important to display the degree of union between characters. In plant breeding programme, these studies have importance.

Hazare and Basu (2000) reported that the fruit yield per plant was significantly and positively associated with plant height, whereas, days to first flowering showed negative association with number of fruits per plant.

Gandhi and Yadav (2002) noticed that the dry fruit yield was highly and significantly dependent on the number of nodes per plant, inter nodal length, number of fruits per plant and yield per plant.

Nimbalkar et al. (2002) observed that the dry fruit yield exhibited positive and significant correlation with number of days to maturity, plant height, seed yield per plant and number of fruits per plant, seed yield recording the highest correlation ($r=0.667$) with dry fruit yield. Regression studies showed that seed yield per plant contributed 62.8% genetic variability to the total 71.1% variability of the cultivars examined.

Niranjan and Mishra (2003) found that in general, the genotypic correlations were higher than the corresponding phenotypic correlation for all the character combinations. Fruit yield was positively and significantly

correlated with edibility period of fruits, number of fruits per plant, fruit length, number of seeds per fruit, fruit weight, plant height and number of branches per plant at both genotypic and phenotypic level. Associations were significant at the genotypic level only between edibility period of fruits and number of branches per plant. All characters had positive and significant association among each other at both levels.

Bendale et al. (2003) reported that the pod length, pod weight, plant height, nodes per plant and number of pods per plant were positively correlated with the yield.

Duzyaman et al. (2003) investigated that pod weight and diameter were positively correlated with total yield. Early flowering was negatively correlated with total yield. Pod weight and pod number per plant were highly associated with flowering behavior and pod composition on the first year. Pod weight per plant was associated with average pod weight, pod width and flesh thickness, whereas pod number per plant was correlated with dry matter content only. Significant correlation was observed among pod weight, pod width and flesh thickness.

Jaiprakash Narayan and Mulge (2004) reported that total yield per plant was positively and significantly correlated with number of fruits per plant, average fruit weight, number of nodes on main stem, fruit length, plant height (at 60 & 100 DAS) and number of leaves (at 45 & 100 DAS), but negatively and significantly correlated with number of locules per fruit, number of nodes at first flowering and first fruiting.

Patro and Ravishankar (2004) observed that fruit yield per plant have significant and positive correlation with number of branches per plant, fruit length and fruit weight. Significant negative correlation of fruit yield per plant was recorded with plant height and number of days taken to first pod setting.

Sureshbabu et al. (2004) noted that the significant phenotypic and genotypic correlation with yield was shown by fruit length and fruits per plant.

Subrata et al. (2004) reported in his studies that, in 25 genotypes of okra fruit yield had significant positive correlation with number of fruits per plant and fruit weight.

Bhalekar et al. (2005) observed that fruit length, inter-nodal length, number of fruits per plant and number of branches per plant had positive and strong correlation with fruit yield.

Ghosh (2005) reported that fruit yield per plant was recorded significantly positively correlated with fruiting span, inter-nodal length, number of seeds per fruit, plant height at maturity and weight of fruit.

Pawar (2005) found that the yield per plant was significantly positively correlated with number of fruits per plant, fruit weight, fruit length and fruit girth.

Sankaran et al. (2005) investigated that the fruit length (0.977), fruit girth (0.922), fruit weight (0.984), crude fiber (0.973), total sugar (0.875) and acidity (0.993) had higher positive correlation with advancement of maturity.

Choudhary (2006) noted that the yield per plant showed positively significant association with number of fruits per plant, fruit weight, length of fruit, number of seeds per fruit, plant height, fruiting span, fruit girth and number of branches per plant.

Akinyele and Oseikita (2006) observed that the seed yield per plant showed significant positive correlation with number of pods per plant, height at flowering, pod width and weight of hundred seeds.

Verma et al., (2007) reported that yield per plant exhibited positive and significant correlation with fruits per plant, fruit weight, fruit length, and fruit girth. Negative correlation was found in 100 seed weight, days to 50% flowering and days to first flowering with yield per plant.

Adeniji and Aremu (2007) observed the significant differences among the segregating population for pods per branch, seeds per pod, inter node distance, seeds per ridge, branch length, height at flower bud initiation and height at flowering. A positive correlation was recorded for number of pods per plant and seed weight, height at maturity, ridges per pod and seeds per ridge. The seed weight recorded a positive correlation coefficient with edible pod width, seeds per ridge and pods per plant.

Osekita and Akinyele (2008) noticed that there is a strong relationship between pod length and pod width with the number of seeds per pod.

Ali et al. (2008) reported that the Correlation coefficients were estimated among parents, F1 hybrids and F2 population separately at genotypic and phenotypic correlation coefficients. The correlation coefficients were consistently significant and positive in all the three population between fruit yield per plant and number of fruits per plant at both genotypic and phenotypic levels. The consistency was also observed in F1 and F2 generations between fruit yield per plant and plant height at both genotypic and phenotypic levels. Fruit yield per plant showed significant and positive correlation between length of fruit and width of fruit at genotypic level in both F1 and F2 generations.

Kumar et al. (2009) revealed that the magnitudes of genotypic correlation coefficient were invariably higher than phenotypic correlation coefficient, suggesting therefore a strong inherent trait. The most important trait, no. of flower per plant was positively and significantly correlated with no. of leaves per plant, diameter of stem and no. of days to flower at genotypic and phenotypic levels. The data also revealed that no. of fruits per branch, no. of fruits per plant and no. of days to flower were positively and significantly correlated at genotypic and phenotypic levels.

Sharma and Prasad (2010) found that the positive significant correlation for days to 50% flowering with days to first harvest, number of pod per plant with pod yield per plant and pod yield per plot and pod yield per plant with pod yield per plot and negative correlation was observed for pod weight with number of pod per plant.

Nagre et al. (2011) investigated that the yield per plant was closely associated positively and significantly with number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit, leaf area, chlorophyll content of leaves plant height and number of primary branches per plant. The characters like number of leaves per plant, number of lobes per leaf, inter nodal length, node at which first fruit appears and ascorbic acid content of fruits exhibited positive, however non-significant correlation with yield per

plant. The characters diameter of fruit was negatively and significantly correlated with yield per plant. Number of ridges per fruit also showed negative but non-significant correlation with yield per plant.

Chaukhande et al. (2011) revealed that the yield per plant exhibit positive and significant correlation with plant height, number of flowering nodes on main stem, number of fruits per plant and average weight of fruit.

Senapati et al. (2011) reported that the correlation studies exhibited that the genotypic estimates were higher than the phenotypic ones for the most of the traits, indicated a strong inherited association between the characters. Fruit yield is the most important economic trait showed positive and significant association with number of nodes per plant, number of fruits per plant and fruit length.

Nwangburuka et al. (2012) expressed that the positive and significant phenotypic and genotypic correlation between plant height at maturity, fresh pod width, seeds per pod and pods per plant, branches per plant with seed weight per plant and pod weight per plant, suggests that selection on the basis of the phenotype of these characters will lead to high seed and pod yield in okra.

Mihretu et al. (2014) found that Correlation study between various quantitative characters highlighted significant association among characters. Fruit yield was positive and highly significant genotypic correlation with fruit length ($r=0.74$), average fruit weight ($r=0.62$), fruit diameter ($r=0.61$), seed per pod ($r=0.56$), hundred seed weight ($r=0.68$) and number of pod per plant ($r=0.66$).

Balai et al. (2014) revealed that average weight of edible pod (0.943g) had highest positive direct effect followed by number of pods per plant (0.372) and number of leaves per plant (0.125) on yield per plant. The study suggested that plant height, length of pod, average weight of edible pod and number of seeds per pod are important traits which should be used as selection criteria to develop high yielding varieties in okra.

Saryam et al. (2015) reported that Yield plant-1 had highly significant positive phenotypic correlation with viz., number of fruits per plant (0.803),

fruit diameter (0.376), fruit length (0.349), number of seeds fruit-1 (0.316), days to maturity (0.301), fruit weight (0.274) leaf blade width (0.219), 100 seed weight (0.219), flower diameter (0.154), fruiting span (0.152), petiole length (0.151), and stem diameter (0.150). Highly negative non-significant association was observed with incidence of YVMV (-0.389), days to 50 per cent flowering (-0.319) and node at first flower appears (-0.307) this correlation study indicated that close interrelationship between genotypic and phenotypic correlation co-efficient and magnitude of genotypic correlation were higher than their corresponding phenotypic correlation for most of the traits.

Mishra et al. (2015) observed that wide variability was found for different traits in Okra. Invariably, higher values were observed for phenotypic coefficient of variation with respect to corresponding genotypic coefficient of variation indicating the impact of environmental factors towards trait expression. The presence of moderate to high heritability coupled with moderate genetic advance for fruit weight, days to 50% flowering, fruits per plant as well as fruit yield per plant indicated their possibility of improvement with simple selection procedure in okra. Similarly, highly significant and positive correlation of fruit yield per plant with plant height, nodes per plant and fruits per plant was observed.

Ahamed et al. (2015) revealed that the highest range of variation was recorded in average fruit weight (18.25- 25.41g), followed by yield per plant (98.90 – 1650.00g). The highest GCV (46.70 %) and PCV (47.72 %) were recorded for fruit yield per plant while both were lowest for days to maturity (8.07 % and 8.25 %)

Sreenivas et al. (2015) found that fruit length had significant positive correlation with fruit girth, fruit weight, number of fruits per plant and duration. Fruit girth had significant positive correlation with fruit length, fruit weight and number of fruits per plant. Fruit weight had significant positive correlation with fruit length, fruit girth, number of fruits per plant and duration. Number of fruits per plant had significant positive correlation with all characters.

2.4 Path analysis

Dhall et al. (2000) reported that the marketable yield per plant, number of fruits per plant, fruit weight, fruit length and plant height had the highest direct effect on the total yield, indicating that emphasis should be given on such characters to improve the yield potential.

Subrata et al. (2004) found that number of fruits per plant and fruit weight had positive and high direct effect on fruit yield, indicating their importance as reliable selection criteria for improvement of yield in okra.

Sarkar et al. (2004) investigated that path coefficient analysis with partitioning of phenotypic correlation revealed that number of fruits per plant and fruit weight had positive and high direct effect on fruit yield, indicating their importance as reliable selection criteria for improvement of yield in okra.

Mehta et al. (2006) revealed that fruit girth had the maximum direct effect followed by fruit length towards fruit yield. Thus, the fruit yield in okra can be improved by selecting for higher fruit length, fruit girth and average fruit weight simultaneously.

Magar and madre (2009) reported that 41 genotypes of okra path coefficient study the number of fruits per plant had the maximum direct contribution towards total yield followed by fruit weight, plant height and days to first flowering. These important traits may be viewed in selection programme for the further improvement of okra.

Ramanjinappa et al. (2011) revealed that in path coefficient analysis, number of fruit per plant had the highest direct influence towards fruit yield per plant followed by number of seed per fruit, harvest index and number of nodes per plant.

Senapati et al. (2011) found in path coefficient analysis that the number of fruits/plant (0.242), fruit girth (0.218) and fruit length (0.058) exhibited maximum direct effects on fruit yield as phenotypic level. On the basis of above findings, it was concluded that the number of fruits/plant and fruit length would be considered for improvement of fruit yield of okra hybrid and among the genotypes, JOH 05-9 was found the most promising hybrid followed by HOK 152 and AOH-23.

Sibsankar et al (2012) reported in path coefficient analyses, that the top priority should be given to selection based on numbers of fruit per plant and fruit weight for yield improvement and could be considered while formulating selection indices in the improvement of okra.

Gangashetti et al. (2013) investigated that path analysis depicted high effect on number fruit per plant, fruit weight, plant height, and number of branches per plant with fruit yield per plant. To release importance of fruit yield, direct selection can be practices for the characters.

Mihretu et al. (2014) reported that path coefficient analysis at genotypic level revealed that internodes number had high positive direct effect on fruit yield ($p=6.90$) followed by average fruit weight ($p=6.89$) which had positive genotypic correlation with yield. The present study indicated a considerable amount of variability for majority of quantitative characters in okra for exploration.

Saryam et al. (2015) found that Phenotypic path coefficient analysis revealed traits viz., number of fruits plant⁻¹(0.733) followed by number of seeds fruit⁻¹ (0.165), number of branches plant⁻¹(0.147), fruit diameter (0.133), fruit weight (0.097), days to maturity (0.058), fruiting span (0.056), 100 seed weight (0.055), stem diameter (0.027) and plant height (0.023) have positive and high direct effects with fruit yield per plant. Number of fruits plant⁻¹, fruit diameter, fruit length, plant height, number of seeds fruit⁻¹, days to maturity, fruit weight, and stem diameter indicating importance of these characters and can be strategically used for selection criteria to develop and improve high yielding okra varieties.

