

**VARIABILITY STUDIES IN ELITE TYPE OF OKRA
(*Abelmoschus esculentus* L. Monech) GENOTYPES**

by

Miss. Khode Vaishnavi Vijendra

(Reg. No. 019/309)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA**

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

VEGETABLE SCIENCE



DEPARTMENT OF HORTICULTURE

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
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MAHARASHTRA, INDIA.**

2023

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

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Date : / /2023

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CERTIFICATE

This is to certify that the thesis entitled, “**VARIABILITY STUDIES IN ELITE TYPE OF OKRA (*Abelmoschus esculentus* L. Monech) GENOTYPES**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M. S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE**, embodies the results of a piece of *bona fide* research work carried out by **Miss. KHODE VAISHNAVI VIJENDRA**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place : MPKV., Rahuri

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LIST OF ABBREVIATIONS AND SYMBOLS

%	:	Per cent
/	:	Per (or)
°C	:	Degree Celsius
AICRP	:	All India Co-ordinated Research Project
ANOVA	:	Analysis of Variance
C.D.	:	Critical difference
C.V.	:	Coefficient of variance
Cm	:	Centimeter (s)
DAS	:	Days After Sowing
DSI	:	Disease Severity Index
<i>et al.</i>	:	et alli (Co-workers)
Fig.	:	Figure (s)
G	:	Gram (s)
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent mean
GCV	:	Genotypic coefficient of variation
H	:	High
h^2	:	Heritability
Ha	:	Hectare (s)
HR	:	Highly resistant
HS	:	Highly susceptible
<i>i. e.</i>	:	that is
Kg	:	Kilogram (s)
L	:	Low
M	:	Medium
MPKV,	:	Mahatma Phule Krishi Vidyapeeth
MR	:	Medium Resistant
PCV	:	Phenotypic coefficient of variation
PDI	:	Percentage Disease Incidence
Q	:	Quintal
R	:	Resistant
RBD	:	Randomized Block Design
RBD	:	Randomised Block Design
RH	:	Relative Humidity
S	:	Susceptible
S.E.	:	Standard Error
<i>viz.</i>	:	Videlicet (Namely)
YVMV	:	Yellow vein mosaic virus

ABSTRACT

VARIABILITY STUDIES IN ELITE TYPE OF OKRA (*Abelmoschus esculentus* L. Monech) GENOTYPES

By

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A candidate for the degree of
MASTER OF SCIENCE (HORTICULTURE)
in
VEGETABLE SCIENCE
2023

Research Guide	: Dr. Sharmila Shinde
Department	: Horticulture

The present experiment entitled “Variability studies in elite type of okra (*Abelmoschus esculentus* L. Monech) genotypes” was completed during Late *Kharif* 2020 at AICRP on Vegetables, MPKV, Rahuri. This experiment consists of thirty-one genotypes and one standard check, arranged in a Randomized Block Design with two replications. These genotypes were studied for the extent of variability, heritability (b.s), Genetic Advance, Correlation, Path Analysis and genetic divergence among the genotypes. The analysis of variance revealed that there is significant difference among the genotypes for all the characters.

The observations were recorded on yield and yield contributing characters viz. days to 50 % flowering, first fruiting node, internodal length, plant height, days to first harvest, harvest duration, fruit length, fruit diameter, average fruit weight, number of fruits per plant, and fruit yield per plant. The magnitude of GCV and PCV was highest for number of branches per plant (25.90;27.12). Also, high heritability was observed for plant height (89.4 %), followed by number of branches per plant (83.8 %), fruit yield per plant (78.3 %), internodal length (70.1 %), fruit weight (66.9 %), number of fruits per plant (63.4) and days to 50 per cent flowering (61.8 %). High heritability along with Genetic advance as of per cent mean was observed for number of branches per plant (48.84 %), fruit yield per plant (24.88 %) and plant height (21.51 %).

In correlation studies it is estimated that fruit yield per plant had significant positive correlation with internodal length, plant height, number of branches per plant, fruit length, fruit weight, number of fruits per plant. Whereas the characters *viz.* number of fruits per plant, fruit length, fruit weight, plant height, and number of branches per plant had significant positive direct effect on fruit yield per plant indicating role of above characters in yield estimation.

The genetic divergence (D^2 value) revealed that there was presence of genetic diversity among all the thirty two genotypes studied. These genotypes were further divided into six clusters, from which Cluster I was largest consisting of twenty-one genotypes while cluster II IV V and VI were solitary in nature. The maximum intra cluster distance were found in cluster III followed by cluster I.

Considering the above results it is concluded that the genotypes, *viz.*, RHROK 02, RHROK 26, RHROK 07, RHROK 09, RHROK 32, RHROK 12, RHROK 03, RHROK 31, and RHROK 05 are potential parents for the future breeding programmes.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Monech) is an important vegetable crop that is cultivated and consumed in various tropical and subtropical regions of the world. It is a crop with multiple uses as it is used in various delicacies and also in medicinal preparations. All of its parts are edible, including the fresh leaves, buds, flowers, pods, stem and seeds. Immature fruits of okra are eaten as vegetable in salads, soups and it is also added to stews and sauces because of its mucilaginous consistency. It is a good source of vitamins including riboflavin, thiamine, vitamin C and vitamin A as well as minerals like calcium, potassium and magnesium. Okra's mucilage can be utilized as a blood volume expander or as a plasma replacement. Moreover, it binds cholesterol and toxins from the liver carried by bile acid. Okra seeds are potential oil producers and consist of about 40 per cent oil in it. Linoleic acid, a polyunsaturated fatty acid necessary for human nutrition, can be found in quantities of up to 47.4 per cent of the total oil produced by okra seeds (Gemede *et al.*, 2014).

India ranks 1st in area and production of okra in the world. India's share in world's total okra production is 62 per cent. Total area and production in India under okra become 519 [000 Ha] and 6371 [000MT] in 2019-20 from 504 [000] Ha and 5079 [000 MT] in 2015-16 respectively. Also Productivity of okra increases from 11.4 [MT/Ha] in 2015-16 to 12 [MT/Ha] in 2017-18. As per 2017-18, State having highest area of okra is West Bengal [77,500 Ha] whereas state having highest production in okra is Gujarat [9,21,720 MT/ha]. The state having highest Productivity is in Jammu and Kashmir [41.42 MT/Ha]. In Maharashtra, in 2017-18 the total area of okra production is 13.98[000 Ha] and production is 139.40 [000MT]. The productivity of okra in Maharashtra is 9.97 MT/Ha. From above Statistical Data, it shows that there is a lot of scope to increase in production of okra in Maharashtra (Anon., 2020).

Okra has a huge market potential in export as a fresh vegetable. Major targets of export are our neighboring nations in the Gulf and South East Asia, especially Mauritius, Singapore, Malaysia, Bangladesh and Sri Lanka which require vegetable supply throughout the year. It accounts for 70 per cent of the 30 per cent exchange revenues from exporting vegetables, other than onions. Exports to the European and

Japanese markets have recently begun, although there are additional quality limitations and price competition. Okra is imported into European markets from, Thailand, Zimbabwe and Kenya. Potential markets for Indian vegetable exports from the Middle East include Abu Dhabi, Qatar, Kuwait, Saudi Arabia, Muscat, Tehran and Bahrain. Although okra is cultivated for export in many regions of the nation, However in Maharashtra, Nasik, Narayangaon , Saikheda, Ozar, Dindori, Kolhapur and Solapur are the main exporting areas (Thamburaj and Singh, 2005).

Improving yield and quality of crop by evolving superior varieties is the primary objective of any breeding programme. The green pod yield is most economically important quantitative character in okra, which is highly influenced by the environment. Improvement of cultivars and the formulation of Breeding Procedures primarily depend on the amount of genetic variability present in breeding material/ germplasm and the nature of gene action respectively. Magnitude of estimates of total genetic variances indicates genetic variance. The relative proportion of the components of total genetic variances indicates the nature of gene action. The estimates of genotypic variances serve as indicator for potentiality of a population for the choice and improvement of breeding procedures (Patel, 1983).

The crop improvement is correlated to the magnitude of its genetic variability present in the germplasm. The genotypic coefficient of variation implies the range of genetic variability present in characters which are selected for breeding improvement. The partitioning of total variance so as to assess the true breeding nature of a particular trait under selection is important as interaction between the genotype and environment results the phenotypic expression of the character (Adiger *et al.*, 2011).

Correlation coefficient analysis computes the mutual relationship between growth and yield characters of plant and determines the component character on which selection can be made for genetic improvement of yield. The analysis regarding the presence of component and nature of association among themselves is essential and pre-requisite for improvement in yield. Correlation coefficient gives a clear view 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 understanding of genetic association between yield and its component characters help in improvement in efficiency of

selection for yield by making adequate choice and balancing the components with each other. The magnitude of genotypic correlation has been found higher than the phenotypic correlation for all the traits that indicated inherent association between various characters (Binepal *et al.*, 2019).

The path analysis formulated by Dewey and Lu (1959) provides an effective means to find out direct and indirect causes of association and allows a critical analysis of given correlation and scale the relative importance of each factor. This information reveals the probability of simultaneous improvement of different attributes and also helps in increasing the effectiveness in selection of complex inherited traits.

The clustering of okra genotypes which is based on genetic divergence (D^2) may provide the basis for selection of suitable parents for further hybridization programme. The genetic divergence among genotypes was determined by using D^2 statistics (Mahalanobis, 1936). All the genotypes used were clustered into groups by using Tocher's method (Rao, 1952). The average intra and inter cluster distances were estimated by the formulae drawn by Singh and Chaudhary (1997).

The significant okra types grown in various regions of India are Pusa Sawani, Prabhani Kranti, Punjab Padmani, Azad Ganga, Phule Utkarsha, Phule Vimukta, etc. The main obstacle to okra production is the yellow vein mosaic virus, which lowers quality and quantity of production across the nation. Introduction, selection and hybridization all contribute to evolve numerous new types. The extent of genetic variability present in a crop species has a significant impact on its capability of improvement. The breeder can determine the most appropriate genotype by having a thorough understanding of the diversity present within a breeding material of a crop species for the desired trait. Interaction between the genotype and environment results phenotypic variation and for making effective selections, genetic variation is most important as it gets inherited in the next generation.

Therefore, present investigation was carried out in okra considering the scope in increasing production, seeking variability and desirable germplasm which can be used in future breeding programmes. The experiment consisting of thirty one genotypes with standard check which was undertaken at the farm of AICRP on Vegetables,

Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri During the year 2020-21 with the following objectives:-

1. To assess the nature and extent of variability present in different okra genotypes.
2. To workout the association of yield with different horticultural traits.
3. To identify most suitable and best performing elite genotypes of okra cultivation.
4. To identify elite genotypes for disease resistance.

2. REVIEW OF LITERATURE

A Breeding programme aims to improve the yield and quality characters of a crop. Wise selection is a key for successful breeding programme. For this, information on phenotypic as well as genotypic expression of various yield contributing traits, growth and qualitative traits is very useful. In this present chapter, attempt is made to review the literature available on various aspects of the investigation in okra so that we could have sound knowledge of findings. These results are discussed under following points:

- 2.1 Variability studies
- 2.2 Correlation studies
- 2.3 Path Analysis Studies
- 2.3 Divergence studies

2.1 Variability studies

2.1.1 Analysis of Variance

Jindal *et al.* (2010) revealed that all the characters taken under study namely first fruiting node, Average fruit weight, fruit diameter, Average fruit length, number of fruits per plant, plant height, internodal length, number of branches per plant and total yield per plant had highly significant differences among the genotypes.

The study was conducted on hundred genotypes of okra and the estimated values of analysis of variance resulted significant differences for the characters studied which are plant height, number of branches per plant, internodal length, days to 50 per cent flowering, first fruiting node, fruit length, width and weight, total number of fruits and yield per plant by Reddy *et al.* (2012)

Duggi *et al.* (2013) stated that the characters such as 50 per cent flowering, number of branches, plant height, harvest duration, number of fruits per plant fruit weight, fruit length, fruit yield per plant had significant differences among the genotypes.

Barche *et al.* (2014) indicated from the analysis of variance, that there was significantly higher differences for traits such as plant height, number of fruits per plant, weight of fruit, fruit length and fruit yield per plant.

Chandramouli *et al.* (2016) studies thirty genotypes of okra and revealed that there are significant differences among the genotypes for all the character studied which are plant height, number of branches per plant, internodal length, number of fruits per plant, fruit length, fruit weight, days to 50 per cent flowering, first fruiting node, days to first harvest, harvest duration and fruit yield per plant.

Kumar *et al.* (2019) revealed that analysis of variance for the characters such as plant height, number of fruits per plant, length and width of fruit, number of branches per plant, first fruiting node and fruit yield per plant.

Singh *et al.* (2020) revealed that the genotypes differed significantly among themselves for days to 50 per cent flowering, first fruiting node, fruit length, fruit diameter, average fruit weight, number of fruits per plants, number of primary branches per plant, plant height, internodal length and fruit yield per plant.

Ranga *et al.* (2021) carried out the analysis of variance for ten traits *viz.* Plant height, days to 50 percent flowering, number of fruits per plant, fruit length, first flowering node and yield per plant showed highly significant and positive difference.

2.1.2 Phenotypic and Genotypic Variance

Alam and Hossain (2008) studied the genotypic and phenotypic variance for the fifty genotypes of okra and found wide variation for plant height along with moderate variation for yield and lesser variation for number of primary branches per plant.

Prakash and Pitchaimuthu (2010) found that yield per plant had high Phenotypic and genotypic variance followed by plant height. Rest of the characters such as average fruit weight, fruit length, internodal length, 50 per cent flowering, first fruiting node and number of fruits per plant exhibit low values of phenotypic and genotypic variance.

Reddy *et al.* (2012) stated that the phenotypic and genotypic variance was highest for total yield per plant followed by plant height while lowest for fruit width.

2.1.3 Genotypic and Phenotypic coefficient of variance

Patro and Ravishankar (2004) revealed that PCV and GCV were higher in number of branches per plant. On contrary low GCV was observed for number of ridges per fruit.

Alam and Hossain (2008) had found highest values of GCV and PCV for number of branches per plant followed by fruit yield while low GCV and PCV values were observed for plant height.

A wide range of variation was observed in fruit length, fruit diameter and weight per fruit, plant height, number of nodes on main stem and fruit yield per plant. Number of fruiting nodes, fruit yield per plant exhibit high, whereas plant height, internodal distance, number of nodes on main stem and weight per fruit exhibit moderate GCV and PCV and number of ridges per fruit, fruit diameter, fruit length and number of primary branches per plant exhibit low GCV and PCV values reported by Akotkar *et al.* (2010).

Chaurasiya *et al.* (2010) reported very low GCV and PCV indication a narrow range of variation for characters such as days to first flowering, fruit diameter and weight of fruit. Also there were high magnitudinal differences between GCV and PCV of Plant percentage affected by YVMV suggesting the role of environment in the expression of these characters.