Ahamed et al. (2015) revealed that significantly positive correlation was between 100-seed weight and yield per plant ($r = 0.44$), 100-seed weight and leaf length ($r = 0.42$), 100-seed weight and leaf diameter (0.38), number of leaves per plant and 100-seed weight ($r = 0.28$), 100-seed weight and plant height($r = 0.40$), 100-seed weight and fruit length ($r = 0.28$). Significantly positive correlations were also observed for plant height and number of fruits per plant, number of leaves per plant and yield per plant. The path coefficient analysis was done to determine direct and indirect effects of traits on fruit yield. Direct significant positive and negative effect of number of fruits per

plant (-0.091), 100-seed weight (0.174), number of seeds per plant (-0.213), average fruit yield (-0.310) towards yield.

Sreevivas et al. (2015) found that number of fruits per plant had the maximum direct contribution (0.698) towards total yield followed by fruit weight (0.467), fruit girth (0.075) duration (0.042) and plant height (0.014). However, days to first flowering and fruit length exhibited negative direct effect. Hence, selection should be practiced for these characters in order to isolate superior plant types for improvement of fruit yield.

Sharma and Prasad (2015) reported that number of fruits per plant (NP) and fruit weight (FW) contributed major direct positive effect to fruit yield per plot, whereas, number of branches per plant (NB) and days to first harvest (FH) showed highest negative direct effect on yield component. Plant height, however, showed the highest positive indirect effect via number of fruits per plant and negative indirect effect via fruit weight. Number of branches (NB) showed positive indirect effect via number of fruits per plant (0.7655) and plant height (0.2728) and negative indirect effect via fruit weight (-0.2830). The estimated residual effect found was 0.0118 indicated about 98.82% of variability in fruit yield was contributed by yield affecting characters studied.

MATERIAL AND METHODS

This chapter comprises the details about the material used and the methods adopted during the course of present investigation entitled “Genetic Variability, Correlation and Path Analysis in Okra” which was carried out in Kharif season during the year 2015-16.

3.1 Experimental site

The experiment was conducted at Horticulture Complex, Maharajpur, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.).

3.1.1 Soil

The soil of the experimental field was clay loam with good drainage and uniform texture with medium NPK status.

3.1.2 Climate and weather conditions

The field of experimental farm Jabalpur is situated on Agro-climatic Region of Madhya Pradesh at 23.91° North latitude, 79.5° East longitudes and on an altitude of 411.78 meters above the mean sea level. The tropic of cancer passes through the middle of the district. The climate of region is typically semi arid and sub tropical having extreme winter and summer. The average annual rainfall is 1350 mm, which is mostly received during June to October from South-west monsoon. The average maximum temperature remains 46°C and the minimum temperature 6.8°C. With average annual relative humidity 74%.

The meteorological parameters during the crop season such as minimum and maximum temperature, sunshine hours, rainfall, number of rainy days and relative humidity were recorded at Meteorological observatory, Krishi Nagar, JNKVV, Jabalpur are presented in Table 3.1.

Table 3.1. Meteorological Information (week wise) During Entire Crop Season of the Year August 2015 to November 2015 at Jabalpur.

Meteo. Weeks.	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days	Sun shine (hrs.)
	Max.	Min.	Mor.	Evn.			
31	29.8	23.6	90	70	149.4	02	04.7
32	31.2	24.2	91	69	014.0	02	04.6
33	31.2	24.5	91	73	116.8	04	03.0
34	31.3	23.6	88	64	009.4	01	07.4
35	30.4	22.9	93	76	104.6	05	03.0
36	32.2	24.2	87	57	008.2	01	06.7
37	33.5	23.1	91	53	003.4	01	08.4
38	32.0	23.7	92	64	070.2	0.3	05.6
39	32.6	21.1	84	45	000.0	00	09.2
40	33.1	19.5	88	35	000.0	00	09.3
41	35.1	17.9	86	31	000.0	00	09.5
42	34.0	19.0	86	36	000.0	00	09.2
43	33.3	18.4	87	47	000.0	00	06.9
44	28.0	17.0	92	58	040.0	01	05.8
45	31.4	17.9	88	40	000.0	00	05.8
46	30.9	14.1	89	35	000.0	00	07.6

3.2 Experimental Material

The experimental material for this study comprised of 22 genotypes with two checks (Arka Anamika and Arka Abhay collected from IIVR, Varanasi (Table 3.2).

Table 3.2. Details of Genotypes and Checks Used in the Study

S. No.	Name of genotype	S. No.	Name of genotype
1	2013/OKHYB-1	13	2014/OKYVRES-6
2	2013/OKHYB-2	14	2014/OKYVRES-7
3	2014/OKHYB-2	15	2014/OKYVRES-8
4	2014/OKHYB-3	16	2014/OKYVRES-9
5	2014/OKHYB-4	17	2014/OKYVRES-11
6	2014/OKHYB-5	18	2015/OKYVRES-1
7	2014/OKHYB-6	19	2015/OKYVRES-2
8	2014/OKHYB-8	20	2015/OKYVRES-3
9	2014/OKYVRES-1	21	2015/OKYVRES-4
10	2014/OKYVRES-2	22	2015/OKYVRES-5
11	2014/OKYVRES-3	23	ARKA ANAMIKA
12	2014/OKYVRES-4	24	ARKA ABHAY

3.3 Experimental details

3.3.1 Design of experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with 24 genotypes (22 genotypes + 2 checks) in three replications. The experimental details are as follows:-

Design	:	Randomized Complete Block Design
Replication	:	Three
Genotypes	:	24
Number of plots	:	72
Plot size	:	2.40 x 3.00 sqm
Row to row distance	:	60 cm
Plant to plant distance	:	30 cm
Number of row/ plot	:	4
Number of plants per row	:	10
Gross area of experimental field	:	839.30 sq.m
Net area of experiment field	:	583.20 sq.m
Number of plants for observation per plot	:	5
Distance between replications	:	1 m
Crop	:	Okra
Season	:	Kharif (2015-2016)
Date of sowing	:	5 August 2015
Manures	:	20 tonnes FYM/ha
Fertilizer dose (N:P:K)	:	150:110:80 kg/ha

3.3.2 Field preparation and layout

3.3.2.1 Sowing

In order to get good tilth of the soil for sowing one cross cultivation was done by tractor drawn cultivator followed by two harrowings and one ploughing and plastic mulch also apply before sowing of seed by dibbling.

3.3.2.2 Thinning

After two weeks of sowing, thinning was carried out to maintain plant to plant distance. All the recommended package of practices were followed to raise healthy crop.

3.3.3 Irrigation

The irrigation was given by the drip irrigation system as and when required.

3.3.4 Intercultural operations

The experimental plots were kept weed free. Hand weeding was done as and when needed.

3.3.5 Plant protection

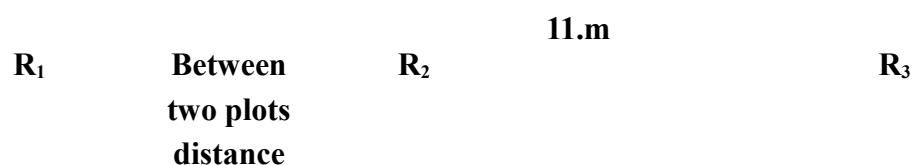
The crop was sprayed with Imidacholoroprid 17.8% SL and Trizophas 40 EC alternate to keep the crop free from pest during crop growth period.

3.3.6 Fertilizer application

A dose of 150kg N, 110kg P₂O₅ and 80kg K₂O/ha along with 20 tonnes FYM/ha was applied. One third nitrogen and entire quantity of P, K and FYM was applied prior to sowing. Remaining dose of nitrogen was applied in two splits at 30 and 60 days after sowing.

3.3.7 Sampling

Sampling was done after 30 days to harvest time for growth analysis. Five plants were randomly selected from each genotype for the study.



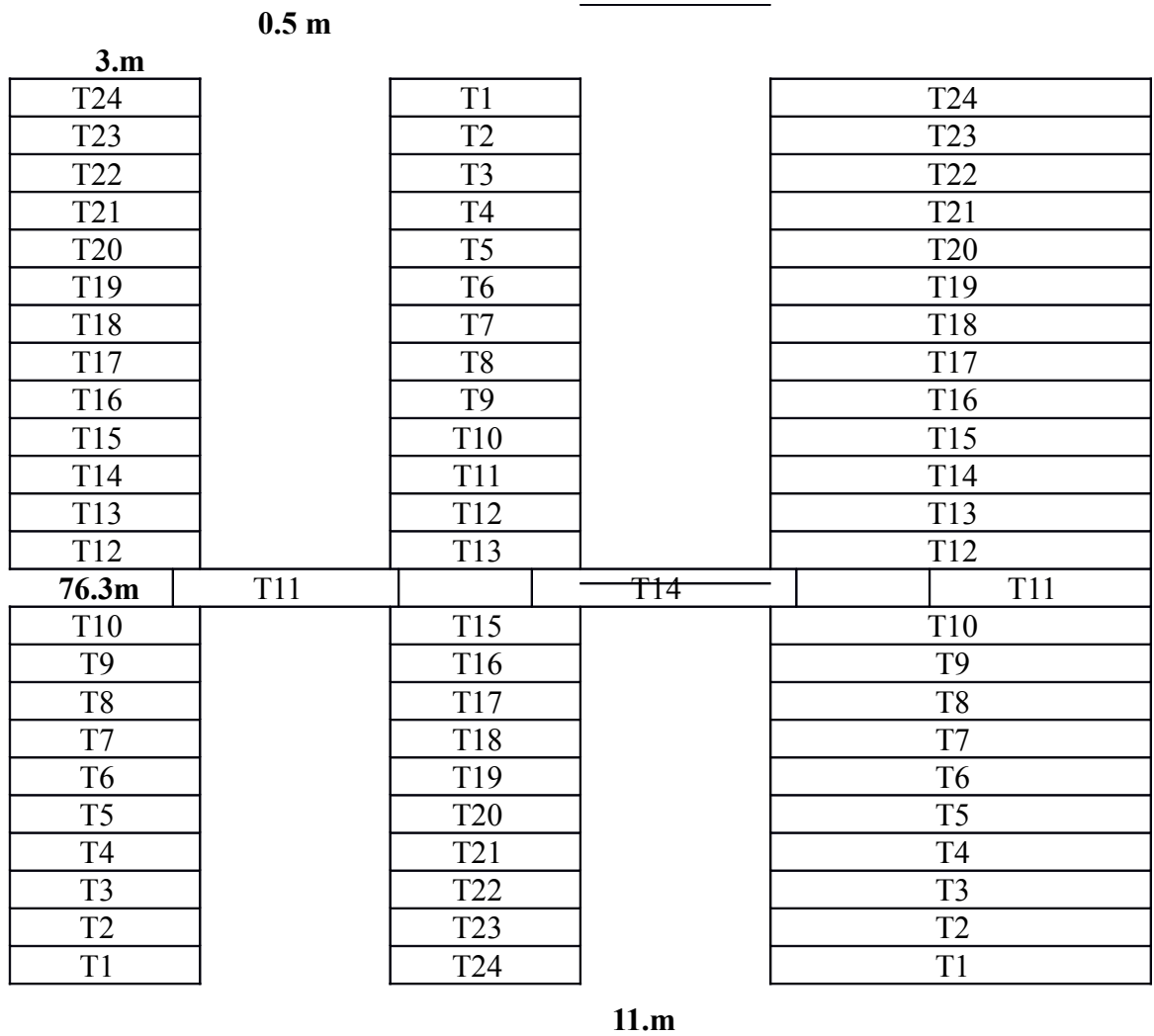


Fig. 3.2 Design of Layout

3.4 Observations

The data recorded on various parameters were subdivided into four categories during the period of experimentation.

(A) Morphological parameters

3.4.1 Plant height (cm)

Height of plant was recorded from the base just above the soil surface to growing point of the plant with the help of meter scale. The height was recorded at 30 days, 60 days and 90 days after sowing.

3.4.2. Number of leaves per plant

The number of leaves of selected plants was counted and average was worked out at 30 days, 60 days and 90 days after sowing.

3.4.3 Number of branches per plant

Number of branches of selected plants was counted and average was worked out at 60 DAS and 90 DAS.

3.4.4 Length of internodes (cm)

The inter-nodal length of the five randomly selected plants was recorded. The length between two nodes from different places such as base, middle and top with the help of scale and average was worked out for each genotype.

3.4.5 Number of nodes to first flowering

Numbers of nodes were counted at the time of first flowering

3.4.6 Days taken to first flowering

Average number of days required to first flowering in each genotype was recorded separately.

3.4.7 Days taken to 50% flowering

Average number of days required to 50% flowering in each genotype was recorded separately.

3.4.8 Days taken to first picking

Number of days required to first picking in each genotype was recorded.

3.4.9 Fruiting span

Fruiting span means the duration between first to last picking was recorded to know the fruiting span of each genotype.

(B) Fruit characters

3.4.10 Fruit length (cm)

The length of fruit was measured randomly of selected five fruits from every genotype with the help of scale and then average was recorded.

3.4.11 Fruit width (cm)

The width of the randomly selected fruits were recorded with the help of Vernier calipers and average was worked out.

3.4.12 Fruit colour

The colour of the fruit was recorded at marketable stage in following categories.

- Dark green
- Green
- Light green

3.4.13 Fruit weight (g)

The weight of five fruits was recorded separately with the help of weighing balance and average was worked out for each genotypes.

3.4.14 Fruit surface

The surface of the fruits was recorded in following categories.

- Hairy
- Non hairy

(C) Yield parameters

3.4.15 Number of fruits per plant

The number of fruits harvested from five randomly selected plants in each genotype was collected during each picking, counted and totaled together and average number of fruits per plant were calculated.

3.4.16 Yield per plant (g)

Picking of fresh marketable fruits was done from the observational plants separately throughout the harvesting period at an interval of 3 days. It was totaled and then average yield per plant was worked out for each genotype.

3.4.17 Yield per plot (kg)

The picking of fresh marketable fruits was done from the observational plants separately throughout the harvesting period at an interval of 3 days. It was noted for all the pickings..

3.4.18 Yield per hectare (q)

The weight of fruits obtained at all pickings was pooled and average yield/ha was calculated by multiplication of the number of plant per plot and per hectare.

3.4.19 Incidence of yellow vein mosaic virus

The number of plants affected due to YVMV was counted at 60 and 90 DAS and percentage of incidence was worked out in each genotypes.

3.5 Statistical methodology

The data obtained in respect of all the characters has been subjected to the following statistical analyses.

3.5.1 Mean: It was calculated by using following formula.

$$\text{Mean} = \frac{\sum x}{n}$$

where,

$\sum x$ = The sum of all the observations

n = Number of observations

3.5.2 Analysis of variance

The data based on the mean of individual plants selected for observations were statistically analysed to find out overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out analysis of variance to test the significance of differences among the populations. The analysis of

variance was carried out as per methods suggested by Panse and Sukhatme (1967). The skeleton of analysis of variance used was as follows:

Table 3.3: ANOVA for Randomized Complete Block Design

Source of Variation	d.f.	Sum of square	Mean sum of squares	F value	F _t 5% or 1% table value
Replication	r-1	RSS	RMS	RMS/EMS	-
Genotypes	g-1	GSS	GMS	GMS/EMS	-
Error	(r-1) (g-1)	ESS	EMS	-	-
Total	rg-1	TSS	-	-	-

where,

r = Number of replications

g = Number of genotypes

d.f. = Degree of freedom

RSS = Replication sum of squares

GSS = Genotype sum of squares

ESS = Error sum of squares

TSS = Total sum of squares

RMS = Replication mean sum of squares

GMS = Genotype mean sum of squares

EMS = Error mean sum of squares

A significant value of F test indicates that the test entries differ significantly among themselves, which require the computing of C.D.

SE diff=

CD at 5% prob. Level = SE diff x t_{5%} table value at error d.f

where,

C.V. %	=	Coefficient of variation
SEm±	=	Standard error of means
S E diff	=	Standard error of difference of mean
GM	=	Grand mean
C.D.	=	Critical difference
t 5%	=	table value of t at 5% probability level at error d.f.

Estimation of mean, components of variance, phenotypic, genotypic and environmental coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean:

The mean of different characters were calculated by conventional method:-

$$\text{Mean} = \frac{\sum X_i}{N}$$

Where,

$\sum X_i$ = The sum of all the observation for i^{th} character.

n = Number of observations.

Range was recorded by observing the lowest and the highest mean values for each character.

The component of variance was calculated as follows:-

Source of variation	M.S.S.	Expected M.S.S.
Replications	-	-
Genotypes	M_i	$\sigma_{e_i}^2 + r. \sigma_{g_i}^2$
Error	E_i	$\sigma_{e_i}^2$

$$\sigma_{g_i}^2 = M_i - E_i$$

$$\sigma_{e_i}^2 = E_i$$

$$\sigma_{p_i}^2 = \sigma_{g_i}^2 + \sigma_{e_i}^2$$

where,

$\sigma_{g_i}^2$ = Genotypic variance for i^{th} character.

$\sigma_{e_i}^2$ = Environmental variance for i^{th} character.

$\sigma_{p_i}^2$ = Phenotypic variance for i^{th} character.

Phenotypic and genotypic coefficient of variation (expressed in %) were calculated by using the formula given by Burton (1952). Genotypic coefficient of variation (GCV) was calculated as below:

Phenotypic coefficient of variation (PCV)

where,

\bar{X}_i = General mean of the i^{th} character under consideration.

$\sigma_{g_i}^2$ and $\sigma_{p_i}^2$ = Genotypic and phenotypic variances of the i^{th} character respectively.

Heritability and genetic advance

Heritability (broad sense) which is ratio of genotypic variance to the total phenotypic variance is symbolized as h^2 (BS) and expressed in percentage. Estimation of heritability was done as per the formula given by Hanson *et al.* (1956).

$$h^2 \text{ (BS)} = \frac{\sigma_{g_i}^2}{\sigma_{p_i}^2} \times 100$$

or

$$= \frac{\text{Genotypic variance of the } i^{\text{th}} \text{ character}}{\text{Phenotypic variance of the } i^{\text{th}} \text{ character}} \times 100$$

Phenotypic variance of the i^{th} character

Expected genetic advance was calculated by using the method suggested by Johnson *et al.* (1955) at 5% selection intensity.

$$\text{Genetic advance (GA)} = K \cdot P_i \cdot h_i^2$$

Genetic advance as percentage of mean was calculated as follows:

$$\frac{\text{Genetic advance}}{\text{Genetic advance}}$$

where,

K = Selection intensity its value at 5% selection level is 2.06.

P_i = Phenotypic standard deviation of the i^{th} character.

h_i^2 = Broad sense heritability (fraction) of the i^{th} character.

\bar{x}_i = General mean of the i^{th} character under consideration.

Correlation coefficients

Correlation coefficients were calculated in all possible combinations taking all the characters into consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller *et al.* (1958).

where,

r = Correlation coefficient

n = Number of treatments

X and Y = Characters under study

Genotypic, phenotypic and environmental correlations were computed by substituting corresponding variance and covariance in the above formula, e.g.

$$r_G (X_i X_j) = \frac{\text{Cov G } (X_i X_j)}{\sqrt{V_G (X_i) \cdot V_G (X_j)}}$$

$$r_P (X_i X_j) = P \frac{\text{Cov P } (X_i X_j)}{\text{Cov P } (X_i X_j)}$$

$$r_E (X_i X_j) = \frac{\text{Cov E } (X_i X_j)}{\sqrt{VE (X_i) \cdot VE (X_j)}}$$

Testing of correlation coefficient:-

The phenotypic correlations were tested for their significance by using the following formula based on “t” test

$$t = \frac{r \sqrt{n-2}}{\sqrt{1-r^2}} \quad \text{at } (n-2) \text{ d.f}$$

where,

n= Number of treatments.

r= phenotypic correlations coefficient.

The calculated value of “t” is compared with table of “t” at (n-2) d.f. If the calculated value is equal to or greater than table value, it is significant at given probability level. If $t_c < t_T$, it is non significant.

3.4.3 Path coefficient analysis:

Path coefficient are standardized partial regression coefficient and as such these provide the means to direct influence of one character upon another character upon another character and also permit portioning of correlation coefficient into direct and indirect effect via other character. The direct indirect contribution of various independent character on a dependent character yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). The following set of simultaneous equation was formed and used for the estimation of direct and indirect effects.

$$\begin{aligned}
r_{1y} &= p_{1y} + r_{12} p_{2y} + r_{13} p_{3y} + \dots + r_{1y} p_{1y} \\
r_{2y} &= r_{2y} p_{1y} + r_{2y} + r_{23} p_{3y} + \dots + r_{21y} p_{1y} \\
r_{ky} &= r_{ki} p_{1y} + r_{k-1} p_{2y} + r_k^3 p_{3y} + \dots + p_{ky} \\
r_{xky} &= r_{xk1} p_{1y} + r_{xk2} p_{2y} + r_{xk3} p_{3y} + \dots + p_{xky}
\end{aligned}$$

where,

- r_{xky} = Coefficient correlation between independent character
- P_{iy} to P_{3y} = Direct effect of character 1 to 3 character y

Direct effect

The direct effects were calculated as follows

$$P_{ky} = \sum_{l=1}^K C_{kirk} Y$$

Indirect effect

Indirect effect of any independent traits on the dependent one (=yield) via other independent traits are computed by multiplying the direct effects (P_{ky}) of that independent variables with the corresponding correlation coefficient as follows:

$$K^{\text{th}} \text{ traits via } (n-1) = r_k (n-1) P (n-1) Y$$

RESULTS

The present investigation entitled “Genetic Variability, Correlation and Path analysis in Okra” was carried out to determine the following objectives:

1. To estimate the various parameters of genetic variability in okra.
2. To find out the inter-relationship among yield and its components at phenotypic and genotypic levels.
3. To assess the direct and indirect effects of yield contributing characters on fruit yield per plant.

The result obtained from the present investigation are presented under the following heads:

- 4.1 Analysis of variance
- 4.2 Mean performance
- 4.3 Genetic variability
- 4.4 Correlation coefficient analysis
- 4.5 Path coefficient analysis

4.1 Analysis of variance

The analysis of variances for all the characters studied has been presented in Table 4.1 It is revealed from the table that mean sum of squares due to genotypes were highly significantly for all the characters, indicating that the presence of genetic diversity in the existing material.

Table 4.1: Analysis of Variance for Various Characters in Okra (mean sum of squares).

Source of Variance	D.F.	Plant height (cm) at			No. of branches / plant at	
		30DAS	60DAS	90DAS	60DAS	90DAS
Replications	2	143.918	340.225	72.101	2.953	10.415
Genotypes	23	14.421**	827.552**	1535.762**	0.145**	0.723**
Error	46	3.607	225.306	201.829	0.041	0.187

Source of Variance	D.F.	No. of leaves per plant at			No. of nodes to 1 st flowering	Length of internods (cm)
		30DAS	60DAS	90DAS		
Replications	2	45.111	193.507	545.577	0.017	81.246
Genotypes	23	2.585**	26.659**	74.460**	0.669**	9.589**
Error	46	0.565	6.944	7.083	0.147	1.468

Source of Variance	D.F.	Days to 1 st flowering	Days to 50% flowering	Days to 1 st picking	Fruiting span
Replications	2	10.166	26.930	4.263	4.263
Genotypes	23	3.545**	4.955**	4.477**	4.477
Error	46	1.195	1.466	1.582	1.582

Source of Variance	D.F.	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Number of fruits per plant
Replications	2	0.204	0.277	19.781	69.362
Genotypes	23	4.957**	0.038**	24.314**	16.494**
Error	46	1.161	0.009	3.922	1.964

Source of variance	D.F.	Fruit yield/ plant (g)	Fruit yield/ plot (kg)	Fruit yield / ha. (q)
Replications	2	29489.608	46.911	9037.400
Genotypes	23	6959.728**	11.243**	2166.232**
Error	46	617.231	0.980	188.821

Source of variance	D.F.	Incidence of YVMV % at	
		60DAS	90DAS

Replications	2	4.253	35.304
Genotypes	23	51.988**	252.794**
Error	46	12.224	59.760

4.2 Range and mean performance of the genotypes

Range and mean performance (maximum and minimum) of the twenty four genotypes of okra for all the twenty two characters are presented in Table 4.2a, b, c, d, e and f.

4.2.1 Plant height (cm)

Plant height varied from 22.71 to 31.57 cm, 70.29 to 150.44 cm and 108.47 to 215.99 with an overall mean performance of 26.43, 123.37 and 174.95 at 30, 60 and 90 DAS respectively. Genotype 2013/OKHYB-2 recorded the maximum plant height 31.57, 150.44 and 215.99 cm, while, genotype 2014/OKYVRES-7 exhibited the minimum 22.71, 70.29 and 108.47 cm plant height at 30, 60 and 90 DAS respectively.

4.2.2 Number of branches per plant

Number of branches per plant ranged between 1.27 to 2.00 and 2.40 to 4.20 with an average performance of 1.68 and 3.44 at 60 and 90 DAS respectively. The maximum 2.00 and 4.20 branches per plant was recorded at 60 and 90 DAS respectively in genotype 2014/OKYVRES -1. While, it was recorded the minimum in Arka Abhay, 1.27 and 2.40 at 60 and 90 DAS respectively. .

4.2.3 Number of leaves per plant

Number of leaves per plant ranged from 9.58 to 12.91, 18.31 to 29.70 and 26.97 to 43.32 with an overall mean performance of 11.20, 24.42 and 36.02 leaves per plant. The maximum 12.91, 29.70 and 43.32 leaves per plant were noted in genotype 2014/OKYVRES -1. While, the minimum 9.58, 18.31 and 26.97 leaves per plant were exhibited in genotype Arka Abhay at 30, 60 and 90 DAS respectively.

4.2.4 Number of node to first flowering

Number of node to first flowering varied from 3.87 to 5.67 nodes with the average nodes being 4.74. The Maximum node to first flowering were observed in genotype 2014/OKYVRES -11 (5.67), while, the genotype 2015/OKYVRES-5 had the lowest nodes (3.87).