Jindal *et al.* (2010) showed that PCV was highest for number of primary branches per plant. Moderate values of PCV was observed for yield per plant followed by marketable yield per plant, days to first harvest, average fruit weight, plant height, internodal length, number of fruits per plant and node at which first flower appears. Low PCV was recorded for fruit diameter and fruit length. However, The GCV were obtained highest for total yield per plant, followed by marketable yield per plant, days to first picking, plant height, internodal length, number of fruits per plant and number of fruits per plant. Low GCV values were observed in fruit length, fruit diameter and first fruiting node.

Prakash and Pitchaimuthu (2010) while studying variation amongst 15 characters stated high phenotypic variance in fruit yield followed by plant height at full maturity. The magnitude of PCV was higher than that of GCV for all the traits. The GCV and PCV were high for plant height, inter nodal length, first flowering node, first fruit producing node and average fruit weight.

AdeOluwa and Kehinde (2011) studied 35 accessions of West African Okra for different morphological and agronomic traits which showed higher phenotypic

variances than respective genotypic variances revealing the role of environmental factors. The genotypic variance was observed high for plant height followed by days to flowering whereas genotypic variance of days to maturity and pod yield per plant were observed very close to magnitude. The difference between phenotypic and genotypic variances was small except for number of ridges per fruit, number of pods per plant and pod yield per plant. Pod yield per plant followed by number of pods per plant, node at which first flower appear, plant height and fruit weight showed maximum and number of ridges per fruit showed minimum GCV and PCV, respectively.

Adiger *et al.* (2011) studied 163 genotypes which shows maximum range of variation was there in fruit yield per plant followed by plant height and number of fruits per plant. The PCV was higher than GCV for all the triats studied showing involvement of environmental effect.

Das *et al.* (2012) showed that the GCV and PCV values were high in case of fruit yield per plant followed by number of fruits per plant and plant height. On the other hand low GCV and PCV values were shown by node at first flowering and number of ridges per fruit.

Reddy *et al.* (2012) reveals that high magnitude of genotypic coefficient of variation ($> 20.00\%$) for number of branches per plant, total number of fruits per plant, total yield per plant (g) and yellow vein mosaic virus infestation on plants (%) indicated high degree of genetic variability offering great scope for selection of these characters.

Nwangburuka *et al.* (2012) recorded highest GCV and PCV for plant height followed by total weight of fruit per plant, number of fruits per plant, number of branches per plant.

Duggi *et al.* (2013) recorded the highest PCV and GCV for number of primary branches followed by yield per plant and number of fruits while low PCV and GCV was shown by days to 50 % flowering.

Koundinya *et al.* (2013) studied estimates of GCV and PCV which were moderate for plant height, internodal length, number of branches per plant and yield per plant. Moderate PCV and low GCV was observed for first fruiting node. Days to 50% flowering, fruit length, fruit diameter and fruit weight exhibit low GCV and PCV values indicating limited scope in improvement.

Simon *et al.* (2013) recorded higher values of PCV in characters such as Pod yield, number of pods per plant and pod length while low PCV was recorded for internodal distance.

Barche *et al.* (2014) observed that PCV was higher than GCV for most of the traits. But GCV was obtained higher for number of fruits per plant and yield (q/ha) which suggested that these characters are under genetic control. High PCV as well as GCV was recorded for these above characters.

Ahmed *et al.* (2015) studied fifty seven okra genotypes which resulted in high range of variation in average fruit weight followed by yield per plant. The PCV was greater than GCV for fruit yield per plant. As per the study, it showed less difference in genotypic and phenotypic variance for all the fruit characters except for fruit length indicating less environmental influence. Highest GCV and PCV were found for fruit yield per plant, number of fruits per plant and lowest for fruit length.

Mishra *et al.* (2015) observed that maximum difference between GCV and PCV were observed for nodes per plant and plant height showing environmental influence towards their expression.

Chandramouli *et al.* (2016) estimated that GCV and PCV was observed high for fruit yield per plant as well as plot and YVMV infestation hence have scope in improvement by selection. Moderate to low variability was observed in plant height, number of primary branches per plant, number of nodes on main stem, internodal length, number of fruits per plant, fruit length, fruit girth, first flowering node, fruit weight, days to 50 % flowering, days to first picking and picking duration.

Khajuria *et al.* (2016) observed moderate PCV and GCV for number of fruits per plant, fruit weight and number of fruits per plant. The magnitude of PCV is higher than GCV for all the characters indicating expression of environment.

Nikitha *et al.* (2016) reported moderate GCV and PCV values for characters such as number of fruits per plant, fruit weight and yield per plant whereas days to 50 % flowering, fruit length, plant height and duration.

Radha Rani *et al.* (2016) stated that PCV was greater than GCV for all the characters. There was high phenotypic coefficient of variation for fruit yield per plant

followed by number of fruits per plant, internodal length and plant height while low for fruit length and fruit girth.

Sravanthi (2016) recorded high GCV and PCV for percent incidence of YVMV, yield per plant, fruit weight, number of fruit per plant; Moderate for internodal length, number of ridges per fruit, fruit length, plant height, number of branches per plant and low for fruit diameter.

Sharma *et al.* (2016) studies revealed that higher magnitude of GCV and PCV was observed for nodes per plant, plant height and nodes to first fruit set. Moderate variation was observed in number of ridges per fruit and yield per plant. Low GCV and PCV was observed for fruit weight and days to 50 % flowering.

Shivaramgowda *et al.* (2016) studied that the PCV values are greater than GCV for all characters with close correspondence between them. Moderate to high GCV values were observed for most of the characters except days to first flowering, fruit length and fruit girth revealed the presence of high magnitude of genetic variability in the population studied.

Singh *et al.* (2017) stated that the characters such as fruit width, internodal length, plant height, number of primary branches per plant, first flowering node had highest genotypic and phenotypic variability whereas number of ridges per fruit, number of fruits per plant, yield per plant, fruit length, days to 50 % flowering and fruit weight showed low genotypic variability.

Thulasiram *et al.* (2017) estimated high value of GCV and PCV for diameter of fruit and number of primary branches per plant, plant height, number of fruits per plant and total fruit yield, Moderate GCV and PCV was observed for the characters such as yield per plant, length of fruit, number of fruits per plant, whereas low magnitude of GCV and PCV was observed in weight of fruit and days to first harvest.

Kerure *et al.* (2017) observed high GCV and PCV for number of fruits per plant, moderate GCV and PCV was observed for average fruit weight and first fruit producing node. The phenotypic values in general were higher than genotypic values however the differences were less for plant height, number of branches per plant, fruit producing node, fruit length, number of fruits per plant, average fruit weight and yield

per plant hence less influences by environment. Therefore selection on the basis of phenotypic basis would hold good.

Ramgiry *et al.* (2017) revealed that the magnitude of PCV and GCV were comparatively maximum for fruit yield per plant followed by number of branches per plant and number of fruits per plant. Fruit diameter, plant height and fruit length had Moderate GCV and PCV values. Days to 50 % flowering and days to first picking had lowest magnitude of GCV and PCV.

Patra *et al.* (2018) studied coefficient of variation and resulted very low variability for parameter such as Plant height and moderate variability for parameters like days to 50 % flowering, average fruit weight, fruits per plant. High to moderate GCV was observed for fruit length, total yield per plot and YVMV incidence at 45, 60, 75 and 90 DAS.

Syfullah *et al.* (2018) studied the genotypes for 11 characters in which fruit yield per plant had highest phenotypic variance followed by plant height whereas lowest value was recorded for fruit diameter, primary branches per plant and fruit length. Moderate GCV and PCV values were found in plant height and average fruit weight; which suggest that these characters are controlled more of by the genetic factors. Number of primary branches per plant, number of fruits per plant and fruit yield per plant exhibited high degree of GCV and PCV values.

Makhdoomi *et al.* (2018) studied that number of pods per plant and pod yield showed high values of GCV and PCV while Plant height, number of nodes, internodal distance, pod length, pod girth and average pod yield showed moderate values of GCV and PCV. Highest phenotypic and genotypic variances were recorded for plant height and pod yield per plant.

Vishnu Priyanka *et al.* (2018) estimated that the PCV were highest for yellow vein mosaic infestation followed by marketable fruit yield per plant, number of branches per plant, pod borer infestation and number fruits per plant while lowest for fruit width followed by days to first harvest and first flowering node. Also estimates of GCV were highest for yellow vein mosaic virus infestation followed by number of marketable fruits per plant and marketable yield per plant and lowest for fruit width followed by first flowering node and fruit weight. The magnitude of PCV were moderate

for plant height, number of nodes on main stem, fruiting period, total number of fruits per plant and total yield per plant while low for internodal length, days to 50 % flowering, first flowering node, fruit length, fruit width and fruit weight. Moderate GCV estimates were shown by number of branches per plant, fruiting period, total yield per plant and pod borer infestation, while low of magnitude for plant height, internodal length, number of nodes on main stem, days to 50 % flowering, first flowering node, days to first fruit harvest, fruit weight and total number of fruits per plant. These magnitudinal differences between GCV and PCV for number of branches per plant, number of nodes on main stem and pod borer infestation showed influence of environment.

Verma *et al.*(2018) stated that PCV and GCV were high for number of branches per plant and yield per plant, moderate for fruit width, length of internodes, first fruiting node, number of fruits per plant, whereas low for length of fruit, plant height, plant height and days to flowering.

Kumari *et al.* (2019) observed high Values of GCV and PCV for important traits such as yield per plant, number of fruits per plant and primary branches per plant respectively. However, Number of fruits per plant had high PCV followed by internodal length and yield per plant than GCV.

Kumar *et al.* (2019) observed that the genotypic variance was highest for length of fruit followed by pod yield per plant. Similarly the phenotypic variance was highest for number of branches per plant followed by number of first fruiting nodes per plant. The PCV and GCV values were maximum for pod yield per plant and plant height while minimum for width of fruit and length of fruit.

Kumar *et al.* (2020) revealed that the characters such as number of fruits per plant, number of nodes per plant, number of branches per plant, average fruit weight, Total fruit yield per plant and plant height had moderate to high PCV values. Low PCV was recorded for the characters *viz.*, node at which first flower appears and crop duration. However, the characters such as number of fruits per plant, number of nodes per plant, average fruit weight, number of branches per plant, total fruit yield per plant and fruit length. Low GCV was recorded for node at which first flower appear, days to 50 % flowering and crop duration.

Rana *et al.* (2020) recorded moderate GCV and PCV for internodal length, plant height, average fruit weight, number of fruits per plant, fruit yield per plant. Low PCV and GCV values were recorded for days to 50 % flowering.

Singh *et al.* (2020) studied that moderate to high GCV and PCV was observed in traits such as first fruit producing node, average fruit weight, number of primary branches per plant, plant height, number of fruits per plant and fruit yield per plant indicate ample scope in yield improvement through selection. The GCV and PCV values were low for days to 50 % flowering, fruit length and fruit diameter. High PCV but moderate GCV was seen in number of branches per plant and plant height implying the influence of environment.

Ranga *et al.* (2021) observed high PCV and GCV values for the number of fruits per plant, yield per plant and lowest for plant height and days to 50 % flowering which denotes high magnitude of genetic variability in the genotypes.

2.1.4 Heritability and Genetic Advance

Akotkar *et al.* (2010) studies revealed that the character such as Plant height and internodal length had high heritability whereas the other characters like number of fruits per plant, fruit length, fruit diameter, fruit weight and fruit yield per plant had moderate heritability. Number of primary branches per plant had low heritability.

Chaurasiya *et al.* (2010) had revealed that the high heritability coupled with moderate genetic advance had been resulted for the characters such as number of branches per plant and moderate for fruit yield per plant and fruit length.

Jindal *et al.* (2010) studied that yield per plant had highest heritability along with fruit weight, number of fruits per plant, plant height days to first harvest but first fruiting node had moderate heritability. The characters such as fruit yield per plant and plant height had moderate genetic advance and rest of the characters had low genetic advance.

Prakash and Pithaimuthu (2010) observed that the characters under study namely plant height, internodal length, first fruiting node, fruit length, fruit weight, Number of fruits per plant and fruit yield per plant had higher heritability coupled with

high genetic advance. On contrary, 50 per cent flowering showed high heritability with low genetic advance and internodal length had moderate heritability and genetic advance.

Adiger *et al.* (2011) evaluated the okra genotypes and resulted moderate values of heritability for inter nodal length, fruit length and number of fruits per plant and the rest of the characters had high heritability namely ($> 70\%$) Days to 50 per cent flowering, plant height, number of branches per plant, fruit diameter, fruit weight and fruit yield per plant.

Reddy *et al.* (2012) estimated high magnitude of heritability coupled with genetic advance for characters such as plant height, number of branches per plant, internodal length, days to 50 per cent flowering, first flowering node, first fruiting node, fruit length, fruit width, fruit weight and yield per plant.

Duggi *et al.* (2013) resulted that the heritability estimates was maximum for harvest duration, followed by fruit weight, plant height, fruit length, yield per plant, number of fruits per plant, days to 50 per cent flowering and number of branches per plant. The highest genetic advance as of per cent mean was estimated for number of branches per plant followed by yield per plant. Rest of the characters had medium to low genetic advance.

Kaundinya *et al.* (2013) revealed that characters such as plant height, internodal length, number of fruits and yield per plant showed high heritability coupled with high genetic advance which proves that the above given traits are under the strong influence of additive gene action and effective selection can be done based on phenotype performance of these characters.

Barche *et al.* (2014) revealed that the high heritability values along with high genetic advance was estimated for fruit yield per plant and plant height.

Mishra *et al.* (2015) observed that the characters like wise fruit weight, days to 50 per cent flowering, harvest duration and it also had high genetic advance.

Chandramauli *et al.* (2016) estimate that the number of branches per plant, internodal length, number of fruits and fruit yield per plant had high heritability with high genetic advance.

High magnitude of heritability was observed for characters such a fruit length followed by number of fruits per plant and fruit yield per plant, average fruit

weight and plant height, days to 50 per cent flowering, first flowering node, number of branches per plant days to first harvest and harvest duration. Highest values of genetic advance estimated for total fruit yield per plant followed by plant height whereas moderate for harvest duration and low for average fruit weight followed by days to 50 per cent flowering, days to first harvest, number of fruits per plant, fruit length, number of branches per plant and first fruiting node in the study conducted by Kumar *et al.* (2020)

Rana *et al.* (2020) studied heritability percentage for the characters fruit yield per plant, plant height, average fruit weight, number of fruits per plant, internodal length and days to 50 per cent flowering. The characters namely internodal length, fruit weight and fruit yield per plant also had high genetic advance along with high heritability.