Table 4.2a: Mean Performance of Morphological Parameters of Okra

Genotypes	Plant height (cm)			No. of branches /plant	
	30DAS	60DAS	90DAS	60DAS	90DAS
2013/OKHYB -1	25.48	123.30	167.70	1.67	3.93
2013/OKHYB -2	31.57	150.44	215.99	1.87	3.40
2014/OKHYB -2	26.48	136.63	197.61	1.80	3.80
2014/OKHYB -3	28.31	113.62	164.24	1.80	3.53
2014/OKHYB -4	27.34	137.99	211.67	1.33	2.60
2014/OKHYB -5	28.88	106.97	154.49	1.73	3.40
2014/OKHYB -6	24.37	138.25	172.95	1.73	3.33
2014/OKHYB -8	29.02	143.37	193.82	1.67	3.60
2014/OKYVRES -1	24.13	123.17	176.03	2.00	4.20
2014/OKYVRES -2	27.09	132.71	189.87	1.27	3.93
2014/OKYVRES -3	27.51	124.09	179.32	1.93	3.87
2014/OKYVRES -4	24.37	124.39	182.60	1.73	3.73
2014/OKYVRES -6	28.33	132.83	185.97	1.53	3.40
2014/OKYVRES -7	22.71	70.29	108.47	1.73	3.93
2014/OKYVRES -8	24.23	112.02	158.66	1.40	3.40
2014/OKYVRES -9	25.51	114.32	154.16	1.93	3.13
2014/OKYVRES -11	24.72	138.02	199.24	1.87	2.40
2015/OKYVRES-1	23.29	121.23	165.59	1.93	3.87
2015/OKYVRES-2	24.16	130.00	184.11	1.53	3.13
2015/OKYVRES-3	25.95	103.99	154.89	1.47	3.47
2015/OKYVRES-4	27.69	104.74	152.44	1.87	4.00
2015/OKYVRES-5	26.49	128.65	182.10	1.47	3.13
Arka Anamika	28.91	122.57	170.73	1.73	3.07
Arka Abhay	27.74	127.35	176.24	1.27	2.40
S.Em±	1.09	8.66	8.20	0.11	0.25
C.D.5% level	3.13	24.76	23.44	0.33	0.71

4.2.5 Length of internodes (cm)

Length of internodes varied from 3.16 to 9.67 cm with an overall mean performance of 6.54 cm. The maximum 9.67 cm length of internode was

recorded in genotypes 2013/OKHYB-2. While, it was recorded the minimum in 2014/OKYVRES -7 (3.16cm).

4.2.6 Days to first flowering

Days to first flowering were recorded the minimum in genotype 2015/OKYVRES-5 (38.67 days). While, the genotype 2014/OKYVRES -11 required the maximum days (42.67) for first flowering. The average days for first flowering were 40.74 and it ranged from 38.67 to 42.67 days.

4.2.7 Days to 50 per cent flowering

Early 50 per cent flowering was recorded minimum in genotype 2015/OKYVRES-5 (43.00 days), while the genotype 2014/OKYVRES -11 was required the maximum (47.00 days) for 50 per cent flowering. The average days for 50 per cent flowering were 44.85 and it ranged from 43.00 to 47.00 days.

4.2.8 Days to first picking

Days to first picking were recorded the minimum in genotype 2015/OKYVRES-5 (45.00 days). While, the genotype 2014/OKYVRES -11 was required the maximum days (49.00 days) for first picking. The average days for first picking were 46.65 days and it ranged from 45.00 to 49.00 days.

4.2.9 Fruiting span

The mean for fruiting span was 56.35 days and it ranged from 54.00 to 58.00 days. The Maximum span (58.00 Days) of fruiting period was observed in 2015/OKYVRES-5. However, the minimum fruiting span was recorded in 2014/OKYVRES -11 (54.00 days).

Table 4.2b: Mean Performance of Morphological Parameters of Okra

Genotypes	No. of leaves/ plant			No. of nodes to 1 st flowering	Length of internodes (cm)
	30DAS	60DAS	90DAS		
2013/OKHYB -1	12.10	22.86	31.58	5.67	8.35

2013/OKHYB -2	12.05	24.45	37.23	4.47	9.67
2014/OKHYB -2	12.13	26.90	38.91	5.13	6.80
2014/OKHYB -3	9.84	25.54	38.32	4.27	6.98
2014/OKHYB -4	10.78	26.40	38.84	4.60	9.16
2014/OKHYB -5	10.24	19.79	29.91	4.80	6.75
2014/OKHYB -6	12.16	27.46	41.32	4.33	7.19
2014/OKHYB -8	10.69	20.36	33.36	5.00	5.90
2014/OKYVRES -1	12.91	29.70	43.32	4.47	4.17
2014/OKYVRES -2	10.24	25.29	40.16	4.27	8.99
2014/OKYVRES -3	12.18	23.37	37.23	5.27	5.48
2014/OKYVRES -4	11.45	25.62	42.52	4.73	6.07
2014/OKYVRES -6	11.04	25.70	43.09	4.80	6.62
2014/OKYVRES -7	12.71	28.91	41.39	4.40	3.16
2014/OKYVRES -8	10.68	24.40	31.43	4.67	6.34
2014/OKYVRES -9	11.01	25.86	31.54	4.33	8.99
2014/OKYVRES -11	11.57	25.12	32.20	5.67	7.63
2015/OKYVRES-1	9.88	20.32	28.07	4.40	5.38
2015/OKYVRES-2	10.59	22.34	31.81	4.53	8.32
2015/OKYVRES-3	11.97	23.00	34.30	4.40	6.27
2015/OKYVRES-4	10.90	20.74	31.92	4.87	4.71
2015/OKYVRES-5	10.73	27.90	39.54	3.87	3.38
Arka Anamika	11.46	25.78	39.46	5.33	5.08
Arka Abhay	9.58	18.31	26.97	5.40	5.68
S.Em±	0.43	1.52	1.53	0.22	0.69
C.D.5% level	1.24	4.34	4.39	0.63	1.99

Table 4.2c: Mean Performance of Phenological Parameters of Okra

Genotypes	Days to 1st flowering	Days to 50% flowering	Days to 1st picking	Fruiting span
2013/OKHYB -1	42.00	46.00	47.67	55.33
2013/OKHYB -2	39.67	44.00	46.00	57.00
2014/OKHYB -2	41.33	45.33	47.67	55.33
2014/OKHYB -3	40.00	44.00	45.67	57.33

2014/OKHYB -4	42.00	46.00	47.33	55.67
2014/OKHYB -5	41.67	45.33	47.00	56.00
2014/OKHYB -6	40.00	44.67	45.67	57.33
2014/OKHYB -8	40.33	44.00	45.33	57.67
2014/OKYVRES -1	39.67	43.00	46.00	57.00
2014/OKYVRES -2	39.67	44.00	45.33	57.67
2014/OKYVRES -3	41.67	45.00	46.33	56.67
2014/OKYVRES -4	40.67	46.67	48.33	54.67
2014/OKYVRES -6	41.67	46.00	48.33	54.67
2014/OKYVRES -7	40.00	44.00	45.33	57.67
2014/OKYVRES -8	39.33	43.00	45.33	57.67
2014/OKYVRES -9	39.00	43.00	45.33	57.67
2014/OKYVRES -11	42.67	47.00	49.00	54.00
2015/OKYVRES-1	41.67	45.67	46.67	56.33
2015/OKYVRES-2	41.00	44.00	46.33	56.67
2015/OKYVRES-3	40.33	44.00	46.00	57.00
2015/OKYVRES-4	42.00	45.67	47.67	55.33
2015/OKYVRES-5	38.67	43.00	45.00	58.00
Arka Anamika	41.00	46.33	48.33	54.67
Arka Abhay	41.00	46.67	48.00	55.00
S.Em±	0.63	0.69	0.72	0.72
C.D.5% level	1.80	1.99	2.07	2.07

4.2.10 Fruit length (cm)

The fruit length varied from 11.27 to 16.33 cm with a mean value of 13.57 cm. Genotypes 2014/OKYVRES-1 produced the longest fruit (16.33 cm). While, Arka Abhay produced the smallest fruit (11.27 cm).

4.2.11 Fruit width (cm)

Fruit width ranged from 1.67 to 2.22 cm, and the average was calculated to be 1.81 cm. Fruit width was recorded the highest in genotype 2014/OKYVRES -1 (2.22cm) and it was recorded to be the least in Arka Abhay (1.67cm).

4.2.12 Fruit weight (g)

The heaviest mean of fruit was observed in genotype 2014/OKYVRES -1 (29.17gm) and it was the lightest in Arka Abhay (17.28gm). The weight of fruit lied between 17.28gm to 29.17 gm. While, the average fruit weight was 23.10 gm.

4.2.13 Number of fruits per plant

The maximum number of fruits per plant was observed in 2014/OKYVRES -1 (14.53). While, it was the minimum in genotype Arka Abhay (5.83). The average number of fruits per plant was 10.22 and it ranged from 5.33 to 14.53.

4.2.14 Fruit yield per plant (g)

The maximum fruit yield per plant was recorded in genotype 2014/OKYVRES -1 (292.17gm). Genotype Arka Abhay was the poorest yielder (118.60gm). The average yield per plant was 232.30 gm and it ranged from 118.60gm to 292.17gm.

Table 4.2d: Mean Performance of Fruit Characters of Okra

Genotypes	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Number of fruits per plant
2013/OKHYB -1	12.29	1.75	26.22	6.33
2013/OKHYB -2	13.39	1.85	23.48	11.53
2014/OKHYB -2	13.33	1.77	25.12	10.50
2014/OKHYB -3	14.07	1.70	25.28	11.07
2014/OKHYB -4	14.07	1.81	20.60	12.40
2014/OKHYB -5	13.89	1.76	23.52	11.60
2014/OKHYB -6	12.75	1.75	20.87	12.27

2014/OKHYB -8	13.74	1.68	24.51	11.00
2014/OKYVRES -1	16.33	2.22	29.17	14.53
2014/OKYVRES -2	15.63	1.84	19.55	12.47
2014/OKYVRES -3	12.21	1.71	22.53	7.33
2014/OKYVRES -4	15.18	1.68	27.61	9.97
2014/OKYVRES -6	14.96	1.86	23.70	11.13
2014/OKYVRES -7	13.04	1.78	22.72	8.80
2014/OKYVRES -8	13.30	1.81	21.44	9.17
2014/OKYVRES -9	14.08	1.78	19.22	11.67
2014/OKYVRES -11	14.18	1.89	24.11	8.87
2015/OKYVRES-1	12.63	1.72	23.57	11.00
2015/OKYVRES-2	15.47	1.92	21.51	13.27
2015/OKYVRES-3	12.98	1.84	23.84	11.50
2015/OKYVRES-4	11.83	1.83	23.23	9.87
2015/OKYVRES-5	12.93	1.87	26.32	6.80
Arka Anamika	12.09	1.85	18.93	6.37
Arka Abhay	11.27	1.67	17.28	5.83
S.Em±	0.62	0.05	1.14	0.80
C.D.5% level	1.77	0.15	3.26	2.31

4.2.16 Fruit yield per plot (kg)

Fruit yield per plot was observed significantly the maximum 11.62 kg/plot in the genotype 2014/OKYVRES -1. While, it was found lowest in Arka Abhay (4.66 kg). The fruit yield per plot varied from 4.66 kg to 11.62 kg with an average of 9.26 kg/plot.

4.2.17 Fruit yield per hectare (q)

The fruit yield in quintal per hectare varied from (64.73 to 161.28 q/ha and average yield in quintal per hectare was found to be 128.55 q/ha. The

maximum fruit yield per hectare was recorded in 2014/OKYVRES -1 (161.28 q/ha). However, it was found the minimum in Arka Abhay (64.73 q/ha).

4.3 Genetic variability

Estimation of component of genetic parameters of variation for fruit yield and its attributes exhibited a wide range for the characters studied (Table 4.3). The result indicated that the values of phenotypic variance and phenotypic coefficient of variations were of higher magnitude than that of genotypic variance and genotypic coefficient of variations for all the characters showing that the environment had an important role in influencing the expressions of the characters.

4.3.1 Coefficient of variations

Estimation of components of genetic parameters of variation for yield and its attributes exhibited a wide range of variation for the characters studies (Table 4.3). Results indicated that the value of phenotypic coefficient of variations were of higher in magnitude than that of genotypic coefficient of variation for all the characters showing that the environment had an important role in influencing the expression of the characters.

Table 4.2e: Mean Performance of Yields of Okra

Genotypes	Fruit yield / plant (g)	Fruit yield / plot (kg)	Fruit yield / hectare (q)
2013/OKHYB -1	183.93	7.290	101.19
2013/OKHYB -2	270.38	10.762	149.37
2014/OKHYB -2	262.25	10.530	146.16
2014/OKHYB -3	280.63	11.192	155.34
2014/OKHYB -4	253.53	10.088	140.03
2014/OKHYB -5	270.30	10.838	150.43
2014/OKHYB -6	258.83	10.287	142.78
2014/OKHYB -8	270.37	10.802	149.93

2014/OKYVRES -1	292.17	11.620	161.28
2014/OKYVRES -2	242.17	9.647	133.90
2014/OKYVRES -3	165.45	6.618	91.86
2014/OKYVRES -4	270.58	10.837	150.41
2014/OKYVRES -6	248.83	9.953	138.15
2014/OKYVRES -7	196.92	7.823	108.59
2014/OKYVRES -8	195.22	7.742	107.45
2014/OKYVRES -9	220.47	8.792	122.03
2014/OKYVRES -11	213.58	8.503	118.03
2015/OKYVRES-1	258.92	10.357	143.75
2015/OKYVRES-2	282.00	11.240	156.01
2015/OKYVRES-3	272.05	10.842	150.48
2015/OKYVRES-4	228.78	9.152	127.03
2015/OKYVRES-5	182.37	7.255	100.70
Arka Anamika	136.97	5.452	75.67
Arka Abhay	118.60	4.663	64.73
S.Em±	14.34	0.57	7.93
C.D.5% level	40.99	1.63	22.67

Table 4.3: Genetic Parameters in Okra

Character s		Grand Mean	Range		Coefficient of variations		Heritability % (BS)	GA as % of mean	
			Min.	Max.	Phenotypic	Genotypic			
Plant height (cm)	30 DAS	26.43	22.71	31.57	10.16	7.18	49.98	2.76	10.46
	60 DAS	123.37	70.29	150.44	16.73	11.48	47.12	20.03	16.24
	90 DAS	174.95	108.47	215.99	14.53	12.05	68.78	36.03	20.59
No. of branches / plant	60 DAS	1.68			16.45	11.11	45.62		
	90 DAS	3.44	1.27	2.00	17.56	12.26	48.73	0.26	15.44
No. of leaves / plant	30 DAS	11.20			9.93	7.32	64.82		
	60 DAS	24.42	9.58	12.91	15.05	10.49	48.61	1.25	11.13
	90 DAS	36.02	18.31	29.70	15.09	13.16	76.02	3.68	15.08
			26.97	43.32	15.09	13.16	76.02	8.51	23.63
No. of nodes to 1 st flowering	4.74		3.87	5.67	31.22	25.13		2.73	57.57
Length of internodes (cm)	6.54		3.16	9.67	11.97	8.80		0.63	9.66
Days to 1 st flowering	40.74		38.67	42.67	3.45	2.17		1.15	2.82
Days to 50% flowering	44.85		43.00	47.00	3.61	2.40		1.48	3.29
Days to 1 st picking	46.65		45.00	49.00	3.42	2.10		1.25	2.67
Fruiting	56.35		54.00	58.00	2.83	1.74		1.25	2.21

span							
Fruit length (cm)	13.57	11.27	18.33	11.48	8.29	1.67	12.33
Fruit width (cm)	1.81	1.67	2.22	7.61	5.49	0.15	8.15
Fruit weight (g)	23.10	17.28	29.17	14.17	11.28	4.28	18.51
Number of fruits per plant	10.22	5.33	14.53	25.53	21.53	3.82	37.42
Fruit yield /plant (g)	232.30	118.60	292.17	22.49	19.79	83.33	35.87
Fruit yield /plot (kg)	9.26	4.66	11.62	22.65	19.97	3.36	36.28
Fruit yield /ha (q)	128.55	64.73	161.28	22.65	19.97	46.63	36.27

4.3.1.2 Genotypic coefficient of variation

It is revealed from the Table 4.3 that genotypic coefficient of variation varied from 1.74% for fruiting span to 25.13% for number of nodes to first flowering.

The highest genotypic coefficient of variation was noted for number of nodes to first flowering (25.13%) and number of fruits per plant (21.53%), fruiting span (1.74%), days to first picking (2.10%), days to first flowering (2.17%), days to 50% flowering (2.40%), fruit width (5.49%), plant height at 30 DAS (7.18%), number of leaves per plant at 30 DAS (7.32%), fruit length (8.29%) and length of internodes (8.80%), showed lowest genotypic coefficient of variation. While it was moderate for rest of the characters such as fruit yield per plot (19.97%), fruit yield per ha (19.97%), fruit yield per plant (19.79%), number of leaves per plant at 90 DAS (13.16%), number of branches per plant at 90 DAS (12.26%), plant height at 90 DAS (12.05%), plant height at 60 DAS (11.48%), fruit weight (11.28%), number of branches per plant at 60 DAS (11.11%) and number of leaves per plant at 60 DAS (10.49%).

4.3.3 Heritability

The heritability (BS) was computed for each of the characters by the variance components for estimating their relative magnitudes of genotypic and phenotypic variability contributed through environmental factors. The estimates of heritability (BS) for all the characters (Table 4.3) have been discussed as follows. It was partitioned as very high (above 90%), high (70-90%), medium (50-70%) and low (less than 50%).

The result indicated that the heritability estimates were observed high for fruit yield per plot (77.73%), fruit yield per ha (77.73%), followed by fruit yield per plant (77.40%), number of leaves per plant at 90 DAS (76.02%) and number of fruits per plant (71.14%). Medium for plant height at 90 DAS (68.78%) followed by number of leaves per plant at 30 DAS (64.82%), number of nodes to first flowering (64.82%), fruit weight (63.41%), length of internodes (54.08%), fruit length (52.13%) and fruit width (52.05%). Low estimation of heritability was recorded for plant height at 30 DAS (49.98%) followed by number of branches per plant at 90 DAS (48.73%), number of

leaves per plant at 60 DAS (48.61%), plant height at 60 DAS (47.12%), days to 50% flowering (44.22%), days to first flowering (39.57%), days to first picking (37.87%) and fruiting span (37.87%).

4.3.4 Genetic advance

Based on the estimate of heritability (BS) expected genetic advance was computed on the hypothetical selection at 5 per cent the best individual ($K= 2.06$). Due to masking influence of environment upon characters concerned, values of genetic advance exhibited high fluctuations. Therefore, to attain relative comparison of the characters in relation to environment, genetic advance as percentage of mean was calculated to predict the genetic gain (Table 4.3).

Genetic advance as percentage of mean ranged between 2.21% for fruiting span to 57.57% for number of nodes to first flowering. The highest estimate of genetic advance as percentage of mean was recorded for number of nodes to first flowering (57.57%), number of fruits per plant (37.42%), fruit yield per plot (36.28%), fruit yield per hectare (36.27%) and fruit yield per plant (35.87%).

Number of leaves per plant at 90 DAS (23.63%), plant height at 90 DAS (20.59%), fruit weight (18.51%), number of branches per plant at 90 DAS (17.66%), plant height at 60 DAS (16.24%), number of branches per plant at 60 DAS (15.44%), number of leaves per plant at 60 DAS (15.08%), fruit length (12.33%), number of leaves per plant at 30 DAS (11.13%) and plant height at 30 DAS (10.46%) showed moderate value of genetic advance as percentage of mean. Whereas, low estimates were observed for length of internodes (9.66%), fruit width (8.15%), days to 50% flowering (3.29%), days to first flowering (2.82%), days to first picking (2.67%) and fruiting span (2.21%).

4.4 Correlation coefficient analysis

Correlation coefficient was worked out at phenotypic, genotypic and environmental levels for all possible combination of yield and its attributing characters (Table 4.4). Results indicated that in general genotypic correlation coefficient, were of higher magnitude than the corresponding phenotypic correlation coefficient for all the characters.

The results of phenotypic correlation coefficients have been discussed only as the genotypic and environmental correlation were mostly influenced by the environmental conditions, hence phenotypic correlation will give the correct idea about the association between two variables.

4.4.1 Plant height (cm)

Plant height at 90 DAS was recorded highly significant and positive association with number of leaves per plant at 90 DAS (0.342) and length of internodes (0.304). Whereas, highly significant and negative association with number of branches per plant at 90 DAS (-0.362).

4.4.2 Number of branches per plant

Association of number of branches per plant at 90 DAS was recorded significant and negative with length of internodes (-0.546) and fruit width (-0.342).

4.4.3 Number of nodes to first flowering

Association of number of nodes to first flowering was recorded significant and positive with days to first flowering (0.276), days to 50% flowering (0.245) and day to first picking (0.248). While it was found significant and negative with fruiting span (-0.248), fruit width (-0.248) and fruit yield per plant (-0.243).

4.4.4 Length of internodes

Length of internodes recorded significant and positive with fruit width (0.352).

4.4.5 Days to first flowering

Association of days to first flowering was exhibited significant and positive with days to 50% flowering (0.463) and days to first picking (0.538). While, it was found significant and negative with fruiting span (-0.538) and fruit length (-0.240).

4.4.6 Days to 50 % flowering

Days to 50 % flowering was recorded highly significant and positive association with days to first picking (0.675) and it was found significant and negative association with fruiting span (-0.675).

4.4.7 Fruit length

Fruit length expressed significant and positive correlation with number of fruits per plant (0.318) and fruit yield per plant (0.243).

4.4.8 Fruit weight

Fruit weight expressed significant and negative correlation with number of fruits per plant (-0.345).

4.4.9 Number of fruits per plant

The correlation coefficient of number of fruits per plant was found to be significant and it was positively correlated with fruit yield per plant (0.778).

4.5 Path coefficient analysis

To measure the direct as well as indirect association of one variable (cause) through another on the end product (effect). Path coefficient was calculated at genotypic and phenotypic level for all the yield attributing traits. The observed correlation coefficients of fruit yield with its contributing traits were partitioned into direct and indirect effects. In the present investigation, important characters viz., fruit yield per plant has been used as dependent variable. Since, the value of genotypic path is more reliable in predicting the correct idea about the direct and indirect effect of the component traits, only this has been discussed below.

The estimates of path coefficient are furnished in the table 4.5 and 4.6. In general, the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects are presented as under.

Table 4.4: Estimates of Genotypic and Phenotypic Correlation Coefficients among Fruit Yield and its Attributing Traits in Okra

Characters		No. of branches / plant 90 DAS	No. of leaves / plant 90 DAS	No. of nodes to 1 st flowering	Length of internodes (cm)	Days to 1 st flowering	Days to 50% flowering	Days to 1 st picking	Fruiting span	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of fruits /plant	Fruit yield /plant (g)
Plant height (cm) 90 DAS	G	-0.580	0.462	0.268	0.473	-0.103	0.036	0.064	-0.064	0.315	0.286	-0.058	0.080	0.074
	P	-0.362**	0.342*	0.190	0.304**	0.024	0.115	0.181	-0.181	0.173	0.078	0.004	0.109	0.063
No. of branches / plant 90 DAS	G	1	-0.070	0.349	-0.935	0.190	0.027	0.020	-0.020	-0.212	0.009	0.126	-0.269	-0.217
	P		-0.049	0.117	-0.546**	-0.065	-0.024	-0.135	0.135	-0.129	-0.342**	0.116	-0.179	-0.098
No. of leaves / plant 90 DAS	G		1	0.027	-0.253	0.002	0.319	0.341	-0.341	0.196	0.013	-0.265	0.172	0.057
	P			0.094	-0.134	0.018	0.210	0.124	-0.124	0.150	0.015	-0.157	0.161	0.055
No. of nodes to 1 st flowering	G			1	-0.009	0.663	0.585	0.667	-0.667	-0.091	-0.231	0.214	-0.525	-0.431
	P				-0.007	0.276*	0.245*	0.248*	-0.248*	0.079	-0.248*	0.153	-0.262*	-0.243*
Length of internodes (cm)	G				1	-0.080	0.014	0.015	-0.015	0.182	0.516	0.143	0.138	0.148
	P					0.014	-0.014	-0.007	0.007	0.186	0.352**	0.109	0.069	0.159
Days to 1 st flowering	G					1	0.196	0.974	-0.974	-0.614	-0.158	-0.051	-0.287	-0.346

	P						0.463**	0.538**	-0.538**	-0.240*	-0.183	0.118	-0.161	-0.194
Days to 50% flowering	G						1	0.210	-0.210	-0.201	-0.289	0.059	-0.309	-0.317
	P							0.675**	-0.675**	-0.101	-0.161	0.022	-0.151	-0.188
Days to 1 st picking	G							1	-0.009	-0.063	-0.117	0.018	-0.242	-0.245
	P								-0.015	-0.090	-0.126	0.123	-0.160	-0.184
Fruiting span	G								1	0.063	0.117	-0.018	0.242	0.245
	P									0.090	0.126	-0.123	0.160	0.184
Fruit length (cm)	G									1	0.463	-0.242	0.515	0.436
	P										0.190	-0.128	0.318**	0.243*
Fruit width (cm)	G											-0.430	0.338	0.037
	P											-0.189	0.177	0.068
Fruit weight (g)	G												-0.477	0.131
	P												-0.345**	0.145
No. of fruits /plant	G													0.862
	P													0.778*

Significant at 5% level = *

Significant at 1% level = **

4.5.1 Direct effect

Path coefficient analysis of different characters contributing towards fruit yield per plant showed that number of fruits per plant (1.2408) had highest positive direct effect followed by fruit weight (0.6136), number of nodes to first flowering (0.1246), number of branches per plant at 90 DAS (0.1042), length of internodes (0.0899), number of leaves per plant at 90 DAS (0.0787), plant height at 90 DAS (0.0191) and fruiting span (0.0127).