Singh *et al.* (2020) estimated that the heritability of fruit yield per plant was maximum followed by number of fruits per plant, inter nodal length, days to 50 per cent flowering which indicates that these characters are the ones which are least affected by environment. Average fruit weight, plant height, first fruiting node and number of primary, branches per plant had moderate level of heritability whereas low for fruit length and fruit diameter. This traits are greatly influenced by the environmental effect and hence selection foe genetic improvement of these traits is hard due to masking effect. Days to 50 per cent flowering and fruit length exhibit low genetic advance values. Except for it all the other traits had gigh genetic advance values.

Ranga *et al.* (2021) found that the traits studies *viz.* Plant height, days to 50 per cent flowering, number of fruits per plant, fruit length, first fruiting node and yield per plant had high magnitude of heritability and genetic advance.'

2.2 Correlation Studies

Dhall *et al.*(2000) discovered that total yield per plant was highly significant positively correlated with fruit weight, fruit length, number of fruit per plant and plant height were observed at genotypic and phenotypic levels whereas highly significant negatively correlated with node at which first flower appears and days to first picking.

Patro and Ravishankar (2004) assessed genotypic and phenotypic correlation coefficients in which the fruit yield per plant exhibited a significant and

positive correlation with number of pods per plant, number of ridges, fruit length and fruit weight while a significant and negative correlation with plant height.

Correlation studies have been carried out on fifteen diverse genotypes by Balakrishnan and Sreenivasan (2010) which revealed that fruit borer infestation and plant height, number of fruit, fruit yield had significantly negative correlation. Fruit yield per plant was positively correlated with number of fruits, number of internodes, fruit weight and plant height however it is negatively correlated with days to first flowering and fruit infestation. As per the correlation studies, flowering period, number of internodes and internodal length have significant positive association with shoot infestation and negative association between fruit length and shoot infestation. There was negative association between fruit infestation and the characters such as plant height, number of internodes, number of fruits, Fruit yield and flowering period.

Adiger *et al.* (2011) stated that there was significant negative correlation at genotypic level was observed in between fruit yield per plant and days to 50 % flowering whereas significantly positive correlation was observed in fruit yield per plant and internodal length, plant height, number of branches per plant, fruit length, fruit weight and number of fruits per plant at genotypic and phenotypic level, showing mutual association of these traits.

Das *et al.* (2012) reported that plant height, number of nodes on main stem, fruit length, fruit diameter, fruit weight, number of fruits per plant have significantly positive correlation coefficient with green fruit yield per plant whereas number of lateral branches per plant have non significant positive correlation with it. Node at first flowering was significantly negative correlated with fruit yield per plant.

Nwangburuka *et al.* (2012) studied that the highest positive genotypic and phenotypic correlation between plant height, pod width and pods per plant, branches per plant and pod weight per plant.

Ahiakpa *et al.* (2013) resulted that the maximum number of internodes was positively correlated with maximum plant height and number of fruits per plant but negatively correlated with total fruit production and first fruiting node. Plant height is negatively correlated to number of fruits per plant. Also there was strong positive correlation between total Fruit Production and first fruit producing node.

Simon *et al.* (2013) studied that internodal distance was non significantly correlated with yield parameters such as pod length, pod weight, pod yield etc at both genotypic and phenotypic level.

Balai *et al.* (2014) undertook study on 27 okra genotypes which resulted that yield per plant showed highly significant positive correlation with plant height, length of the pod and average weight of edible pod at both genotypic and phenotypic level respectively. Also length of pod showed highly significant and positive association at both genotypic and phenotypic levels.

Barche *et al.* (2014) observed that fruit yield was significantly and positively associated with number of fruits per plant, weight of fruit and fruit length. The plant height had positive significant correlation with fruit length while negatively significantly correlated with weight of fruits.

Ahmed *et al.* (2015) observed highest positive correlation between number of fruits per plant. Plant height and number of fruits per plant, fruit length, yield per plant also show significantly positive correlation. Significant negative correlation was shown by yield per plant with branches per plant and days to 50% flowering. Also, Average fruit weight had positive correlation with fruit length, branches per plant, number of fruits per plant and yield per plant.

Mishra *et al.* (2015) revealed that fruit yield per plant had highly positive and significant correlation with plant height, nodes per plant and fruits per plant at both genotypic and phenotypic level. Also plant height showed significant and positive correlation with nodes per plant, fruit length, number of fruits per plant, yield per plant which implies more fruit yield in taller plants because of more number of nodes on main stem.

Saryam *et al.* (2015) showed that yield per plant had highly significant positive phenotypic correlation with number of fruits per plant, fruit diameter, fruit length and fruit weight whereas highly negative non significant association was observed with the incidence of yellow vein mosaic virus, days to 50 % flowering, node at which first flower appear. Selection of these associated traits can help in the improvement of okra genotypes.

Narkhede *et al.* (2015) studied that correlation and path analysis were carried out to study character association and contribution for days to 50 per cent flowering, Plant height at harvest, number of branches per plant, number of nodes per plant, days to first picking, number of fruits per plant, average length of fruit, average weight of fruit, yield per plant (g), yield per plot (kg), yield per hectare (qt) and reaction to yellow vein mosaic for identification of appropriate selection indices. Genotypic and phenotypic correlation revealed that at both level fruit yield was positively associated with number of fruits, number of nodes per plant, fruit length and fruit weight.

The fruit yield per plant showed highly significant positive correlation with plant height, days to 50 % flowering, fresh weight per pod and pod length which indicate that these characters invariably increase pod yield. Days to 50 % flowering was positively correlated with plant height; indicates that when internode formation ceases at floral initiation the early maturing okra cultivars usually have short status. There were positive significant phenotypic and genotypic correlations of fresh weight per pod with days to 50 % flowering, pod length and diameter. In this study, the pod yield per plant had negative significant relationship with days to 50 % flowering. This study was conducted by Aminu *et al.* (2016).

Radha Rani *et al.* (2016) stated that first fruiting node showed negative association with yield per plant. Apart from this, all the studied characters were positively and significantly correlated with yield per plant. Number of fruits per plant exhibited highest positive correlation with yield followed by plant height both at genotypic and phenotypic levels and fruit girth at genotypic level only. Plant height had high positive and significant correlation coefficients with internodal length, fruit girth, number of fruits per plant and number of nodes per plant at genotypic and phenotypic level respectively. Number of fruits per plant had positive correlation with plant height.

Shivaramgowda *et al.* (2016) revealed that there was a significant positive correlation among fruit length and fruit weight. The yield per plant has strong positive correlation with number of fruits per plant, fruit weight and number of primary branches.

Kerure *et al.* (2017) showed that the fruit yield per plant show positive association with stem girth, number of branches per plant, plant height, first fruit

producing node, fruit length, fruit diameter, average fruit weight and number of fruits per plant at genotypic and phenotypic levels. The fruit yield per plant have negative correlation with days to 50 % flowering.

Prasath *et al.* (2017) observed that number of branches showed positive and significant correlation with internodal length, fruit length, fruit weight, number of fruits per plant. internodal length showed positive and significant correlation with fruit length, fruit weight, number of fruits per plant. Days to 50 % flowering showed positive correlation with days to first harvest. Fruit length showed significantly positive correlation with fruit weight, number of fruits per plant. Also fruit girth showed significantly positive correlation with fruit weight and number of fruit per plant.

Pithiya *et al.* (2017) studied that the characters such as number of fruits per plant followed by plant height showed highest positive significant correlation with yield per hectare.

Syfullah *et al.* (2018) observed that there was a significant positive genotypic and phenotypic correlation between fruit yield and plant height, number of fruits per plant and average fruit weight. Also fruit yield per plant shown negatively and insignificantly correlated with fruit length and fruit diameter and only negative phenotypic correlation with days to 50 % flowering.

Shuirkar *et al.* (2018) observed that length of internode, days to 50 % flowering, fresh fruit weight had significant and positive correlation with plant height whereas length of internode, first fruiting node, days to first fruit length had highest significant and negative association with plant height. Length of internode was recorded positive and significant correlation with days to 50 % flowering, days to first picking and highly significant to fresh weight. Days to 50 % flowering had significant and positive association with first fruiting node, days to first harvesting, fruit length and fruit weight. Days to first picking was recorded highly significant positively correlated with number of fruits per plant. Length of fruit was observed highly significant and positive correlation coefficient with fresh fruit weight. Fresh fruit weight was observed positive correlation with yield per plant. Number of fruits per plant was observed positive correlation with fresh fruit weight.

Patra *et al.* (2018) revealed that there was significant negative correlation between incidence of YVMV at 30DAS and number of fruits per plant as compared to YVMV incidence at 45, 60 and 75 DAS. It suggested that selection of genotype against YVMV screening of okra should be done at 30 DAS only.

Raval *et al.* (2019) stated that plant height, number of branches per plant and fruit weight had significant highly positive correlation with number of fruits per plant. Number of branches per plant had positive and highly significant correlation with plant height, followed by internodal length and fruit weight. Fruit weight had positive and highly significant correlation with fruit length. Days to first picking showed negative and highly significant correlation with yield per plant, plant height and number of fruits per plant. Also Plant height exhibited positive and highly significant correlation with internodal length.

Kumari *et al.* (2019) reported according to the Phenotypic correlation analysis that the yield per plant showed highly significant positive correlation with fruit length, fruit width, average fruit weight and number of fruits per plant whereas it showed highly significant negative association with internodal length and number of nodes. At genotypic level, yield per plant has significant positive correlation with fruit width, fruit length, fruit weight, number of fruits per plant and number of nodes per plant while had a significant negative correlation with plant height, days to 50 % flowering and internodal length.

Binepal *et al.* (2019) observed significant positive phenotypic correlation of fruit yield per plant with fruit weight, number of fruits per plant, number of branches per plant, fruit width, days to first picking and 50 % flowering. Fruit yield per plant recorded highest significant coefficient of correlation with fruit weight, number of fruits per plant, number of branches per plant, fruit width, days to first picking and days to 50% flowering. Hence this character may help to determine yield in okra. It is also observed that plant height had highly significant positive association with length of internodes and highly significant negative association with number of branches per plant. Also number of branches per plant was recorded significant and positive association with number of fruits per plant with number of fruit per plant, fruit yield per plant, fruit weight, fruit width and fruit length.

Hamim Ashraf *et al.* (2020) studied that there was highly significant positive genotypic correlation of picking duration with fruit diameter and fruit length, plant height at final harvest with fruit length and fruit weight, fruit length with fruit weight and diameter and also of fruit weight with fruit yield. There was a significant positive genotypic and phenotypic correlation of fruit per plant with fruit yield.

Pawar *et al.* (2020) revealed that Days to 50 % flowering and internodal length had negative genotypic and phenotypic correlation whereas number of primary branches per plant, fruit length, fruit width, fruit weight, number of fruits per plant, number of nodes per plant and plant height had positive phenotypic and genotypic correlation with fruit yield per plant.

Rynjah *et al.* (2020) carried out correlation and path coefficient analysis studies in thirty six okra genotypes for fourteen traits. The study revealed that yield per plant was positively correlated with fruit girth, fruit length, number of fruits per plant, plant height and fruit weight at genotypic level of correlation. Whereas the characters, per cent disease incidence, days to fifty per cent flowering, internodal length and days to first flowering were found to have negative correlation with single plant yield at genotypic level.

Ranga *et al.* (2021) observed that the plant height showed a highly significant and positive correlation with days to 50% flowering. The number of fruits per plant showed significant and positive results with fruit length and yield per plant. Fruit length showed a significant and positive correlation with yield per plant.

2.3 Path coefficient analysis

Dhall *et al.* (2000) revealed that there was maximum direct effect on total yield of number of fruits per plant, fruit weight, fruit length and plant height. Such characters should be sought for improving yield potential.

Patro and Ravishankar (2004) revealed high positive direct effect on fruit yield per plant of characters such as fruit weight, fruit length, number of ridges. Also Plant height, number of branches per plant number of nodes per plant and YVMV incidence showed direct positive effect. Maximum negative direct effect was recorded in fruit length. Maximum positive indirect effect was observed between fruit weight and number of ridges.

Adiger *et al.* (2011) observed that the fruit weight had the highest direct effect followed by number of fruits per plant, plant height and number of branches per plant in path coefficient analysis studies and the highest negative direct effect was shown by Days to 50 % flowering followed by fruit diameter. However high positive indirect effect was found in case of number of fruits per plant via number of branches per plant, plant height and fruit length

Das *et al.* (2012) reported highly positive direct effects of number of fruits per plant and fruit weight on fruit yield per plant.

Balai *et al.* (2014) stated that Plant height had high indirect and positive effect via average weight of edible pod which was also positively and significantly correlated with yield per plant; though characters such as number of branches per plant, plant height, length of pod and days to first harvest showed negative direct effect on yield per plant.

Ahmed *et al.* (2015) studied path coefficient analysis which revealed that plant height had shown negative direct effect on yield per plant however there was indirect and significant positive effect through number of fruits per plant which recompense the yield.

Saryam *et al.* (2015) recorded positive direct effect of number of fruits per plant, branches per plant, fruit diameter on yield per plant of okra.

The Correlation and Path analysis revealed that characters days to first picking, plant height at harvest, number of nodes per plant and number of fruits per plant not only had positive significant association with yield per plant but also had high positive direct effects on marketable yield per plant and are regarded as the main determinants of yield per plant. If selection is based on these characters then improvement in yield will be efficient resulted by Narkhede *et al.* (2015)

Aminu *et al.* (2016) studied Path coefficient analysis and showed that number of pods per plant had direct positive effect on pod yield. The characters having indirect positive effect are days to 50 % flowering, plant height, number of pods per plant, pod diameter, number of primary branches per plant and fresh weight per pod. Hence this characters could be taken into consideration for selection and development of high yielding varieties in okra.

Radha Rani *et al.* (2016) revealed that number of fruits per plant had highest positive effect on yield per plant. Among all the characters studied, all the traits showed positive direct effect on yield except internodal length which showed negative direct effect on yield per plant. The highest indirect effect of number of fruits per plant observed with plant height, internodal length followed girth.

Kerure *et al.* (2017) revealed in the path analysis studies that fruit yield had positive direct effect of number of fruits per plant followed by average fruit weight, days to 50 % flowering and fruit length and high positive indirect effect was recorded in case of number of branches per plant, plant height, first fruit producing node, fruit length, fruit diameter, average fruit weight and number of fruits per plant.

Prasath *et al.* (2017) studies path analysis and stated that there was a positive direct effect on fruit yield per plant because of plant height, internodal length, fruit girth, fruit weight, number of fruits per plant. Number of fruits per plant had high positive and indirect effect through plant height, number of branches, internodal length and fruit weight.

Pithiya *et al.* (2017) studied path analysis and resulted direct positive effect of number of fruits per plant, plant height fruit length and number of branches on yield of okra.

The path coefficient analysis study done by Syfullah *et al.* (2018) revealed that number of fruits per plant had highest positive direct effect on fruit yield per plant followed by fruit weight and plant height; whereas indirect positive effect on plant height, fruit weight, number of primary branches per plant and fruit length. Plant height showed positive direct phenotypic and genotypic effects on pod yield while indirect positive effect was observed via days to 50 % flowering, primary branches, number of fruit s per plant, fruit length, fruit diameter and fruit weight. Fruit length shows negatively direct effect on fruit yield and indirect positive effect on fruit weight, fruit diameter and days to 50 % flowering.

Patra *et al.* (2018) revealed that there was a positive direct effect of YVMV incidence at 90 DAS in fruit yield. On contrary, YVMV incidence at 45 and 60 DAS has negative direct effect on fruit yield.

Raval *et al.* (2018) analysed the path coefficient and revealed that number of fruits per plant, days to first picking, fruit weight, internodal length had highest positive direct effect on fruit yield per plant. However, fruit girth, plant height, number of branches per plant had negative direct effect on fruit yield per plant.

Kumari *et al.* (2019) resulted that the fruit width, number of nodes per plant,, days to 50 % flowering had positive direct effect on fruit yield hence this characters are of great importance for future okra genetic improvement.

Hamim Ashraf *et al.* (2020) stated that fruit yield had high positive direct effect with fruits per plant and fruit weight indicating major contribution of fruit yield in genotypes.

Pawar *et al.* (2020) found that at phenotypic level as well as genotypic level, fruit weight had highest direct effect on fruit yield followed by number of fruits per plant, plant height, fruit length, number of branches per plant, fruit width, number of nodes per plant, internodal length while days to 50 % flowering record negative direct effect. In terms of indirect effect, Fruit weight had positive indirect effects through fruit width, number of primary branches per plant, days to 50 % flowering, fruit length whereas negative indirect effect through number of nodes per plant, plant height, internodal length, internodal length and number of fruits per plant. Days to 50 % flowering exhibited positive indirect effect on fruit length followed by number of fruits per plant, internodal length and negative indirect effect throughout plant height, number of primary branches, fruit weight, number of nodes per plant and fruit width at both phenotypic and genotypic level. Number of primary branches per plant at both genotypic and phenotypic level show negative indirect effect through plant height, number of nodes per plant and fruit length whereas positive indirect effect through fruit width, followed by internodal length, number of fruits per plant, fruit weight and days to 50 % flowering.

Rana *et al.*(2020) observed that the average fruit weight had highest positive direct effect of number of fruits per plant, plant height and internodal length whereas negative direct effect was shown by number of primary branches and fruit diameter. Positive direct effects showing traits might be beneficial for the improvement of fruit yield.

Rynjah *et al.* (2020) revealed that the high positive direct effect on yield plant was contributed by fruit girth followed by plant height, fruit weight, fruit length and number of branches per plant. Hence, improvement in yield will be efficient if selection is based on fruit girth, fruit length, number of fruits per plant, plant height and fruit weight and short flowering period.

Ranga *et al.* (2021) observed that the number of fruits per plant had the highest direct positive effect towards the yield per plant and other traits such as fruit length had direct effects. Traits such as days to the first flowering node and plant height had a direct effect with a negative sign whereas days to 50% flowering had no effect on yield.

2.4 Cluster Analysis

Patro and Ravishankar (2004) grouped 41 varieties into eight clusters; in which cluster IV had highest number of genotypes and cluster VII had least numbers. The cluster pattern did not seem to have direct association with genetic diversity. The inter cluster distance is maximum between VII and VIII whereas minimum between II and VIII. Cluster VI showed high mean values for number of branches per plant, number of branches per plant, number of ridges per fruit, fruit length, fruit weight and yield per plant which makes it superior to other clusters.

Akotkar *et al.* (2010) analyse 50 genotypes according to Mahalanobis D^2 analysis which are grouped in five clusters. Cluster I consists of 45 genotypes while cluster II have 2 genotypes and the rest are monogenotypic. On comparison, cluster II and cluster IV showed maximum distance followed by II & V and IV & V.

Prakash and Pitchaimuthu (2010) grouped 44 genotypes into twelve clusters. Cluster III was the largest with eight genotypes followed by I and VIII with seven, cluster II with five, cluster XII with three, genotypes while clusters IV, V, IX, X and XI had two genotypes each. These genotypes are grouped irrespective of their geographical origin. The cluster XII followed by cluster VIII recorded the maximum intra cluster distance. Maximum inter-cluster distance was observed between cluster VI and VIII and after that cluster I and IX which validate them as more divergent than rest of the clusters and can be taken in evolving good hybrids.

Ahiakpa *et al.*, (2013) noted above 95% of inter-cluster genetic distances among the thirty okra accessions studied. Direct relation was observed between the ecogeographical origins of the okra accessions and their clustering patterns. All the accessions were clustered together except Nkuruma tia, likewise accessions from Ashanti and Greater Accra regions.

Koundinya *et al.* (2013) studied D^2 analysis in which genotypes were grouped in nine clusters from which cluster V consists of highest number of genotypes and lowest in cluster VI. Maximum intra cluster distance was recorded in cluster IX. The highest inter cluster distance was between cluster VI and IX followed by cluster IV and VII. Cluster VI and IV had higher cluster mean values for various important traits.

Umrao *et al.* (2014) assessed genetic diversity of 50 genotypes based on 11 traits using D^2 statistics and grouped it into eight broad clusters. Maximum inter cluster distance was observed in between cluster II and VII followed by cluster I and VII, cluster IV and VII and cluster V and VII and minimum for cluster I and IV. The genotypes grouped in Cluster VII were diverse from the other clusters also had highest mean values for plant height and weight of fruit. Cluster II genotypes had highest mean value for number of branches per plant.

Amoatey *et al.* (2015) studied 29 genotypes for 13 characters and two clusters were formed at 67.90 per cent similarity which are re grouped into two sub-clusters, making total four sub clusters at 76.30 per cent genetic similarities. The four sub clusters consists of 10, 5, 10 and 4 genotypes respectively. There was highest inter-cluster distance between first and last sub cluster which may be useful for future improvement programme through hybridization.

Asare *et al.* (2016) distinguished 21 okra genotypes into 3 main clusters which shows 43 per cent of genetic dissimilarity based on 31 quantitative and qualitative morphological characters. 61.9 per cent of okra genotypes are distinguished in cluster I, 33.3 per cent in cluster III whereas single okra genotype is present in cluster II.

Shivaramgowda *et al.* (2016) 36 germplasm accessions were grouped according to yield and yield related traits into four clusters. Cluster I is largest containing 12 germplasms whereas Cluster III is smallest and made of 6 germplasms. Cluster II and VI contain 8 and 10 germplasms respectively.

Syfullah *et al.* (2018) studied clustering pattern which are grouped into five clusters on the basis of yield component studied. The cluster I, II, III, IV and V comprises of two, six, five, five and ten genotypes respectively. The intra cluster D^2 values recorded maximum in cluster II followed by cluster V. Inter cluster average D^2 values were higher between cluster I and V, followed by cluster I and II.

Patra *et al.* (2018) grouped 14 genotypes into four clusters; within these clusters, Cluster I consists of three genotypes whereas Cluster II and III consists of two and three genotypes respectively. Rest of the genotypes are included in cluster IV. Average inter-cluster difference study revealed that cluster I and II were most divergent followed by cluster IV & I and III & I. According to the presented investigation, The genotypes in Cluster I and II show resistance to YVMV, hence should be used in the development of hybrids.

3. MATERIALS AND METHODS

The present investigation entitled, “Variability studies in elite type okra (*Abelmoschus esculentus* L. Monech) genotypes” was conducted at Research Farm of All India Co-ordinated Research Project on Vegetable crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Late Kharif* Season of Year 2020. The details of material used and methods followed are described in this chapter.

3.1 Experimental Material

The material used under this investigation consisted of thirty-one diverse genotypes and Phule Vimukta as a Standard check obtained from Senior Vegetable Breeder, All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri. The detailed information about the genotypes is provided in Table 3.1.

3.2 Climatic conditions

Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra is situated between 19°47' and 19°57' North latitudes and between 74°82' and 74°19' East longitudes according to geographical standpoints. The altitude varies from 495 to 565 meters above the main sea level. This tract lie on the eastern side of Western Ghats and falls under the rain shadow areas.

With respect to climate, the central campus falls under semi- arid and subtropical zone with the rainfall varying from 307 to 619 mm with the average annual rainfall as 520 mm. However, the precipitation is erratic and ill distributed, 80 per cent of it is received during the period from June to September. Most of the rainfall is generally received from South-west Monsoon. Agro climatically the area falls under drought prone areas of Maharashtra state facing droughts frequently.

The Meteorological Data on important weather parameters recorded during the crop growth period at the meteorological observatory of Central Campus Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra are presented in Table 3.2.

The maximum temperatures during the experimentation period ranged between 27.7 to 32.9°C while minimum temperature ranges from 12.3 to 23.8°C. The relative humidity during morning and evening ranged between 93.4 – 82 per cent and between 40.7- 75 per cent, respectively. The wind velocity ranged between 0.6 – 4.7

Km/hr. During the Experimental period the highest average rainfall of 40mm was observed.

3.3 Methods

Seeds of 31 genotypes with Phule Vimukta as standard check of okra were directly sown during late *kharif* season of 2020. This experiment was laid out in Randomized Block Design with two replications to study the variability in the genotypes and to identify the elite genotypes for the future hybridization programme.

Sowing of each genotype of okra was directly sown on both sides of the ridges. The Ridges were prepared by keeping the distance of 60 cm between two ridges and 30 cm distance between two plants. The net plot size is $2.4 \times 3 \text{ m}^2$. For recording the observations ten plants were randomly selected among the treatment and all the observations were recorded from the selected plants.

3.4 Observation recorded

3.4.1 Growth character

Following observations were recorded on ten randomly selected plants from each treatment in each replication and averages were worked out.

3.4.1.1 Days to 50 % flowering

Days to 50 % flowering were recorded as number of days required from the day of sowing to the day on which 50 percent of the plants flowered.

3.4.1.2 First fruiting node

Randomly ten plants are selected and the node at which first flower appears subsequently first fruit appears was counted and average was calculated.

3.4.1.3 Internodal length

Average length of internodes was calculated by dividing height of the plant by number of nodes per plant.

3.4.1.4 Plant height (cm)

At the time of last harvesting, plant height was measured from the ground level to the tip of the plants in centimetres.

3.4.1.5 Days to first harvest (Days)

Number of days taken from the date of sowing to date of first picking of the edible fruits in selected plants was recorded as days to first harvest.

3.4.1.6 Harvest duration

Total number of days from first fruit harvesting to final fruit harvesting were recorded and average value was expressed as harvest duration.

3.4.1.7 Number of lobes per leaf

The number of lobes per leaf were counted for randomly selected ten plants and average was calculated.

3.4.1.8 Number of branches per plant

The number of primary branches per plant was counted for randomly selected ten plants at the time of last harvesting and average was worked out.

3.4.2 Yield contributing character**3.4.2.1 Fruit length (cm)**

The length of marketable fruit was measured from the base (without pedicel) to the tip of fruit at the time of harvest for ten randomly selected fruits of selected plants from each replication.

3.4.2.2 Fruit diameter (cm)

The diameter of previously selected ten fruits for fruit length from each selected plant was recorded using Vernier calliper.

3.4.2.3 Average fruit weight (g)

Previously used selected ten fruits for fruit length and diameter were used for calculating Average fruit weight by dividing total weight of ten harvested fruits with total number of selected fruits and an average is worked out and recorded for each replication.

3.4.2.4 Number of fruits per plant

The number of fruits per plant were counted at every harvesting and were summed up and average was taken.

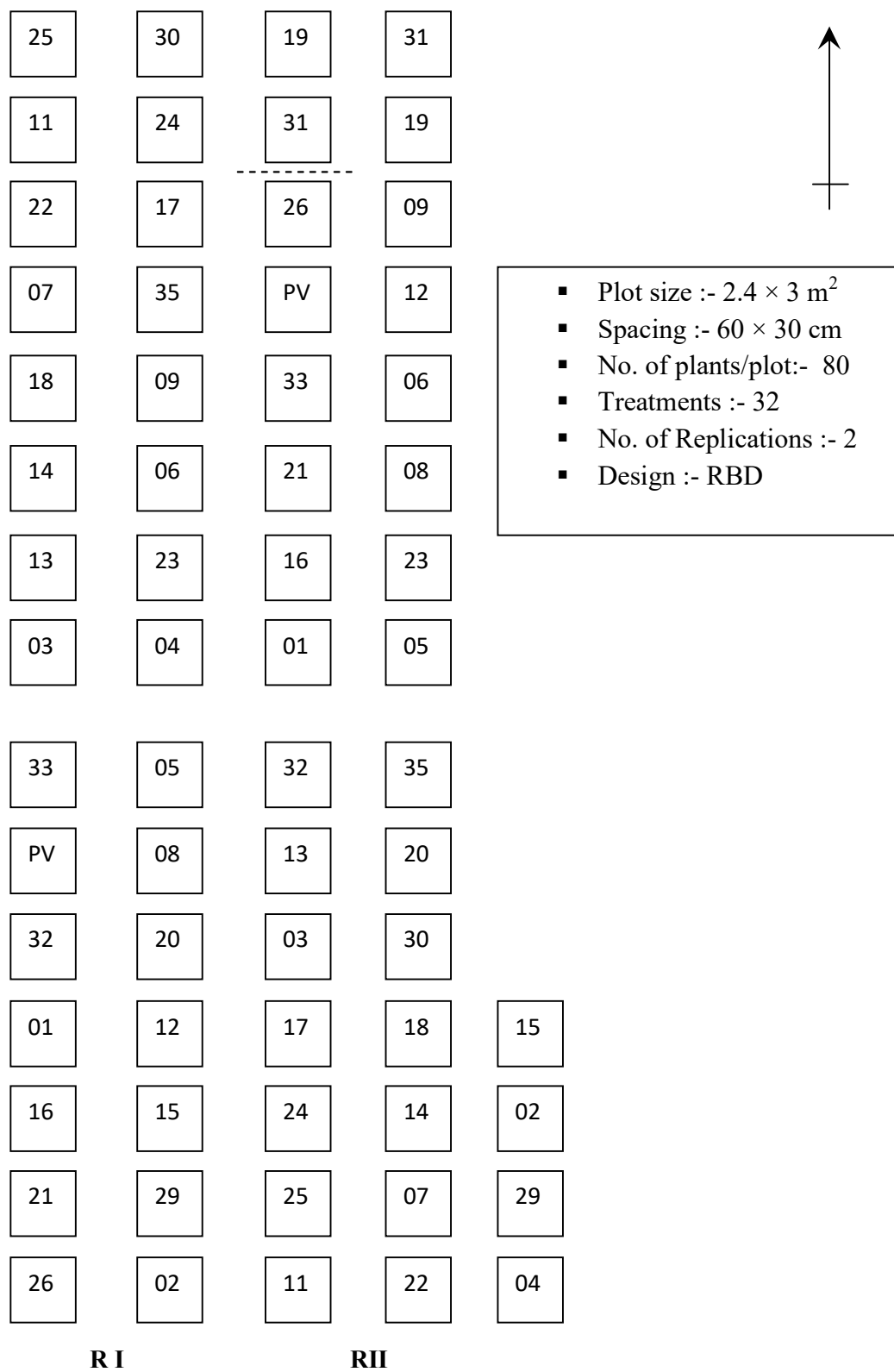
Fig. 3.1 Layout of the experimental site