Whereas, fruit width (-0.1689) had the highest negative direct effect on fruit yield per plant followed by days to 50% flowering (-0.1131), days to first flowering (-0.0578), fruit length (-0.0406) and days to first picking (0.0127).

4.5.2 Indirect effect

4.5.2.1 Plant height (cm)

Plant height at 90 DAS imparted the highest positive indirect effect on fruit yield per plant via number of fruits per plant (0.0993), length of internodes (0.0425), number of leaves per plant at 90 DAS (0.0363), and number of nodes to first flowering (0.0334). However, indirect effect was negative via number of branches per plant at 90 DAS (-0.0604), fruit width (-0.0483), fruit weight (-0.0358) and fruit length (0.0128).

4.5.2.2 Number of branches per plant

Number of branches at 90 DAS was recorded to have positive indirect effect on fruit yield per plant through fruit weight (0.0775) and number of nodes to first flowering (0.0435). However, negative indirect effect was expressed via number of fruits per plant (-0.3336), length of internodes (-0.0841), plant height (-0.0111) and days to first flowering (-0.0110).

4.5.2.3 Number of leaves per plant

Number of leaves per plant at 90 DAS was recorded to have positive indirect effect on fruit yield per plant through number of fruit per plant (0.2136). However, negative indirect effect was expressed via fruit weight (-0.01627), days to 50% flowering (-0.0361) and number of length of internodes (-0.0227).

4.5.2.4 Number of nodes to first flowering

Number of nodes to first flowering revealed that high value of positive indirect effect on fruit yield per plant through fruit weight (0.1313), fruit width (0.0390) and number of branches per plant at 90 DAS (0.0364). While, negative indirect effect was exhibited in the character i.e. number of fruit per plant (-0.6511), days to 50% flowering (-0.0662) and days to first flowering (-0.0383).

4.5.2.5 Length of internodes

Length of internodes exhibited significant positive indirect effect via number of fruits of per plant (0.1718) and fruit weight (0.0880). Negative indirect effect was observed through number of branches per plant at 90 DAS (-0.0975), fruit width (-0.0872) and number of leaves of per plant at 90 DAS (-0.0199).

4.5.2.9 Fruiting span

Fruiting span manifested the highest positive indirect effect on fruit yield per plant through number of fruits per plant (0.3000), days to first flowering (0.0563) and days to 50% flowering (0.238). However, rest of characters showed negative indirect effect was recorded in the character viz., number of nodes to first flowering (0.0831), number of leaves per plant at 90 DAS (-0.0269), fruit width (-0.0197) and fruit weight (-0.0112).

4.5.2.10 Fruit length

Length of fruit revealed positive indirect effect on fruit yield per plant through number of fruits per plant (0.6393), days to 50% flowering (0.0228) length of internodes (0.0163) and number of leaves per plant at 90 DAS (0.0154). However, the remaining character showed negative indirect effect via, fruit weight (-0.1487), fruit width (-0.0782), number of branches per plant at 90 DAS (-0.0221) and number of nodes to first flowering (-0.0113).

Table 4.5: Genotypic Path Coefficients Showing Direct and Indirect Effects of Different Characters on Fruit Yield per Plant (g) in Okra

Characters	Plant height (cm) 90 DAS	No. of branches / plant 90 DAS	No. of leaves / plant 90 DAS	No. of nodes to 1 st flowering	Days to 1 st flowering	Days to 1 st picking	Fruiting span	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of fruits /plant	"r" value Fruit yield /plant (g)
Plant height (cm) 90 DAS	0.0191	-0.0604	0.0363	0.0334	0.0060	-0.0008	-0.0008	-0.0128	0.0483	-0.0358	0.0993	0.074
No. of branches / plant 90 DAS	-0.0111	0.1042	-0.0055	0.0435	-0.0110	-0.0003	-0.0003	0.0086	0.0015	0.0775	-0.3336	-0.217
No. of leaves / plant 90 DAS	0.0088	-0.0073	0.0787	0.0034	-0.0001	-0.0043	-0.0043	-0.0079	0.0022	-0.1627	0.2136	0.057
No. of nodes to 1 st flowering	0.0051	0.0364	0.0021	0.1246	-0.0383	-0.0084	-0.0084	0.0037	0.0390	0.1313	-0.6511	-0.431
Length of internodes (cm)	0.0090	-0.0975	-0.0199	-0.0011	0.0046	-0.0002	-0.0002	-0.0074	0.0088	0.0880	0.1718	0.148
Days to 1 st flowering	-0.0020	0.0198	0.0002	0.0826	-0.0578	-0.0123	-0.0123	0.0249	0.0267	-0.0310	-0.3558	-0.346
Days to 50% flowering	0.0007	0.0028	0.0251	0.0729	-0.0113	-0.0027	-0.0027	0.0082	0.0488	0.0364	-0.3833	-0.317
Days to 1 st picking	0.0012	0.0021	0.0269	0.0831	-0.0563	-0.0127	-0.0001	0.0025	0.0197	0.0112	-0.3000	-0.245

Fruiting span	-0.0012	-0.0021	-0.0269	-0.0831	0.0563	0.0001	0.0127	-0.0025	-0.0112	0.3000	0.245
Fruit length (cm)	0.0060	-0.0221	0.0154	-0.0113	0.0355	0.0008	0.0008	-0.0406	-0.1487	0.6393	0.436
Fruit width (cm)	0.0055	0.0009	0.0010	-0.0288	0.0091	0.0015	0.0015	-0.0188	-0.2639	0.4188	0.037
Fruit weight (g)	-0.0011	0.0132	-0.0209	0.0267	0.0029	-0.0002	-0.0002	0.0098	0.6136	-0.5913	0.131
No. of fruits /plant	0.0015	-0.0280	0.0135	-0.0654	0.0166	0.0031	0.0031	-0.0209	-0.2924	1.2408	0.862

Residual effect Genotypic = -0.3618

Table 4.6: Phenotypic Path Coefficients Showing Direct and Indirect Effects of Different Characters on Fruit Yield per Plant (g)

in okra

Characters	Plant height (cm) 90 DAS	No. of branches / plant 90 DAS	No. of leaves / plant 90 DAS	No. of nodes to 1 st flowering	Length of internodes (cm)	Days to 1 st flowering	Days to 1 st picking	Fruiting span	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of fruits /plant	"r" value Fruit yield /plant (g)
Plant height (cm) 90 DAS	-0.0285	0.0697	0.0024	-0.0499	-0.0095	-0.0026	-0.0148	-0.0148	0.0409	-0.0171	0.0020	0.0942	0.063
No. of branches / plant 90 DAS	0.0103	-0.1924	-0.0003	-0.0307	0.0170	0.0070	0.0111	0.0111	0.0305	0.0752	0.0603	-0.1544	-0.098
No. of leaves / plant 90 DAS	-0.0097	0.0094	0.0070	-0.0247	0.0042	-0.0019	-0.0102	-0.0102	0.0354	-0.0032	-0.0811	0.1393	0.055

							6							
No. of nodes to 1 st flowering	-0.0054	-0.0225	0.0007	-0.2627	0.0002	-0.0299	0	-0.0203	-0.0203	0.0546	0.0793	-0.2264	-0.243	
Length of internodes (cm)	-0.0087	0.1050	-0.0009	0.0017	-0.0311	-0.0015	2	0.0005	0.0005	-0.0773	0.0567	0.0597	0.159	
Days to 1 st flowering	-0.0007	0.0124	0.0001	-0.0725	-0.0004	-0.1082	5	-0.0441	-0.0441	0.0402	0.0612	-0.1395	-0.194	
Days to 50% flowering	-0.0033	0.0047	0.0015	-0.0644	0.0004	-0.0501	3	-0.0554	-0.0554	0.0354	0.0116	-0.1304	-0.188	
Days to 1 st picking	-0.0052	0.0260	0.0009	-0.0651	0.0002	-0.0582	8	-0.0820	-0.0012	0.0277	0.0638	-0.1386	-0.184	
Fruiting span	0.0052	-0.0260	-0.0009	0.0651	-0.0002	0.0582	3	0.0012	0.0821	-0.0277	-0.0638	0.1386	0.184	
Fruit length (cm)	-0.0049	0.0248	0.0010	-0.0208	-0.0058	0.0259	0	0.0074	0.0074	-0.0417	-0.0666	0.2745	0.243	

							0 0 1 2			3 5 9				
Fruit width (cm)	-0.0022	0.0658	0.0001	0.0653	-0.0109	0.0198	0	0.0104	0.0103	8	-0.2196	-0.0979	0.1533	0.068
Fruit weight (g)	-0.0001	-0.0223	-0.0011	-0.0402	-0.0034	-0.0128	0	-0.0101	-0.0101	3	0.0415	0.5182	-0.2984	0.145
No. of fruits /plant	-0.0031	0.0344	0.0011	0.0688	-0.0021	0.0175	0	0.0132	0.0131	0	-0.0389	-0.1790	0.8639	0.778

Residual effect Phenotypic = 0.2917

4.5.2.11 Fruit width

Fruit width exhibited significant positive indirect effect on fruit yield per plant through number of fruits per plant (0.4188), length of internodes (0.0464) and number of days to 50% flowering (0.0327). However, negative indirect effect observed through fruit weight (-0.2369), number of nodes to first flowering (-0.0288) and fruit length (-0.0188).

4.5.2.12 Fruit weight

Fruit weight manifested positive indirect effect on fruit yield per plant through fruit width (0.0726), length of number of branches per plant at 90 DAS (0.0132) and length of internodes (0.0129). However, rest of character showed negative indirect effect via, number of fruit per plant (-0.5913) and number of leaves per plant at 90 DAS (-0.0209).

4.5.2.13 Number of fruits per plant

Number of fruits per plant revealed positive indirect effect on fruit yield per plant due to days to 50% flowering (0.0349), days to first flowering (0.0166) and length of internodes (0.0124). However, rest characters showed negative indirect effect via, fruit weight (-0.2924), number of nodes to first flowering (-0.0654) and number of branches per plant at 90 DAS (-0.0280).

4.6. Other fruit characters

4.6.1. Fruit colour and fruit surface

The fruit colour was observed as dark green, green and light green and fruit surface was recorded as non hairy and hairy. The result obtained by visual observation is depicted in Table 4.2f.

4.6.2. Incidence of YVMV (%)

Incidence of YVMV ranged between 0.0 to 17.50% and 0.0 to 39.17% with an average performance of 1.68 and 3.44 at 60 and 90 DAS respectively. The maximum 17.50% and 39.17% Incidence of YVMV was recorded in genotype Arka Abhay at 60 and 90 DAS respectively, while it was recorded the minimum (0.0%) in genotypes (2013/OKHYB-2, 2014/OKHYB-4, 2014/OKHYB-5, 2014/OKHYB-6, 2014/OKHYB-8, 2014/OKYVRES-4, 2014/OKYVRES-6, 2014/OKYVRES-7, 2014/OKYVRES-11 and 2015/OKYVRES-3) and (2014/OKHYB-4, 2014/OKHYB-5, 2014/OKHYB-6, 2014/OKHYB-8, 2014/OKYVRES-4 and 2014/OKYVRES-7) at 60 and 90 DAS respectively.

Table 4.7: Mean Performance of Incidence of YVMV (%) and Fruit Characters of Okra

Genotypes	Incidence of YVMV (%)		Fruit colour	Fruit surface
	30DAS	60DAS		
2013/OKHYB -1	1.67	5.83	Green	Hairy
2013/OKHYB -2	0.00	0.83	Dark Green	Hairy
2014/OKHYB -2	1.67	5.00	Green	Hairy
2014/OKHYB -3	0.83	2.50	Light Green	Non hairy
2014/OKHYB -4	0.00	0.00	Green	Hairy
2014/OKHYB -5	0.00	0.00	Green	Non hairy
2014/OKHYB -6	0.00	0.00	Green	Hairy
2014/OKHYB -8	0.00	0.00	Green	Hairy
2014/OKYVRES -1	3.33	10.83	Light Green	Non hairy
2014/OKYVRES -2	5.00	13.33	Light Green	Non hairy
2014/OKYVRES -3	2.50	8.33	Dark Green	Non hairy
2014/OKYVRES -4	0.00	0.00	Dark Green	Non hairy
2014/OKYVRES -6	0.00	1.67	Dark Green	Non hairy
2014/OKYVRES -7	0.00	0.00	Light Green	Non Hairy
2014/OKYVRES -8	8.33	20.00	Dark Green	Non hairy
2014/OKYVRES -9	5.00	15.00	Green	Non hairy
2014/OKYVRES -11	0.00	2.50	Green	Non hairy
2015/OKYVRES-1	4.17	13.33	Light Green	Non hairy
2015/OKYVRES-2	2.50	7.50	Green	Non hairy
2015/OKYVRES-3	0.00	0.83	Green	Non hairy
2015/OKYVRES-4	2.50	6.67	Green	Non hairy
2015/OKYVRES-5	6.67	15.70	Green	Non hairy
Arka Anamika	9.17	15.00	Green	Non hairy
Arka Abhay	17.50	39.17	Light Green	Non hairy
S.Em±	2.01	4.46		
C.D.5% level	5.76	12.75		

DISCUSSION

The experimental findings of the present investigation “Studies on Genetic Variability, Correlation and Path Coefficient Analysis in Okra [*Abelmoschus esculentus* (L.) Moench]” have been discussed on the following heads in the light of the available literature.