Table 3.1. Different okra genotypes and their sources

Sr. No.	Genotype notation	Source of Genotype
1	Phule Vimukta	AICRP on Vegetables, MPKV, Rahuri
2	RKROK-25	AICRP on Vegetables, MPKV, Rahuri
3	RKROK-11	AICRP on Vegetables, MPKV, Rahuri
4	RKROK-22	AICRP on Vegetables, MPKV, Rahuri
5	RKROK-07	AICRP on Vegetables, MPKV, Rahuri
6	RKROK-18	AICRP on Vegetables, MPKV, Rahuri
7	RKROK-14	AICRP on Vegetables, MPKV, Rahuri
8	RKROK-13	AICRP on Vegetables, MPKV, Rahuri
9	RKROK-03	AICRP on Vegetables, MPKV, Rahuri
10	RKROK-33	AICRP on Vegetables, MPKV, Rahuri
11	RKROK-32	AICRP on Vegetables, MPKV, Rahuri
12	RKROK01	AICRP on Vegetables, MPKV, Rahuri
13	RKROK-16	AICRP on Vegetables, MPKV, Rahuri
14	RKROK-21	AICRP on Vegetables, MPKV, Rahuri
15	RKROK-26	AICRP on Vegetables, MPKV, Rahuri
16	RKROK-30	AICRP on Vegetables, MPKV, Rahuri
17	RKROK-24	AICRP on Vegetables, MPKV, Rahuri
18	RKROK-17	AICRP on Vegetables, MPKV, Rahuri
19	RKROK-35	AICRP on Vegetables, MPKV, Rahuri
20	RKROK-09	AICRP on Vegetables, MPKV, Rahuri
21	RKROK-06	AICRP on Vegetables, MPKV, Rahuri
22	RKROK-23	AICRP on Vegetables, MPKV, Rahuri
23	RKROK-04	AICRP on Vegetables, MPKV, Rahuri
24	RKROK-05	AICRP on Vegetables, MPKV, Rahuri
25	RKROK-08	AICRP on Vegetables, MPKV, Rahuri
26	RKROK-20	AICRP on Vegetables, MPKV, Rahuri
27	RKROK-12	AICRP on Vegetables, MPKV, Rahuri
28	RKROK-15	AICRP on Vegetables, MPKV, Rahuri
29	RKROK-29	AICRP on Vegetables, MPKV, Rahuri
30	RKROK-02	AICRP on Vegetables, MPKV, Rahuri
31	RKROK-19	AICRP on Vegetables, MPKV, Rahuri
32	RKROK-31	AICRP on Vegetables, MPKV, Rahuri

3.4.2.5 Number of ridges per fruit

The number of ridges on randomly selected ten fruits were counted and average was worked out.

3.4.2.6 Fruit yield per plant (g)

Fruit yield per plant was calculated by each harvesting and finally all were summed up and worked out as yield per plant in grams.

3.4.2.7 Fruit yield per plot (kg)

At each harvesting fruits were harvested and summed up and worked out as fruit yield per plot to each treatment and mentioned in quintal.

3.4.2.8 Fruit yield per hectare (q/ha)

The yield per hectare is calculated by multiplying hector factor to yield per plot to each treatment and mentioned in quintal.

3.4.3 Qualitative characters

3.4.3.1 Stem colour

The stem colour was recorded on the basis of visual observation as Red, reddish green and green.

3.4.3.2 Petiole colour

The petiole colour was recorded on the visual observation as Red, reddish green and green.

3.4.3.3 Leaf colour

The leaf colour was recorded on the visual observation as reddish green, green, dark green

3.4.3.4 Flower colour

The flower colour was recorded as yellow and yellow reddish tinge.

3.4.3.5 Fruit colour

The fruit colour was recorded as green, dark green, light green and reddish green.

3.4.3.6 Pubescence

Pubescence was recorded on visual observation as high, low and medium.

3.4.4 Incidence of Pests and Diseases

3.4.4.1 Incidence of Yellow Vein Mosaic Virus

Disease symptoms and number of diseased plants were recorded 30, 45, 90 and 120 days after planting. Disease severity was recorded according to the procedure given by Ali *et al.* (2005) with a slight modification. Table 3.2 summarizes the disease symptoms and respective severity scale used in this study. Based on that scale Percentage of Disease Incidence (PDI) (Sankara and Acharyya, 2012) and Disease Severity Index (DSI) (McKinney, 1923) were calculated.

The percentage Disease Incidence was Calculated by the formula

$$\text{PDI} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

PDI = Percentage of Disease Incidence, (Sankara and Acharyya, 2012)

The Disease Severity Index was calculated by the formula

$$\frac{\sum \text{severity scale} \times \text{Total of infected plants}}{5 \times \text{Total number of plants}} \times 100$$

DSI - Disease Severity Index (McKinney, 1923)

3.4.4.2 Incidence of Fruit and shoot borer

The fruit borer incidence was calculated by the formula given below

$$\text{Fruit borer incidence} = \frac{\text{Number of fruits infected}}{\text{Total number of fruits harvested}} \times 100$$

Table 3.2. Description of Okra YVMV disease symptoms used for scoring

Description of symptoms	Severity scale	Rating Scale	Severity Range (%)
Absence of symptoms	0	HR	0
Very mild symptoms, initial vein clearing	1	R	1-20
Leaf veins completely yellow and inter-veinal regions remain green or normal	2	MR	20-40
Curly leaves and whole leaf get yellow color	3	MS	40-60
Whole leaf yellow coloured. Leaf Margin start drying	4	S	60-80
Yellowish and deformed pods with whole leaf yellow coloured. All leaves of the plant get affected	5	HS	80-100

Adopted from : Ali *et al.* (2005)

Note : R – Resistant, HR – Highly resistant, MR – Moderately resistant, MS – Moderately susceptible, S – Susceptible, HS – Highly Susceptible

3.5 Statistical Analysis

The mean values of ten randomly selected observational plants for seventeen different traits were used for statistical analysis. The following statistical

measures/ parameters were calculated for presentation of the data on different quantitative attributes.

3.5.1 Analysis of Variance

The analysis of variance was done as suggested by Panse and Sukhatme (1985). The data was done as subjected to computer analysis *viz.*, variation due to replication, treatment and error. Significance of treatment effects were tested by 'F' test. The analysis was done in the following form

Sr. No.	Source of variation	Degree of freedom	MSS	Expected mean sum of squares
1	Replication	r-1	MSS Rep	$\sigma e^2 + t \sigma^2 r$
2	Gentotypes	t-1	MSS Gen	$\sigma e^2 + r \sigma^2 t$
3	Error	(r-1)(t-1)	MSSE	σe^2
4	Total	Rt-1		

Where,

r = number of replication

t = number of treatments

3.5.2 Test of Significance

If the variance ratio (MSSTrt / MSSE) is greater than the tabulated value of F, then the differences were considered as significant. On the basis of above condition we could reject the null hypothesis. The differences were considered as non significant only if it was lower than the Table value. We accept the null hypothesis in this condition.

3.5.3 Variability Parameters

3.5.3.1 Mean Performance

Mean is calculated by dividing the sum of all observations in a sample by their number. The formula for calculating the mean is presented as below.

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

Where,

$\sum X$ = Summation of all the observations for the character in each replication

N = Corresponding number of observations

3.5.3.2 Range

It is the difference between the lowest and highest values presented in the observation included in the sample. The lowest and highest value for each character observed was taken into consideration.

3.5.3.3 Variance

The sum of squares of deviations of all observations of a sample from its mean divided by degrees of freedom.

3.5.3.3.1 Genotypic Variance

It is calculated by the formula given below.

$$\sigma^2 = \frac{\text{MSSTrt} - \text{MSSE}}{r}$$

Where,

MSSTrt = Treatment mean sum of squares

MSSE = Error Mean sum of squares

r = Number of replications

3.5.3.3.2 Phenotypic Variance

Phenotypic variance was calculated by the following formula

$$\sigma^2_p = \text{Genotypic variance} + \text{Environmental Variance}$$

Where,

Environmental Variance = Mean sum of squares due to error

3.5.3.4 Standard error of mean

Standard error of mean was calculated by the formula

$$\text{SED} = \sqrt{\frac{2\text{MSSE}}{r}}$$

3.5.3.5 Critical Difference

The following is the formula to calculate critical difference

Standard error of mean was calculated by the formula

$$\text{CD} = \sqrt{\frac{2\text{MSSE}}{r}} \times t_{\alpha}$$

Where,

t_{α} = “t” Table value at error degree of freedom at 5 % level of significance

R = number of replications

MSSE = Mean sum of square due to error

3.5.3.6 Coefficient of Variation

It is an important measure of variability and is the per cent ratio of standard deviation of a sample to its mean.

3.5.3.6.1 Genotypic coefficient of variation (GCV)

It was estimated as per the formula suggested by Burton (1952).

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

Where,

σ^2_g = Genotypic variance

$\bar{X}$ = General mean of the character

3.5.3.6.2 Phenotypic coefficient of variation (PCV)

It was estimated as per the formula suggested by Burton (1952)

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

Where,

$\sigma^2_p = V_p$ = Phenotypic Variance

3.5.3.7 Heritability (broad sense)

Heritability denotes the proportion of phenotypic variance that is due to genotype and hence heritable. Heritability (h^2) was worked out by using formula suggested by Lush (1949) and Burton and Devane (1953).

The values of heritability are categorized as follows (Johnson *et al*, 1955)

Low	:	less than 30 %
Moderate	:	30- 60 %
High	:	More than 60 %

$$h^2 \text{ (broad sense)} = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

Where,

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

3.5.3.8 Genetic Advance

The formula for genetic advance that means expected genetic gain was suggested by Lush (1949) and Johnson *et al.*, (1955) is presented below

$$GA = k\sigma_p h^2 (bs)$$

$$GA = k \sigma_p h^2 (bs)$$

Where,

K = Selection differential in standard units which is 2.06 at 5 % of selection intensity (in the present study)

$h^2 (bs)$ = Heritability

σ_p = Phenotypic standard deviation

3.5.3.9 Genetic advance as % of mean (GAM)

$$GAM (\%) = \frac{GA}{\text{Grand mean}} \times 100$$

Genetic advance as % of mean values are categorized as follows

High : More than 20 %

Medium : 10 – 20 %

Low : Less than 10 %

3.5.4 Correlation

To understand the association among the characters, genotypic and phenotypic correlation coefficients were worked out by adopting method described by Singh and Choudhary (1977).

3.5.4.1 Phenotypic correlation coefficients

$$\gamma_p = \frac{\text{Covariance } X, Y_{(p)}}{\sqrt{\text{Variance } X_{(p)}, \text{Variance } Y_{(p)}}}$$

Where,

r_p = Phenotypic correlation coefficient between character X and Y

p = Phenotypic

3.5.4.2 Genotypic correlation coefficient

$$\gamma_g = \frac{\text{Covariance } X, Y_{(g)}}{\sqrt{\text{Variance } X_{(g)}, \text{Variance } Y_{(p)}}}$$

Where,

r_g = Genotypic correlation coefficient between character X and Y

g = Genotypic

Significance of correlation coefficients were tested by 't' test (Panse and Sukhatme, 1985)

3.5.5 Path Analysis

The direct and indirect influence of components of flower yield path coefficient analysis was done by the methods employed by Dewey and Lu (1959) for the first time in plants. When the cause and effect relationship was well defined the whole systems of variables was represented by "Path Diagram" which was very helpful for solving the simultaneous equations directly. Path coefficient was obtained by solving a set of simultaneous equations as per Dewey and Lu (1959).

$$Rn_y = Pn_y + r_{n_2} \cdot P_2y + r_{n_3} \cdot P_3x + \dots$$

Where, r_{n_y} = correlation coefficient between one component and yield

Pn_y = Path coefficient between character and yield

Rn_2 = correlation between that character and each of the other yield component.

Direct effect of the character was given by Pn_y

Indirect effect of a particular character through other characters was obtained by multiplication of direct paths and respected correlation coefficients between these characters respectively.

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

$$i = 1 \text{ to } 10 \text{ and } j = 1 \text{ to } 10$$

$$P_{ij} = P_{1y}, p_{2y}, \dots, P_{10y}$$

The Residual effect R was calculated as below,

$$R^2 = 1 - (P_{1y} \cdot r_{1y} + P_{2y} \cdot r_{2y} + \dots + P_{ny} \cdot r_{ny})$$

Where,

$P_{1y}, P_{2y}, \dots, P_{ny}$ = Direct effects of respective characters on fruit yield.

$r_{1y}, r_{2y}, \dots, r_{ny}$ – Correlation coefficient between respective characters and yield.

The scales for path coefficient (Lenka and Mishra, 1973)

Values for Direct or Indirect effects	Rate or Scale
0.00 – 0.09	Negligible
0.1 – 0.19	Low
0.20 – 0.29	Moderate
0.30 – 0.99	High
More than 1.00	Very high

3.5.6 Genetic Divergence

3.5.6.1 D^2 analysis

The generalized distance between any two populations is defined as

$$\Delta^2 = \sum \sum \lambda_{ij} \sigma^i \sigma^j$$

Where,

λ_{ij} = Reciprocal matrix to the common dispersion matrix

σ^i = Difference between the mean values of the two populations for i^{th} character.

$$D^2 = \sum \sum S_{ij} \sigma^i \sigma^j$$

Where,

S_{ij} = sample estimates of σ_{ij}

σ^i = sample estimate of σ_i

This formula requires the inversion of 16^{th} order of determinant and the evaluation of 16 (16 + 1/2) terms whose sum is D^2 .

3.5.6.2 Wilk's criteria

A simultaneous test of significance of difference in the values of a number of correlated variables with regard to the Pooled effect of the ten characters considered together was carried using Wilk's criteria (Wilk, 1932)

Where,

$$\Lambda = \frac{|E|}{|E + V|}$$

$|E|$ = Determinant of the error sum of squares and sum of products matrix

$|E + V|$ = Determinant of error sum of squares and sum of products plus population sum of squares and product matrix. #

Significance of Λ was estimated by X as

$$X^2_{pq} = -m \log_e \Lambda$$

Where,

$$m = \frac{p + q + 1}{2}$$

n = $N_1 + \dots + N_{k-1}$, = Total number of observations - 1

p = Number of characters

q = $K - 1$

K = Number of genotypes

3.5.6.3 Determination of population constellation

Tocher's method as described by Rao (1952) was followed for cluster formation. No formal rules can be laid down for finding the cluster because a cluster is not a well defined term. The only criteria appears to be that any two groups belonging to the two different clusters. A simple device suggested by K. D. Tocher is to start with the two closely associated groups and find a third group which has the smallest D^2 from the first two. Similarly, the fourth group is chosen to have the smallest D^2 from the first three and so on. If at any stage the average D^2 of a group from those already listed appears to be high, then this group does not fit in the former groups and is therefore taken outside the formal cluster. The groups of the first cluster then omitted and the rest are treated similarly. It is also useful to calculate the change in average D^2 within the cluster due to

the inclusion of an additional group. If the changes are appreciable, then the newly added group has to be considered as outside the cluster.

3.5.6.4 Average Intra and Inter-cluster D^2 and D values

3.5.6.4.1 Average Intra-cluster D^2 and D Values

$$D^2 = \frac{\sum D_i^2}{N}$$

Where,

D_i = Sum of distances between all possible combinations (n) of the population included in the cluster.

3.5.6.4.2 Average Inter-cluster D^2

$$D^2 = \frac{\sum \text{distance between the population of cluster } i \text{ and } j}{n_i n_j}$$

Where,

n_i = Number of populations in the cluster i

n_j = Number of populations in the cluster j.

3.5.6.5 Cluster mean

Cluster mean where calculated for individual character on the basis of mean performance of the genotypes included in that cluster.

3.4.6.6 Contribution of individual characters towards genetic divergence

The character contribution towards genetic divergence was computed as suggested Singh and Chaudhary (1977). From all combinations, each character was ranked on the basis of $d_i = y_{ij} - y_{ik}$ values. Where, d_i = mean deviation y_{ij} = mean of the jth genotype for the ith character and y_{ik} = mean value of the kth genotype for the character. Rank 'I' is given to the highest mean difference and rank 'P' is given to the lowest mean difference Where, P is the total characters. For estimation of per cent contribution of characters towards divergence, the number of times that each character appeared in the first rank is computed.

4. RESULT AND DISCUSSION

In plant breeding, it is necessary to select best genotype combination having genetic variability present within it to obtain a superior genotype. For this, a complete study should be done on the plant population available to access variability present in it and to further select suitable genotypes as per our desired objectives and which can be further used as a parent in breeding programmes.

In this chapter, the results of the presented experiment entitled, “Variability Studies of elite type okra (*Abelmoschus esculentus* L. Monech) genotypes” are described under suitable headings. This experiment was carried out during late *kharif*-2020 and studies were carried out according to the following points:

- 4.1 Study of Qualitative Characters
- 4.2 Analysis of Variance
- 4.3 Mean Performance of Genotypes
- 4.4 Genetic Variability Studies
- 4.5 Correlation Coefficient Analysis
- 4.6 Path Coefficient Analysis
- 4.7 Genetic Divergence

4.1 Study of Qualitative Characters

Along with the growth and yield contributing characters, qualitative characters also have equal importance with respect to market and export. In this experiment, the qualitative characters recorded are namely; stem colour, petiole colour, leaf colour, flower Colour, fruit colour, pubescence and seediness which are further given in the Table 4.1 and elaborated as under.

4.1.1 Stem Colour

For stem colour, all the thirty two genotypes studied are grouped into three categories *viz.*, Reddish green, Green and Red. Eleven genotypes including standard check Phule Vimukta is of reddish green colour stem whereas three genotypes had red stem colour and rest of the genotypes had green coloured stem.

4.1.2 Petiole Colour

With respect to petiole colour, twelve genotypes had reddish green petiole including Phule Vimukta, three genotypes had red coloured petioles and rest of the genotypes had green coloured petioles.

4.1.3 Leaf Colour

The standard check Phule Vimukta had dark green colour foliage. All the rest of the genotypes had green foliage colour except for RHROK 32, RHROK 19 and RHROK 11 having reddish green leaves.

4.1.4 Flower Colour

The plant had borne flowers of yellow colour with red centre to all the genotypes but the genotypes namely RHROK 32, RHROK 19 and RHROK 11 had yellow coloured corolla with reddish tinge.

4.1.5 Fruit Colour

The genotypes *viz.* RHROK 24, RHROK 22, Phule Vimukta, RHROK 09, RHROK 18, RHROK 30 had dark green coloured fruits. Genotypes namely RHROK 32, RHROK 19 and RHROK 11 bore reddish green coloured fruits. Fruits of eleven genotypes bore light green coloured fruits and rest of the other genotypes had green coloured fruits.

4.1.6 Pubescence

Based on the intensity of presence of pubescence on the fruits of Okra, the genotypes are grouped into High (H), Medium (M), Low (L). From which five genotypes had high pubescence, eighteen genotypes had medium pubescence while nine genotypes had low pubescence.

4.1.7 Seediness

According to the observations recorded visually, there were thirteen genotypes having no seediness in the fruits while twelve genotypes had slight seediness present. Two genotypes had medium and rest of the four genotypes had high seediness is present,

Table 4.1. Qualitative characters of thirty- two okra genotypes

Sr. No.	Genotypes	Stem colour	Petiole colour	Leaf colour	Flower colour	Fruit colour	Pubescence	Seediness
1	RHROK02	Reddish Green	Reddish Green	Green	Yellow	Light Green	L	High
2	RHROK05	Green	Green	Green	Yellow	Green	M	No
3	RHROK09	Reddish Green	Reddish Green	Green	Yellow	Dark Green	L	Slight
4	RHROK12	Green	Green	Green	Yellow	Green	H	No
5	RHROK18	Green	Green	Green	Yellow	Dark Green	M	Slight
6	Phule Vimukta	Reddish Green	Reddish Green	Dark Green	Yellow	Dark Green	M	No
7	RHROK07	Green	Green	Green	Yellow	Green	L	No
8	RHROK31	Reddish Green	Reddish Green	Green	Yellow	Green	H	No
9	RHROK08	Green	Green	Green	Yellow	Light Green	M	No
10	RHROK01	Green	Green	Green	Yellow	Light Green	L	Slight
11	RHROK17	Reddish Green	Reddish Green	Green	Yellow	Green	L	High
12	RHROK26	Green	Green	Green	Yellow	Light Green	M	No
13	RHROK23	Green	Green	Green	Yellow	Light Green	M	Slight
14	RHROK20	Green	Green	Green	Yellow	Light Green	L	Slight
15	RHROK15	Green	Green	Green	Yellow	Green	M	No
16	RHROK29	Green	Green	Green	Yellow	Green	M	No
17	RHROK14	Green	Green	Green	Yellow	Light Green	M	Slight
18	RHROK33	Green	Green	Green	Yellow	Light Green	L	Slight
9	RHROK03	Reddish Green	Reddish Green	Green	Yellow	Light Green	M	Slight
20	RHROK24	Reddish Green	Green	Green	Yellow	Dark Green	M	Medium
21	RHROK06	Green	Green	Green	Yellow	Green	M	High
22	RHROK04	Green	Green	Green	Yellow	Light Green	M	No
23	RHROK22	Green	Green	Green	Yellow	Dark Green	H	Slight
24	RHROK35	Reddish Green	Reddish Green	Green	Yellow	Green	M	Slight
25	RHROK16	Green	Reddish Green	Green	Yellow	Light Green	L	No
26	RHROK30	Reddish Green	Reddish Green	Green	Yellow	Green	M	No
27	RHROK21	Green	Green	Green	Yellow	Green	H	High
28	RHROK32	Red	Reddish Green	Reddish Green	Yellow with red tinge	Green with reddish tinge	H	Medium
29	RHROK19	Red	Red	Reddish Green	Yellow with red tinge	Green with reddish tinge	M	High
30	RHROK25	Reddish Green	Reddish Green	Green	Yellow	Dark Green	L	Slight
31	RHROK13	Reddish Green	Reddish Green	Green	Yellow	Green	M	No
32	RHROK11	Red	Red	Reddish Green	Yellow with red tinge	Green with reddish tinge	M	Slight

4.2 Analysis of Variance

All the eleven characters studied in analysis of variance (Table 4.2) showed significant differences among the thirty two genotypes studied which implies substantial variability is present among the genotypes of those characters.

The characters that found to have significant differences in the presented study was also observed by the following scientists, Jindal *et al.* (2010), Reddy *et al.* (2012), Duggi *et al.* (2013), Barche *et al.* (2014), Chandramouli *et al.* (2016), Kumar *et al.* (2019), Singh *et al.* (2020), Ranga *et al.* (2021).

Table 4.2. Analysis of Variance (ANOVA) for eleven characters of okra

Sr. No	Character	Mean Sum of Squares		
		Replication (II)	Treatment (31)	Error (31)
1	50 % flowering	16.00**	12.563**	2.968
2	first fruiting node	0.123**	0.205**	0.059
3	Internodal length (cm)	0.817**	0.920**	0.359
4	Plant height(cm)	434.7597**	333.859**	18.729
5	Days to first harvest	19.141**	8.346*	4.786
6	Number of branches/plant	0.681*	1.486**	0.131
7	Fruit length(cm)	0.865	0.847**	0.279
8	Fruit Diameter(cm)	0.0002	0.008**	0.002
9	Fruit Weight (cm)	2.176**	1.242**	0.247
10	Number of fruits/plant	8.237*	8.327**	1.893
11	Fruit yield/plant (g)	989.024*	1491.981**	181.870

*,** indicates level of significance at 1 % and 5 % respectively

4.3 Mean Performance of Okra genotypes

4.3.1 Growth characters

The average mean performance estimated for all the eleven characters from Growth, yield contributing and disease and pest incidence was covered for all the thirty-two genotypes under the Table 4.3.

4.3.1.1 50 % Flowering

The days required for the 50 percent plants in a plot to bear flowers ranges from 42.50 DAS (Phule Vimukta and RHROK 09) to 49 DAS (RHROK 03 and RHROK 31) for all the genotypes studied. Sixteen genotypes were found to be significantly early than the general mean (45.71) but only one of the genotype borne 50 per cent flowering in the similar time span of standard check Phule Vimukta and genotypes *viz.* RHROK 02 (42.50 DAS), RHROK 11 (42.50) and RHROK 35 (43 DAS) had bore 50 per cent flowering in the same range of same time.

4.3.1.2 First Fruiting Node

The values estimated of first fruiting node ranges from 5.00 (RHROK 29) to 6.70 (RHROK 11) from the ground level. For genotype RHROK 29, the fruiting node appears at lowest levels followed by RHROK 06 (5.50), RHROK 07 (5.30), RHROK 01 (5.30), RHROK 17 (5.30) and about sixteen genotypes had bore fruits at significantly lower level than the general mean (5.6) including the above mentioned genotypes which are also significantly superior to Phule Vimukta.

4.3.1.3 Internodal Length

Short internodal length is a desirable character for increased yield. In this case minimum internodal length was noticed in RHROK15 (5.03 cm) followed by RHROK 14 (5.12 cm), RHROK 21 (5.25), RHROK 06 (5.68 cm) and rest of the genotypes further. The internodal length for these studied genotypes ranges from 5.03 cm (RHROK 15) to 7.70 cm (RHROK 07). In terms of numerical value of internodal length, there are nineteen genotypes which are superior to standard check Phule Vimukta (6.73) including the genotypes mentioned above.

4.3.1.4 Plant Height

For plant height, the genotype RHROK 09 (135.41 cm) was found to be tallest followed by RHROK 02 (134.03 cm), RHROK 12 (133.87 cm), RHROK 32 (132.25 cm), RHROK 07 (130.89), RHROK 03 (129.83 cm) and the rest. Above mentioned genotypes along with three more genotypes are significantly superior to Phule Vimukta. Apart from these, RHROK 21(90.97 cm) followed by RHROK 29 (99.20 cm) and RHROK 35 (110.50 cm) had minimum height amongst all the genotypes.

Table 4.3. Mean performance of all the genotypes for the following characters

Sr. No.	Genotypes	50 % flowering	First fruiting node	Internodal length (cm)	Plant height (cm)	Days to first harvest	Harvest duration	No. of branches/ plant	Fruit length (cm)
1	RHROK02	42.50	5.70	6.97	134.03	50.50	66.50	2.90	11.21
2	RHROK05	47.00	5.40	7.47	127.94	50.50	66.50	5.00	10.24
3	RHROK09	41.50	5.50	6.85	135.41	48.00	69.00	2.80	10.76
4	RHROK12	45.00	5.10	6.72	133.87	51.50	65.50	2.70	11.61
5	RHROK18	47.50	6.00	6.86	123.37	51.50	65.50	3.00	10.63
6	Phule Vimukta	42.50	5.40	6.73	123.25	48.00	69.00	2.80	10.67
7	RHROK07	46.50	5.30	7.70	130.89	49.00	68.00	5.90	10.70
8	RHROK31	49.00	5.50	6.92	122.98	59.00	58.00	4.30	10.89
9	RHROK08	46.50	5.40	6.29	121.25	53.00	64.00	2.70	10.71
10	RHROK01	46.00	5.30	6.21	118.63	49.00	68.00	3.40	11.72
11	RHROK17	44.00	5.30	7.00	124.24	50.50	66.50	3.60	10.91
12	RHROK26	48.50	5.80	6.13	100.60	50.00	67.00	5.30	11.22
13	RHROK23	44.50	5.60	6.68	113.26	50.50	66.50	3.00	11.22
14	RHROK20	48.50	5.40	6.01	104.03	53.00	64.00	3.20	10.31
15	RHROK15	44.50	5.70	5.03	102.94	51.50	65.50	3.20	10.63
16	RHROK29	46.00	5.00	5.86	99.20	51.50	65.50	3.00	10.62
17	RHROK14	45.00	5.60	5.12	107.38	50.50	66.50	3.20	10.64
18	RHROK33	44.00	5.70	6.20	101.88	49.00	68.00	3.30	10.57
19	RHROK03	49.00	5.60	7.34	129.83	53.00	64.00	2.80	11.13
20	RHROK24	43.50	5.90	5.94	103.81	50.50	66.50	2.70	11.36
21	RHROK06	43.00	5.50	5.68	100.76	50.50	66.50	2.70	10.62
22	RHROK04	48.50	5.70	6.41	100.52	53.00	64.00	2.60	11.11
23	RHROK22	45.50	5.70	7.64	107.34	50.00	67.00	3.10	11.02
24	RHROK35	43.00	5.60	6.82	110.50	49.00	68.00	2.60	10.61
25	RHROK16	48.50	5.50	6.00	103.66	50.00	67.00	2.80	10.78
26	RHROK30	48.50	6.20	6.44	104.57	53.00	64.00	3.80	11.45
27	RHROK21	46.00	5.50	5.25	90.97	50.00	67.00	3.40	10.87
28	RHROK32	45.50	5.60	7.22	132.25	49.00	68.00	1.90	9.81
29	RHROK19	46.50	5.50	6.30	117.26	51.50	65.50	2.40	10.76
30	RHROK25	45.50	6.00	6.03	100.63	51.50	65.50	2.40	10.87
31	RHROK13	48.50	5.50	6.45	103.68	50.50	66.50	2.70	10.39
32	RHROK11	42.50	6.70	6.13	105.21	50.50	66.50	2.50	10.44
	Mean	45.71	5.60	6.45	113.63	50.89	66.11	3.17	10.83
	S.E.	1.22	0.17	0.28	3.06	1.41	1.41	0.26	0.37
	C.D. 5%	3.51	0.49	0.82	8.83	4.07	4.07	0.74	1.08
	C.V.	3.78	4.35	6.23	3.81	3.92	3.03	11.39	4.81

Table 4.3 contd....