5.1 Analysis of variance

5.2 Genetic Variability

5.2.1 Range and Mean Performance

5.2.2 Coefficient of variation

5.2.3 Heritability

5.2.4 Genetic advance

5.3 Correlation Coefficient analysais

5.4 Path coefficient analysais

5.5 Other parameters

5.1 Analysis of variance

The main objective of the present investigation was to study the diversity present in twenty four genotypes of okra. The estimates of mean sum of squares due to genotypes were highly significant for all the characters (Table 4.1), indicating the presence of genetic diversity in the existing material. The findings of Verma *et al.* (2004), Manivannan *et al.* (2007), Naidu *et al.* (2007), Jindal *et al.* (2009), Saifullah and Rabbani (2009), Shantha kumar and Salimath (2010), Prashant Kumar *et al.* (2011), Senapati *et al.* (2011) and Singh and Jain (2012) are similar to that of the present findings.

5.2 Genetic variability

5.2.1 Mean performance of the genotypes

The mean performance of the genotypes (Table 4.2 a,b,c,d and e) revealed a wide range of variability for all the traits. The variation was the highest for fruit yield per plant (g) (118.60-292.17) followed by plant height at 90DAS (108.47-215.99), fruit yield per ha (q) (64.73-161.28) and plant height at 60 DAS (70.29-150.44). The findings were quite similar to as reported by Hazara and basu (2000),

Naidu et al. (2007). Somashekhar and Salimath (2011) for fruit yield per plant, Hamed et al. (2003), Bendale et al. (2003), Naidu et al. (2007) for fruit yield per plant, plant height and fruiting span Senapati et al. (2011) for fruit yield per hectare and plant height and Jain (2012) and Mishra and Senapati (2015) and Singh (1986) for plant height .

5.2.2 Coefficient of variation

In the present findings, phenotypic coefficient of variation were observed to be higher than the corresponding genotypic coefficient of variation for all the characters studied. However, the differences were narrow which implied their relative resistance to environmental variation. It is also described that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively on the basis of phenotypic performance. The findings of Bendale et al. (2003), Senapati et al. (2011)), Mihretu et al. (2014) are similar to that of the present findings.

5.2.2.1 Phenotypic coefficient of variations

The phenotypic coefficient of variation ranged from 2.83 for fruiting span to 31.22 % for number of nodes to first flowering. The phenotypic coefficient of variations was the highest for characters viz., number of nodes to first flowering, number of fruits per plant, fruit yield per plot and fruit yield per ha. The findings are in close harmony with the result of Bendale et al. (2003), Verma et al. (2004) for number of branches per plant, fruit yield per plant. Soma shekhar and Salimath (2011), Nwangburuka et al. (2012) for average fruit weight and fruit yield per plant. Prashant Kumar et al. (2011) for fruit yield per plant and Nagre et al. (2011) for yield per plant.

However, it was exhibited low for characters like fruiting span, days to first picking, days to first flowering, days to 50% flowering, nodes to fruit width and number of leaves per plant at 30 DAS. The findings are in close harmony with the result of Shantha kumar and Salimath (2010) for days to first flowering and fruit length. The rest of the characters such as plant height at 60 DAS, number of branches per plant 90 DAS, number of branches per plant 60 DAS, fruit length and plant height at 30 DAS exhibited moderate phenotypic coefficient of variation The findings of Hazra and Basu (2000) for plant height and Hazara and basu (2000) for leaves per plant was similar to the present finding.

5.2.2.2 Genotypic coefficient of variation

It is revealed from the Table 4.3 that genotypic coefficient of variation varied from 1.74% for fruiting span to 25.13% for number of nodes to first flowering.

High genotypic coefficient of variation was noted for number of nodes to first flowering and number of fruits per plant. The findings are in close harmony with the result of Ahemad et al. (2015) for number of branches at 90 DAS and Nwangburuka et al. (2012) and Hazara and Basu (2000) for fruit yield. The high values of GCV suggested greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection.

The highest genotypic coefficient of variation was noted for number of nodes to first flowering and number of fruits per plant. Fruiting span, days to first picking, days to first flowering, days to 50% flowering, fruit width, plant height at 30 DAS, number of leaves per plant at 30 DAS, fruit length and length of internodes, showed the lowest genotypic coefficient of variation. The finding of Shantha kumar and Salimath (2010) for days to first flowering was similar to the present finding which indicated that there is limited scope for improvement. While, it was moderate for rest of the characters such as fruit yield per plot, fruit yield per ha, fruit yield per plant, number of leaves per plant at 90 DAS, number of branches per plant at 90 DAS, plant height at 90 DAS, plant height at 60 DAS, fruit weight, number of branches per plant at 60 DAS and number of leaves per plant at 60 DAS. The finding of Hazra and Basu (2000) for plant height and fruits per plant was similar to the present finding.

5.2.3 Heritability and Genetic advance

Heritability which denotes the proportion of genetically controlled variability expressed by a programme for a particular character or a set of character is very important biometrical tool for guiding plant breeders for adoption of appropriate breeding procedures. High heritability in broad sense is helpful in identifying appropriate character for selection and enables the breeder to select superior genotypes on the basis of phenotypic expression of quantitative characters. The estimated values of heritability in broad sense were classified as very high (above 90%), high (70-90%), medium (50-70%) and low (less than 50%).

Result indicated that the heritability estimates were observed high for fruit yield per plot, fruit yield per ha, followed by fruit yield per plant, number of leaves per plant at 90 DAS and number of fruits per plant. The results were in

close proximation to that of Ahemad et al. (2015) for fruit yield per plant and Hazara and Basu (2000) and Nagre (2011) for number of leaves per plant.

Low estimation of heritability was recorded for plant height at 30 DAS followed by number of branches per plant at 90 DAS, number of leaves per plant at 60 DAS, plant height at 60 DAS, days to 50% flowering, days to first flowering, days to first picking and fruiting span. The results are in close proximation to that of Ahemad et al. (2015) for number of branches per plant at 90 DAS and Hazra and Basu (2000) for days to 50 per cent flowering and number of fruits per plant, Dhankar and Dhankar (2002) for number of fruits per plant and plant height.

5.2.4 Genetic advance

Heritability however, indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimates along with genetic gains are more effective and reliable in predicting the improvement through selection (Johnson et al., 1955). Estimates of genetic advance helps to predict the extent of improvement that can be achieved for improving the different characters. The estimated values of genetic advance as percent of mean are classified as high (more than 30%), moderate (10-30%) and low (less than 10%).

Genetic advance as percentage of mean ranged between 2.21% for fruiting span to 57.57% for number of nodes to first flowering. The highest estimate of genetic advance as percentage of mean was recorded for number of nodes to first flowering, number of fruits per plant, fruit yield per plot, fruit yield per hectare and fruit yield per plant. The results are in consonance with Dhankar and Dhankar (2002) and Nagre et al. (2011) and Nwangburuka et al. (2012) for yield per plant.

Number of leaves per plant at 90 DAS, plant height at 90 DAS, fruit weight, number of branches per plant at 90 DAS, plant height at 60 DAS, number of branches per plant at 60 DAS, number of leaves per plant at 60 DAS, fruit length, number of leaves per plant at 30 DAS and plant height at 30 DAS showed moderate value of genetic advance as percentage of mean. The results are in consonance with Dhankar and Dhankar (2002), Sharma et al (2015) and Mishra et al. (2015) for plant height.

Whereas, low estimates were observed for length of internodes, fruit width, days to 50% flowering, days to first flowering, days to first picking and fruiting

span. The results are in consonance with Sharma and Prasad (2015) for days to 50% flowering and days to first picking.

High heritability coupled with high genetic advance for traits like fruit yield per plant, fruit yield per ha and number of fruits per plant suggested that the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions. The findings are in agreement to the findings of Das et al. (2011), Saifullah and Rabbani (2009), Verma et al. (2004), and Sharma et al. (2015).

High heritability supplemented with moderate genetic advances as percentage of mean is manifested by number of leaves per plant at 90 DAS. This might be attributed to additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about.

Low estimates of heritability coupled with low genetic advances as percentage have been displayed by days to first flowering, days to 50% flowering, days to first picking and fruiting span. It indicates that this character is highly influenced by environmental effects and consequently its selection would be ineffective.

5.3 Correlation coefficient analysis

A wide range of variation in quantitative characters provides the basis for selection in plant breeding programme. The knowledge of association among the characters is useful to the breeder for improving the efficiency of selection. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the component characters on which selection can be made for genetic improvement of yield. Investigation regarding the presence of component and nature of association among themselves is essential and pre-requisite for improvement in yield. Correlation coefficient provides a clear picture of the extent of association between a pair of traits and indicates whether simultaneous improvement of the correlated traits may be possible or not. The knowledge of genetic association between yield and its component characters help in improving the efficiency of selection for yield by making proper choice and balancing one component with another.

The magnitude of genotypic correlation has been found higher than the phenotypic correlation for all the traits that indicated inherent association between various characters. The findings are in agreement with the finding of Niranjana and

Mishra (2003), Kumar et al. (2009), Senapati et al. (2011) and Saryam et al. (2015).

5.3.1 Correlation between yield and its components

In the present findings significant positive phenotypic correlation of fruit yield per plant has been observed with number of fruits per plant and fruit length. The highest positive and significant correlation coefficient of fruit yield per plant has been noted with number of fruits per plant. Indicating that these character are the primary yield determination in okra. These findings corroborated with the earlier findings of Gandhi et. al. (2002), Nimbalkar et al. (2002), Niranjana and Mishra (2003) Jaiprakash Narayan and Mule (2004), Subrata et al.(2004), Bhalekar et al. (2005) , Ghosh (2005) Verma et al. (2007) and Saryam et al. (2015) for number of fruits per plant.

5.3.2 Correlation between yield contributing characters

5.3.2.1 Plant height (cm)

Plant height at 90 DAS was recorded highly significant and positive association with number of leaves per plant at 90 DAS and length of internodes. Whereas, highly significant and negative association with number of branches per plant at 90 DAS. These results are in corroborated with the findings of Shazia Ali et al. (2008), Koundiya et al. (2013) and Saryam et al. (2015) for length of internodes.

5.3.2.2 Number of branches per plant

Association of number of branches per plant at 90 DAS was recorded significant and negative with length of internodes and fruit width. These results are in close harmony with the findings of Saryam et al. (2015) for length of internodes and fruit width and Sharma and Prasad (2015) for fruit width.

5.3.2.3 Number of nodes to first flowering

Association of number of nodes to first flowering was recorded significant and positive with days to first flowering, days to 50% flowering and days to first picking. While it was found significant and negative with fruiting span, fruit width and fruit

yield per plant. These results are in close harmony with the findings of Mishra et al. (2015) for days to first flowering and days to 50% flowering and Saryam et al. (2015) for fruit width.

5.3.2.4 Length of internodes

Length of internodes recorded significant and positive with fruit width. It is closely similar to Verma et al. (2007).

5.3.2.4 Days to first flowering

Association of days to first flowering was exhibited significant and positive with days to 50% flowering and days to first picking. While, it was found significant and negative with fruiting span and fruit length. These results are closely similar with the finding of Das et al. (2014) for fruit length.

5.3.2.5 Days to 50 per cent flowering

Days to 50 % flowering was recorded highly significant and positive association with days to first picking and it was found significant and negative association with fruiting span. These findings corroborated the earlier finding of Mishra et al. (2015) for days to first picking and Mehta et al. (2006) for fruiting span.

5.3.2.6 Fruit length

Length expressed significant and positive correlation with number of fruits per plant and fruit yield per plant. These findings corroborated the earlier finding of Saryam et al. (2015) for number of fruits per plant and Ghosh (2005) for fruit yield per plant.

5.3.2.7 Fruit weight

Fruit weight expressed significant and negative correlation with number of fruits per plant. These findings corroborated the earlier findings of Niranjana and Mishra (2003), Bendale et al. (2003) and Kumar et al. (2011).

5.3.2.8 Number of fruits per plant

The correlation coefficient of number of fruits per plant was found to be significant and positive with fruit yield per plant. These findings corroborated the earlier finding of Mishra et al (2015).

5.4 Path coefficient analysis

Correlation coefficient is the indication of simple association between variables. In a biological system, the relationship may exist in a very complex form. It is, therefore, essential to study the relationship among variables in a comprehensive way. Path coefficient analysis is a powerful tool, which enables portioning of the given relationship in its further components. In other words, it takes into account not only the relationship of component characters with the dependent character, but simultaneously takes care of its relationship with other component also. Thus, it helps in understanding the casual system in a better way because it enables portioning the total correlation coefficient into direct and indirect effects of various characters.