Sr. No.	Genotypes	Fruit diameter (cm)	Fruit weight (g)	No. of fruits/plant	Fruit yield/plant (g)	Fruit yield/plot (kg/ha)	Fruit yield/ha (q/ha)	YVMV Incidence (%)	Borer Incidence (%)
1	RHROK02	1.39	11.80	21.49	255.42	17.88	248.32	10.21	6.29
2	RHROK05	1.45	12.20	18.78	222.62	15.58	216.43	0.00	5.25
3	RHROK09	1.48	12.50	17.98	220.01	15.40	213.90	10.40	5.42
4	RHROK12	1.48	11.00	18.40	210.52	14.74	204.67	5.12	7.32
5	RHROK18	1.43	11.00	18.97	218.01	15.26	211.96	0.00	6.20
6	Phule Vimukta	1.41	12.90	15.84	206.80	14.48	201.06	6.29	4.80
7	RHROK07	1.37	10.80	19.75	215.80	15.11	209.80	0.00	5.33
8	RHROK31	1.53	11.40	18.75	222.31	15.56	216.14	6.69	11.14
9	RHROK08	1.39	10.90	18.15	198.20	13.87	192.70	6.75	7.17
10	RHROK01	1.47	11.10	17.73	197.29	13.81	191.81	0.00	6.20
11	RHROK17	1.50	11.20	18.65	206.17	14.43	200.44	3.56	7.74
12	RHROK26	1.48	11.60	17.47	199.12	13.94	193.59	0.00	4.40
13	RHROK23	1.44	11.00	16.50	189.15	13.24	183.89	9.70	7.57
14	RHROK20	1.42	10.40	17.41	186.93	13.09	181.74	7.91	5.86
15	RHROK15	1.42	10.30	17.57	185.77	13.00	180.61	11.03	9.65
16	RHROK29	1.47	10.30	17.04	180.09	12.61	175.09	0.00	6.45
17	RHROK14	1.49	11.60	16.71	192.68	13.49	187.33	0.00	6.25
18	RHROK33	1.50	10.50	16.03	178.14	12.47	173.19	7.50	6.44
19	RHROK03	1.48	12.60	15.26	187.60	13.13	182.39	3.96	5.20
20	RHROK24	1.46	11.50	16.17	186.88	13.08	181.69	14.93	6.63
21	RHROK06	1.44	10.50	17.45	182.20	12.75	177.14	9.46	4.99
22	RHROK04	1.54	10.80	16.12	173.69	12.16	168.87	0.00	6.32
23	RHROK22	1.50	11.50	15.86	184.08	12.89	178.97	8.23	7.20
24	RHROK35	1.48	11.20	14.63	167.13	11.70	162.49	7.50	9.33
25	RHROK16	1.43	10.50	15.34	168.95	11.83	164.25	7.29	6.01
26	RHROK30	1.52	11.60	14.73	175.79	12.31	170.90	0.00	8.00
27	RHROK21	1.40	10.60	14.36	158.48	11.09	154.07	0.00	5.30
28	RHROK32	1.46	11.60	13.77	165.19	11.56	160.60	0.00	12.52
29	RHROK19	1.48	10.00	14.71	158.27	11.08	153.87	7.88	9.04
30	RHROK25	1.50	10.60	13.54	141.98	9.94	138.03	0.00	9.41
31	RHROK13	1.43	9.20	14.37	136.84	9.58	133.04	0.00	7.18
32	RHROK11	1.46	10.60	12.07	127.96	8.96	124.40	0.00	6.34
	Mean	1.4617	11.10	16.61	187.50	13.12	182.29	4.51	6.97
	S.E.	0.03	0.3	0.97	9.53	0.66	9.27	2.22	0.23
	C.D. 5%	0.09	1.01	2.81	27.50	1.92	26.74	6.44	0.68
	C.V.	3.19	4.47	8.28	7.19	7.18	7.19	3.07	1.82

4.3.1.5 Days to first harvest

The days from sowing to first harvest ranges from 48.00 DAS (Phule Vimukta) to 59.00 DAS (RHROK 31). None of the genotypes was ready to harvest before Phule Vimukta. But some genotypes such as RHROK 09 (48.00 DAS), RHROK 07 (49.00 DAS), RHROK 33 (49.00 DAS), RHROK 35 (49.00 DAS), RHROK 32 (49.00 DAS), were also early for harvest in the similar range of time.

4.3.1.6 Harvest Duration

The maximum harvest duration was seen in the genotype Phule Vimukta (69 Days), RHROK 09 (69 Days), followed by RHROK 07 (68 Days), RHROK 01 (68 Days), RHROK 33 (68 Days), RHROK 35 (68 Days) and RHROK 32 (68 Days). The duration of harvest ranges for 58 days (RHROK 31) to 69 days (Phule Vimukta, RHROK 09). The population mean of the studied okra genotypes was 50.89 and about twelve genotypes exceeds this value. None of the genotype was superior to the check variety for this character but RHROK 09 (69 days) had similar harvest duration.

4.3.1.7 Number of lobes per leaf

For all the genotypes presented under study including standard check Phule Vimukta found to have five lobes per leaf. No variation in this character was found.

4.3.1.8 Number of branches per plant

The number of branches per plant were ranged from 5.90 (RHROK 07) to 1.90 (RHROK 32). The maximum number of branches was observed for RHROK 07 (5.90), RHROK 26 (5.30), RHROK 05 (5.00) and other. Twelve genotypes along with the mentioned genotypes are significantly more number of branches than the population mean (3.17). Also for this character, 20 genotypes were superior to the standard check Phule Vimukta. More side branches suggest more number of fruiting nodes which results in increased yields. Also varieties having more branching habit can also be considered for ratooning.

4.3.2 Yield contributing characters

4.3.2.1 Fruit Length

The maximum to minimum range of fruit length for all the thirty two genotypes is between 11.72 cm (RHROK 01) to 9.81 cm (RHROK 32). Maximum value for fruit length is for RHROK 01 (11.72 cm) followed by RHROK 12 (11.61 cm),

RHROK 30 (11.45 cm) and so on whereas minimum values of fruit length are of RHROK 32 (9.81 cm) followed by RHROK 05 (10.24 cm), RHROK 20 (10.31 cm).

4.3.2.2 Fruit Diameter

Maximum fruit diameter was recorded for RHROK 04 (1.54 cm) followed by RHROK 31 (1.53 cm), RHROK 30 (1.52 cm), RHROK 17 (1.50 cm), RHROK 22 (1.50 cm), RHROK 25 (1.50 cm) and so on. Whereas minimum diameter was recorded for the genotype RHROK 07 (1.37 cm) followed by RHROK 08 (1.39 cm), RHROK 02 (1.39 cm) and the rest.

4.3.2.3 Fruit Weight

The range of mean performance for fruit weight ranges between 9.20 g (RHROK 13) to 12.90 g (Phule Vimukta). Maximum fruit weight was recorded for Phule Vimukta followed by RHROK 03 (12.60 g), RHROK 09 (12.50 g), RHROK 05 (12.20 g) and so on. The general mean for this character was recorded 11.10 g, which was exceeded by fourteen genotypes.

4.3.2.4 Number of fruits per plant

The number of fruits per plant amongst all the genotypes ranges from 21.49 (RHROK 02) to 12.07 (RHROK 11). Maximum number of fruits was recorded for RHROK 02, followed by RHROK 07 (19.75), RHROK 18 (18.97), RHROK 05 (18.78), RHROK 31 (18.75) and so on. The population mean for all the genotypes was 16.61 to which sixteen genotypes were found to be superior and twenty genotypes were superior to standard check Phule Vimukta.

4.3.2.5 Number of ridges per plant

On an average about 5 ridges per fruit were observed for all the genotypes taken in consideration.

4.3.2.6 Fruit yield per plant

The maximum yield per plant was noted for RHROK 02 (255.42 g/plant), followed by RHROK 05 (222.62), RHROK 31 (222.31 g/plant), RHROK 09 (220.01 g/plant), RHROK 18 (218.01 g/plant), RHROK 07 (215.80 g/plant) and so on. Minimum yield was observed for RHROK 11 (127.96 g/plant). The genotypes mentioned above are also superior to the standard check Phule Vimukta and fourteen genotypes were found to be significantly superior to the general mean (187.50).

4.3.2.7 Fruit yield per plot

The mean performance of the genotypes for yield per plot ranges from 17.88 kg/plot (RHROK 02) to 8.96 kg/plant (RHROK 11). The genotypes which were superior to standard check Phule vimukta are RHROK 02 (17.88kg/plot), RHROK 05 (15.58 kg/plot), RHROK 31 (15.56 kg/plot), RHROK 09 (15.40 kg/plot), RHROK 18 (15.26 kg/plot), RHROK 07 (15.11 Kg/plot) and RHROK 12 (14.74 kg /plot).

4.3.2.7 Fruit yield per hectare

The mean performance of the genotypes for yield per hectare ranges from 248.32 q/ha (RHROK 02) to 124.40 q/ha (RHROK 11). The genotypes which were superior to standard check Phule Vimukta are RHROK 02 (248.32 q/ha), RHROK 05 (216.43 q/ha), RHROK 31 (216.14 q/ha), RHROK 09 (213.90 q/ha), RHROK 18 (211.96 q/ha), RHROK 07 (209.80 q/ha) and RHROK 12 (204.67 q/ha).

4.3.3 Disease and pest Incidence

4.3.3.1 YVMV Incidence

The incidence of yellow vein mosaic virus was not seen up to around 120 days after sowing for all the genotypes studied. About Fifteen genotypes including standard check didn't show any symptoms of infestation throughout the harvest duration. And rest of the genotypes showed very mild symptoms of infestation and its incidence ranges from 3.56 per cent (RHROK 17) to 14.93(RHROK 24) per cent which was also considered as resistant to the yellow vein mosaic infestation.

4.3.3.2 Fruit borer Incidence

The fruit borer incidence for all the okra genotypes ranges from 4.40 per cent (RHROK 26) to 12.52 per cent (RHROK 32). The nineteen genotypes had significantly less pest incidence than the population mean (6.97). Only RHROK 26 genotype had significantly lower pest incidence than the standard check Phule Vimukta.

4.4 Parameters of Genetic Variability

Genetic variability is the basis of every crop improvement programme. Testing of the variability parameters is fundamental for the purpose of developing superior cultivars. High variability provides greater scope for improvement. Variability is estimated at genotypic and phenotypic level with the help of genotypic and phenotypic coefficient of correlation, heritability (broad sense h^2) as well as genetic advance.

The range of mean values, genotypic and phenotypic variance, Genotypic and Phenotypic coefficient of variation, heritability and genetic advance were illustrated under the Table 4.5.

4.4.1 Variance

In this experiment, the values of phenotypic variance is greater than genotypic variance indicating presence of environmental influence.

Among the estimated genotypic and phenotypic variances (V_p and V_g) for eleven characters of okra, fruit yield per plant had highest values of genotypic and phenotypic variances (836.93 and 655.06) followed by plant height (176.29 and 157.56) whereas lowest for fruit diameter (0.01 and 0.00).

4.4.2 Coefficient of Variation

The phenotypic and genotypic coefficient of variation was estimated for eleven characters of okra which is presented in the Table 4.4. The magnitude of PCV was higher than the magnitude of GCV for all the eleven characters observed.

The number of branches per plant (25.901, 27.123) had high (>20 %) estimate of GCV and PCV. Moderate values (10-20 %) of GCV and PCV were observed for Fruit yield per plant (13.65, 14.57), plant height (11.05, 11.37) and number of fruits per plant (10.80, 12.28) showing moderate amount of variability among the genotypes. Rest of the characters such as fruit diameter, first fruiting node, fruit length, Days to first harvest, 50 per cent flowering and fruit weight had low (< 10%) values of coefficient of Variation. In the case of internodal length, It has moderate PCV value (10.52) while low GCV value (8.22).

The number of branches per plant obtained maximum magnitude of coefficient of variation at both genotypic and phenotypic level. It confirms the presence of high genetic and non genetic variation present for that specific character. Hence, it should be considered while selecting genotypes.

The magnitude of PCV was higher than GCV was also observed by the scientists Prakash and Pithaimuthu (2010), Adiger *et al.* (2011), Ahmed *et al.* (2015), Barche *et al.* (2014), Khajuria *et al.* (2016), Radha rani *et al.* (2016) and Shivaramegovda *et al.* (2016).

Patro and Ravishankar (2004), Alam and Hossain (2008), Chaurasia *et al.* (2010), Adiger *et al.* (2011), Reddy *et al.* (2012), Duggi *et al.* (2013), Vishnu Priyanka *et al.* (2018) also found high magnitude of GCV and PCV for number of branches per plant. The result for the values of coefficient of variation for plant height, number of fruits and yield per plant is accordance with Adiger *et al.* (2011) and Rana *et al.* (2020).

Moderate values of yield and number of fruits per plant was also estimated by Kaundinya *et al.* (2013), Nikitha *et al.* (2016), Thulasiram *et al.* (2017), Makhdoomi *et al.* (2018), Vishnu priyanka *et al.* (2018) and Kumari (2019) *et al.* Also Chaurasia *et al.* (2010) and Ranga *et al.* (2021) observed moderate values for Plant height.

Kaundinya *et al.* (2013), Vishnu Priyanka *et al.* (2018) and Kumari *et al.* (2019) showed similar results with respect to Days to first harvest, fruit weight, fruit length, fruit diameter and 50 per cent flowering. Whereas Jindal *et al.* (2010) for fruit length and diameter, Adiger *et al.* (2011) and Reddy *et al.* (2012) for 50 per cent flowering and fruit diameter, Chandramauli *et al.* (2016) for 50 percent flowering and fruit weight, Ramgiry *et al.* (2017) for first fruiting node and 50 per cent flowering, Patra *et al.* (2018) for first fruiting node, fruit length and fruit weight and Makhdoomi *et al.* (2018) for Days to first harvest, fruit weight and length showed similar results.

With respect to internodal length, the result was in accordance with Kumari *et al.* (2019) while Makhdoomi *et al.* (2018) showed moderate results at both genotypic and phenotypic levels and Vishnu priyanka *et al.* (2018) observed low magnitude of coefficient of variation.