In the present investigation, path coefficient analysis was carried out for characters under study using genotypic and phenotypic correlation coefficient and taking fruit yield per plant as dependent variable, in order to see the casual factor and so as to identify the components which are responsible for producing fruit yield per plant. In general, the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects indicating the masking effects of the environment.

Path coefficient analysis of different characters contributing towards fruit yield per plant showed that number of fruits per plant had the highest positive direct effect followed by fruit weight, number of nodes to first flowering, number of branches per plant at 90 DAS, length of internodes, number of leaves per plant at 90 DAS, plant height at 90 DAS and fruiting span. The results are in propinquity with Subrata et al. (2004), Sarkar and Madrep (2004), Magar et al. (2009), Ramanjinappa et al. (2011), Senapati et al. (2011), Sibsankar et al. (2012) and Gangashetti et al. (2013). Mehta et al. (2006) and Mihretu et al. (2014) for fruit weight and Saryam et al. (2015) for number of branches per plant. The character fruit yield per plant showed that number of fruits per plant had highest positive direct effect followed by fruit weight, number of nodes to first flowering, number of branches per plant at 90 DAS, length of internodes, number of leaves per plant at 90 DAS, plant height at 90 DAS and fruiting span had correlation coefficient value at par with direct effect on fruit yield per plant and direct selection for these traits would result in higher breeding efficiency for improving yield. Thus, these traits might be reckoned as the most important components traits for fruit yield per plant.

Whereas, fruit width had the highest negative direct effect on fruit yield per plant followed by days to 50% flowering, days to first flowering, fruit length and days to first picking. The results are in propinquity with Sharma and Prasad (2015) for days to first picking, Koundinya et al (2013) for days to 50% flowering and Sharyam et al. (2015) for fruit length.

An overall observation of path coefficient analysis of fruit yield per plant with its components (viz., number of fruits per plant, fruit weight, number of nodes to first flowering, number of branches per plant at 90 DAS, length of internodes, number of leaves per plant at 90 DAS, plant height at 90 DAS, fruiting span, days to 50% flowering, days to first flowering, fruit length and days to first picking) played an important role in determining the fruit yield per plant.

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

6.1 Summary

The present investigation “Genetic Variability, Correlation and Path Analysis in Okra” was carried out during kharif season of 2015-2016 at Horticulture Complex, Department of Horticulture, J.N.K.V.V., Jabalpur (M.P.). The experimental material for the present investigation was comprised of 24 genotypes of okra. These genotypes were sown in Randomized Complete Block Design with three replications. The observations were recorded on the basis of five random competitive plants selected from each genotype separately for morphological, phenological, yield and other parameters were evaluated as per standard procedure. The variance components and coefficient of variation were determined according to Burton (1952). The heritability (broad sense) and genetic advance was worked out by Hanson et al. (1956) and Johnson et al. (1955). Correlation coefficient and path coefficient analysis were computed by the formula suggested by Miller et al. (1958) and Wright (1921) Dewey and Lu (1959). On the basis of results, the present investigation is summarized as follows:

The estimates of mean sum of squares due to genotypes were highly significant for all the characters, indicating the presence of genetic diversity in the existing material.

The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was the highest for plant height at 90 DAS, followed by fruit yield per ha, fruit yield per plant and plant height at 60 DAS.

The present studies revealed that the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits, which might be due to interaction of the genotypes with the environment to some degree or other explaining environmental factors influencing the expression of these characters. High phenotypic and genotypic coefficient of variation was observed for number of nodes to first flowering followed by number of fruits per plant. The high values of GCV suggested greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. However, days taken to 50% flowering, days taken to first flowering, fruiting span, days taken to first picking, fruit width and leaves per plant 30 DAS showed low estimates of genotypic and phenotypic coefficient of variation, indicating the potential of heterosis breeding for their amelioration.

High estimates of heritability were obtained for the traits like yield per plot, fruit yield per ha, followed by fruit yield per plant, number of leaves per plant at 90 DAS and number of fruits per plant which indicated that the high values of broad sense heritability for these characters expressed that they were the least influenced by environmental modification. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable.

High heritability coupled with high genetic advance as percentage of mean for traits like fruit yield per plant, fruit yield per ha and number of fruits per plant, suggested that the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes, as these characters are governed by additive gene actions.

High heritability supplemented with moderate genetic advances as percentage of mean was manifested by number of leaves per plant at 90 DAS. This might be attributed to additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about.

Low estimates of heritability coupled with low genetic advances as percentage of mean were displayed by days taken to first flowering, days taken to 50% flowering, days taken to first picking and fruiting span that indicated that the characters were highly influenced by environmental effects and consequently its selection would be ineffective.

The genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic one, indicating there by strong inherent association between different traits studied. The phenotypic expression of correlation was lessened possibly due to multiple influences of environmental components. In view of their correspondence, selection on phenotypic basis would be effective.

The highest positive and significant correlation coefficient of fruit yield per plant was observed with number of fruits per plant and fruit length. The highest positive and significant correlation coefficient of fruit yield per plant has been noted with number of fruits per plant indicating that these characters are the primary yield determinant in okra. The yield attributing characters exhibited varying trend amongst them.

Plant height at 90 DAS was recorded highly significant and positive association with number of leaves per plant at 90 DAS and length of internodes.

Whereas, highly significant negative association was observed with number of branches per plant at 90 DAS. This indicates the importance of this character in selection. The positive correlation of plant height with number of leaves per plant at 90 DAS and length of internodes indicates that allocation and translocation of photosynthates from the source to the sink.

Association of number of nodes to first flowering was recorded significant and positive with days taken to first flowering, days taken to 50% flowering and days taken to first picking. While it was found significant and negative with fruiting span, fruit width and fruit yield per plant. Length of internodes recorded significant with fruit width. Association of days to first flowering was exhibited significant and positive with days to 50% flowering and days taken to first picking. While, it was found significant and negative with fruiting span and fruit length. Days to 50 % flowering was recorded highly significant and positive association with days taken to first picking and it was found significant and negative association with fruiting span. Length expressed significant and positive correlation with number of fruits per plant and fruit yield per plant. Fruit weight expressed significant and negative correlation with number of fruits per plant. The correlation coefficient of number of fruits per plant was found to be significant and positive correlation with fruit yield per plant.

Path coefficient analysis revealed that number of fruits per plant had highest positive direct effect followed by fruit weight, number of nodes to first flowering, number of branches per plant at 90 DAS, length of internodes, number of leaves per plant at 90 DAS, plant height at 90 DAS and fruiting span are the most important character contributing towards fruit yield and hence purposeful and balance selection based on these characters would be rewarding improvement in okra. Fruit width had the highest negative direct effect on fruit yield per plant followed by days taken to 50% flowering , days to first flowering, fruit length and days taken to first picking should be avoided instead of direct selection.

Incidence of YVMV ranged between 0.0 to 17.50% and 0.0 to 39.17% with an average performance of 1.68 and 3.44 at 60 and 90 DAS respectively. The maximum 17.50% and 39.17% Incidence of YVMV was recorded at 60 and 90 DAS respectively in genotype Arka Abhay. While, it was recorded minimum in genotypes 2013/OKHYB -2, 2014/OKHYB -4, 2014/OKHYB -5, 2014/OKHYB -6, 2014/OKHYB -8, 2014/OKYVRES -4, 2014/OKYVRES -6, 2014/OKYVRES -7, 2014/OKYVRES -11 and 2015/OKYVRES-3 0.0% at 60 DAS and in 2014/OKHYB

-4, 2014/OKHYB -5, 2014/OKHYB -6, 2014/OKHYB -8, 2014/OKYVRES -4 and 2014/OKYVRES -7 at 90 DAS respectively.

6.2 Conclusion

The estimates of mean sum of squares due to genotypes were highly significant for all the characters, indicating the presence of genetic diversity in the existing material.

The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was the highest for plant height at 90 DAS, followed by fruit yield per ha, fruit yield per plant and plant height at 60 DAS.

High heritability coupled with high genetic advance as percentage of mean for traits like fruit yield per plant, fruit yield per ha and number of fruits per plant, suggested that they can be improved through direct selection.

The association studies indicated the advantages of upgrading okra genotypes through simultaneous selection for number of fruits per plant.

Path coefficient analysis revealed that number of fruits per plant, fruit weight, number of nodes to first flowering, number of branches per plant at 90 DAS, length of internodes, number of leaves per plant at 90 DAS, plant height at 90 DAS are the most important character contributing towards fruit yield and hence purposeful and balance selection based on these character would be rewarding improvement in okra. Direct selection of fruit yield per plant followed by days taken to 50% flowering , days to first flowering, fruit length and days taken to first picking should be avoided instead of direct selection.

Considerable variability was observed among the genotypes for the incidence of YVMV. The minimum (0.0%) incidence was recorded in genotypes 2014/OKHYB -4, 2014/OKHYB -5, 2014/OKHYB -6, 2014/OKHYB -8, 2014/OKYVRES -4 and 2014/OKYVRES -7. which are the most important genotypes to help farmers in choosing better cultivars for the market.

6.3 Suggestions for further work

1. Characters having desirable association and direct effect with other fruit yield should be given due consideration for genetic improvement in okra.
2. Stability of distinct traits of okra should be established over the years.

3. Traits identified for high heritability coupled with high or moderate genetic gain may be considered well in selection for the improvement of crop.
4. The genotypes showing greater yield potential with other desirable qualities may be tested under different agro climatic conditions and those found suitable could be recommended for commercial cultivation to the vegetable growers.

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VITA

The author of this thesis **Mr. Om Soni** S/o Shri Shriram Soni was born 01st June, 1990 at Chourai, Chhindwara (M.P.). He passed the High School Examination in the year 2006 with 55.00 percent marks and Higher Secondary Examination in the year 2008 acquiring 75.55 percent marks from, Denialson H.M.H.S School Chhindwara (M.P.) He joined the College of Horticulture, Mandsaur (M.P.) in the year 2010 and successfully completed the degree of B.Sc.

(Horticulture) from Rajmata Vijayaraje Krishi Vishwa Vidyalaya Gwalior (M.P.) during the year July, 2014 with (7.16 OGPA out of 10.00 point scale).

After completing graduation, he was selected for M.Sc. (Ag.) Horticulture degree programme in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur through Joint entrance exam for specialization in Vegetable Science. He successfully completed all the course requirements for master's degree with First Division securing an OG PA of 7.44 out of 10 point scale.

For the fulfillment of the master's degree programme, he was allotted a research problem entitled "**Genetic Variability, Correlation and Path Analysis in Okra**". This is duly completed by him and presented in the form of this thesis.



2013/OKHYB-1



2013/OKHYB-2



2014/OKHYB-2



2014/OKHYB-3



2014/OKHYB-4



2014/OKHYB-5



2014/OKHYB-6



2014/OKHYB-8



2014/OKYVRES-1



2014/OKYVRES-2



2014/OKYVRES-3



2014/OKYVRES-4

PLATE 1- Fruits of different genotypes of okra.



2014/OKYVRES-6



2014/OKYVRES-7



2014/OKYVRES-8



2014/OKYVRES-9



2014/OKYVRES-11



2015/OKYVRES-1



2015/OKYVRES-2



2015/OKYVRES-3



2015/OKYVRES-4



2015/OKYVRES-5



ARKA ABHAY



ARKA ANAMIKA

PLATE 2- Fruits of different genotypes of okra.

APPENDICES

Analysis of Variance for Various Characters in Okra (mean sum of squares).

Source of Variance	D.F.	Plant height (cm)			No. of branches / plant	
		30DAS	60DAS	90DAS	60DAS	90DAS
Replications	2	143.918	340.225	72.101	2.953	10.415
Genotypes	23	14.421**	827.552**	1535.762**	0.145**	0.723**
Error	46	3.607	225.306	201.829	0.041	0.187

Source of Variance	D.F.	No. of leaves per plant			No. of nodes to 1 st flowering	Length of internods (cm)
		30DAS	60DAS	90DAS		
Replications	2	45.111	193.507	545.577	0.017	81.246
Genotypes	23	2.585**	26.659**	74.460**	0.669**	9.589**
Error	46	0.565	6.944	7.083	0.147	1.468

Source of variance	D.F.	Days to 1 st flowering	Days to 50% flowering	Days to 1 st picking	Fruiting span
Replications	2	10.166	26.930	4.263	4.263
Genotypes	23	3.545**	4.955**	4.477**	4.477
Error	46	1.195	1.466	1.582	1.582

Source of Variance	D.F.	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Number of fruits per plant
Replications	2	0.204	0.277	19.781	69.362
Genotypes	23	4.957**	0.038**	24.314**	16.494**
Error	46	1.161	0.009	3.922	1.964

Source of variance	D.F.	Fruit yield/ plant (g)	Fruit yield/ plot (kg)	Fruit yield / ha. (q)
Replications	2	29489.608	46.911	9037.400
Genotypes	23	6959.728**	11.243**	2166.232**
Error	46	617.231	0.980	188.821

Source of variance	D.F.	Incidence of YVMV %	
		60DAS	90DAS
Replications	2	4.253	35.304
Genotypes	23	51.988**	252.794**
Error	46	12.224	59.760