4.4.3 Heritability (bs)

As per the result obtained, heritability (broad sense) per cent values of plant height (89.4 %) was high (>60 %) followed by number of branches (83.8 %), fruit yield per plant (78.3 %), internodal length (70.1 %), fruit weight (66.9 %), number of fruits per plant (63.4 %) and 50 per cent flowering (61.8 %). Moderate values of heritability (30-60 %) was estimated for fruit diameter (56.8 %), first fruiting node (55.2 %), fruit length (50.4 %) and days to first fruit harvest (35.3 %). Lowest heritability (< 30 %) was observed for the character such as days to first harvest, fruit length, first fruiting node, fruit diameter, number of fruits per plant and fruit weight.

For the high values of heritability (h^2), the resulted values are in accordance with Adiger *et al.* (2011), Reddy *et al.* (2012), Singh *et al.* (2017) and Rana *et al.* (2020).

4.4.4 Genetic Advance

The estimates of heritability will not be of practical values without genetic advance which highlights the concurrent use of genetic advance along with heritability. High heritability alone is not enough to make sufficient improvement though selection in genetic advance generation.

The magnitude of genetic advance ranges from 46.64 (fruit yield per plant) to 0.09 (fruit diameter) genetic advance was highest for the fruit yield per plant (46.64) followed by plant height (24.45), 50 per cent flowering (3.55), Number of fruits per plant (2.93) whereas lowest genetic advance was estimated for fruit diameter (0.09). The estimates of both heritability and genetic advance as per cent of mean are high for fruit yield per plant hence is under the control of additive gene effect and selection will be efficient.

4.4.5 Genetic advance as per cent of mean (%)

Highest genetic advance as per cent mean ($> 20\%$) was observed for number of branches per plant (48.84 %), fruit yield per plant (24.88 %), Plant height (21.51 %) whereas Number of fruits per plant (17.65 %) and internodal length (16.47 %) had moderate value of genetic advance as per cent mean (10-20 %). The lowest genetic advance as per cent means ($> 10\%$) was observed for fruit weight (1.52 %) followed by fruit diameter, fruit length, days to first harvest, first fruiting node and 50 per cent flowering.

For the high genetic advance as of mean values, the result is in accordance with Chaurasia *et al.* (2010), Jindal *et al.* (2010), Duggi *et al.* (2013), Kaundinya *et al.* (2013), Shravanti *et al.* (2016), Shivarammegovda *et al.* (2016), Singh *et al.* (2017), Thulasiram *et al.* (2017) and Kerure *et al.* (2017). High GAM values for fruit yield per plant and plant height was also observed by Adiger *et al.* (2011), Kumar *et al.* (2020), Rana *et al.* (2020) and Singh *et al.* (2020). Moderate values for number of fruits per plant was also resulted by Chaurasia *et al.* (2010), Adiger *et al.* (2011), Thulasiram *et al.* (2017) and Verma *et al.* (2018). Moderate values of internodal length was noted by

Table 4.4. Genetic variability parameters of thirty-two genotypes of okra

Sr. No.	Character	Range	General Mean	GV	PV	GCV (%)	PCV (%)	EVC (%)	h²(bs)	GA	GA as 5 % Mean
1.	50 % flowering	38-49	45.59	4.80	7.77	4.80	5.50	3.78	61.8	3.55	7.78
2.	First fruiting node	5-6.8	5.60	0.07	0.13	4.82	5.72	4.35	55.2	0.41	7.38
3.	Internodal length(cm)	4.59-8.41	6.45	0.37	0.54	8.22	10.52	6.23	70.1	1.06	16.47
4.	Plant height(cm)	88.57-140.78	113.63	157.56	176.29	11.05	11.37	3.81	89.4	24.45	21.51
5.	Days to first harvest	48-62	50.89	2.18	6.17	2.62	4.01	3.39	35.3	1.81	3.55
6.	No. of branches/plant	1.8-6.4	3.18	0.67	0.81	25.90	27.12	11.39	83.8	1.55	48.84
7.	Fruit length(cm)	9.81-11.72	10.83	0.28	0.56	4.85	5.93	4.81	50.4	0.78	7.10
8.	Fruit Diameter(cm)	1.37-1.54	1.46	0.00	0.01	3.66	4.30	3.19	56.8	0.09	5.67
9.	Fruit Weight (cm)	8.6-13	11.10	0.50	0.74	6.35	7.10	4.47	66.9	1.19	1.52
10.	No. of fruits/plant	11.57-23.01	16.61	3.21	5.11	10.80	12.28	8.28	63.4	2.93	17.65
11.	Fruit yield/plant(g)	117.66-275.18	187.50	655.06	836.93	13.65	14.57	7.19	78.3	46.64	24.88

Kumar *et al.* (2020). Low values of GAM were observed by Jindal *et al.* (2010) for first fruiting node, fruit length and diameter, Kaundinya *et al.* (2013) for 50 per cent flowering, first fruiting node, fruit length and fruit diameter, Chandramouli *et al.* (2016) for 50 per cent flowering, days to first harvest, first fruiting node, Singh *et al.* (2017) for fruit weight, Thulasiram *et al.* (2017) 50 per cent flowering, days to first harvest and fruit weight, Vishnu Priyanka *et al.* (2018) and Singh *et al.* (2020) for 50 per cent flowering, first fruiting node, days to first harvest, fruit length and fruit diameter.

4.5 Correlation Coefficient Analysis

Correlation coefficient is a statistical measure, for finding out the degree (strength) and direction of relationship between two or more variable. The correlation between traits may occur because of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all.

This correlation studies would provide definitive information about nature, extent and the direction of the selection especially when the breeder needs to combine high yield potential with desirable traits. The genotypic and phenotypic correlation coefficient of different traits with fruit yield per plant and their interrelations are given in Table 4.5 and are discussed here under following points.

4.5.1 Association of fruit yield per plant with other characters

From the correlation studies, it was observed that for all the characters studied the magnitude of genotypic correlation coefficient in general was higher than phenotypic correlation coefficient. The correlation coefficient between the eleven characters at both, genotypic and phenotypic levels are presented as follows.

The fruit yield per plant had significant positive association with internodal length ($r_g = 0.437$, $r_p = 0.367$), plant height ($r_g = 0.719$, $r_p = 0.592$), number of branches per plant ($r_g = 0.504$, $r_p = 0.391$), fruit length ($r_g = 0.749$, $r_p = 0.407$), fruit weight ($r_g = 0.617$, $r_p = 0.529$), number of fruits per plant ($r_g = 0.933$, $r_p = 0.911$). Also fruit yield per plant had significant negative association with first fruiting node ($r_g = 0.489$, $r_p = 0.309$) and non-significant association with 50 % flowering, first fruiting node and days to first harvest.

Adiger *et al.* (2011) also showed high positive significant relationship between fruit yield per plant and internodal length, plant height, number of branches per plant, fruit length, fruit weight and number of fruits per plant. Aminu *et al.* (2020) and Pawar *et al.* (2020) resulted significant positive association with plant height, number of branches per plant, fruit length, fruit weight and number of fruits per plant. Shivaramegovda *et al.* (2016) and Binopal *et al.* (2019) showed significant positive relation of yield with number of branches per plant, fruit weight and number of fruits per plant. Narkhede *et al.* (2015) and Kumari *et al.* (2019) found significant positive association with fruit length and weight as well as number of fruits per plant. Also, Das *et al.* (2012) showed significant positive relationship with plant height, number of fruits per plant, fruit length and fruit weight, Nwangburukha *et al.* (2012) with plant height, number of branches per plant and number of fruits per plant, Balai *et al.* (2014) with plant height fruit weight and number of fruits per plant, Barche *et al.* (2014) with fruit weight and number of fruits per plant, Radha Rani *et al.* (2016) with internodal length, plant height, fruit weight and number of fruits per plant and Prasath *et al.* (2017) with internodal length, plant height, number of branches per plant and fruit length.

Adiger *et al.* (2011) and Aminu *et al.* (2016) also observed non significant positive relation with fruit diameter and Kerure *et al.* (2017), Prasath *et al.* (2017) and Pawar *et al.* (2020) resulted negative non significant relation with plant yield as estimated in the present findings.

4.5.2 Association Among Fruit Yield Component Traits

4.5.2.1 50 per cent flowering

Among inter correlation, there is significant positive relationship with days to first harvest ($r_g=0.821$ $r_p=0.477$) and significant negative relationship with fruit weight ($r_g=-0.032$, $r_p=-0.288$). Number of branches per plant and 50 per cent flowering had significant positive relationship ($r_g=0.409$) at genotypic level and non significant relationship at phenotypic level. 50 per cent flowering had non-significant relationship with first fruiting node, internodal length, plant height, fruit length, number of fruits per plant.

4.5.2.2 First fruiting node

First fruiting node had significant positive association with fruit diameter ($r_g=0.260$) at genotypic level and non significant relation at phenotypic level. First fruiting node had significant negative relation with plant height ($r_g=-0.351$ $r_p=-0.252$). Also first fruiting node had non significant negative relationship with internodal length, Days to first harvest, number of branches per plant, fruit length and fruit weight.

4.5.2.3 Internodal length

Internodal length had significant positive association with plant height ($r_g=0.758$ $r_p=0.679$), fruit diameter ($r_g=0.592$ $r_p=0.255$), fruit weight ($r_g=0.601$ $r_p=0.347$). number of branches per plant had significant positive relationship ($r_g=0.274$) at genotypic level and non significant relationship at phenotypic level. Also internodal length and fruit length had significant positive relation at genotypic level and non significant relationship at phenotypic level. It had nonsignificant relationship with days to first harvest.

4.5.2.4 Plant height

Plant height had nonsignificant relationship with days to first harvest and number of branches per plant. It has significant positive relationship with fruit length ($r_g=0.404$ $r_p=0.269$), fruit weight ($r_g=0.663$ $r_p=0.462$) and number of fruits per plant ($r_g=0.586$ $r_p=0.434$). fruit length ($r_g=0.4514$) had significant positive association with plant height at genotypic level and non significant at phenotypic level.

4.5.2.5 Days to first harvest

Days to first harvest had nonsignificant relationship with number of branches per plant, fruit diameter, fruit weight and number of fruits per plant. Days to first harvest ($r_g=0.461$) had significant positive relation with fruit length at genotypic level and non significant relation at phenotypic level.

4.5.2.6 Number of branches per plant

Number of branches per plant has significant positive relationship with number of fruits per plant ($r_g=0.609$ $r_p=0.395$) and nonsignificant relationship with fruit diameter and fruit weight. Number of branches per plant had significant positive relationship with fruit length ($r_g=0.2988$) at genotypic level and non significant relationship at phenotypic level.

Table 4.5. Estimates of Genotypic (Above Diagonal) and Phenotypic (below Diagonal) Correlation for eleven Characters of okra

Sr. No.	Characters	50 % flowering	First fruiting node	Internodal length (cm)	Plant height	Days to first harvest	Number of branches/plant	Fruit length	Fruit diameter (cm)	Fruit Weight (g)	Number of fruits/plant	Fruit yield/plant (g)
1	50 % flowering	1.000	-0.131	0.046	-0.182	0.821**	0.409**	0.126	-0.192	-0.340**	-0.032	-0.154
2	First fruiting node	0.003	1.000	-0.115	-0.351**	0.027	-0.226	0.032	0.260*	0.082	-0.677**	-0.489**
3	Internodal length (cm)	0.046	-0.122	1.000	0.758**	-0.006	0.274*	0.385**	0.592**	0.601**	0.257*	0.437**
4	Plant height (cm)	-0.172	-0.252*	0.679**	1.000	-0.004	0.092	0.404**	0.451**	0.663**	0.58**	0.719**
5	Days to first harvest	0.477**	0.063	-0.047	-0.068	1.000	0.127	0.462**	0.094	-0.079	0.230	0.159
6	Number of branches/plant	0.240	-0.103	0.209	0.088	0.055	1.000	0.298*	0.059	0.192	0.608**	0.504**
7	Fruit length (cm)	-0.005	-0.066	0.220	0.27	-0.055	0.181	1.000	0.102	0.557**	0.699**	0.749**
8	Fruit Diameter (cm)	-0.125	0.080	0.255*	0.230	0.007	0.098	0.037	1.000	0.605**	-0.033	0.209
9	Fruit Weight (cm)	-0.288*	-0.016	0.347**	0.462	-0.152	0.134	0.365**	0.560**	1.000	0.291*	0.617*
10	Number of fruits/plant	0.011	-0.340**	0.245	0.434	0.089	0.395**	0.309*	-0.018	0.185	1.000	0.933**
11	Fruit yield/plant (g)	-0.11	-0.309*	0.367**	0.593**	0.041	0.391**	0.408**	0.211	0.529**	0.911**	1.000

*, **significance at 1 % and 5 % level, respectively

4.5.2.7 Fruit length

Fruit length and fruit weight ($r_g=0.557$ $r_p=0.365$) had significant positive association with each other along with number of fruits per plant ($r_g=0.698$ $r_p=0.308$)

4.5.2.8 Fruit diameter

Fruit diameter had significant positive relationship with fruit weight ($r_g=0.605$ $r_p=0.5600$) and non significant relationship with number of fruits per plant.

4.5.2.9 Fruit weight

Fruit weight had significant positive association with number of fruits per plant ($r_g=0.291$) at genotypic level where as non significant relationship at phenotypic level.

4.6 Path Analysis Study

Path coefficient analysis is an efficient statistical technique specially formulated to divide the correlation coefficients into direct and indirect effect, which provides the information on actual contribution of a character to the yield. In this approach, it is more important to comprehend genetic makeup of a dependent character when the determining component characters are correlated. The estimates of direct and indirect effect on fruit yield per plant of other characters taken under study are given in the Table 4.6.

Direct effect of any component trait on fruit yield gives an idea about reliability of indirect selection to be made through that trait to bring about improvement in fruit yield. If both correlation coefficient and the direct effect are positive and high and then correlation explains its true relationship and a selection for that character will be effective. If the correlation coefficient is positive, but the direct effect is negative, in such relations the indirect causal factors are to be considered simultaneously for selection, when correlation coefficient is negative but the direct effect is positive and high in such cases direct selection for such traits should be done to reduce the undesirable indirect effect.

The residual effect determines how best the causal factor accounts for variability of the dependent factor, fruit yield per plant. In this case if the value of residual effect is moderate or high, it indicates that besides the characters studied there is some other attributes which contributes for yield.

4.6.1 Direct effects

According to the data estimated, the highest positive direct effect on fruit yield per plant was shown by number of fruits per plant (0.565). Moderate positive direct effect was shown via fruit length (0.237) and fruit weight (0.2328). The characters such as plant height (0.1681) and fruit diameter (0.1227) exhibit low positive direct effect whereas first fruiting node (-0.11) and internodal length (-0.166) exhibit low negative direct effect on fruit yield per plant. Rest of the characters namely 50 per cent flowering (0.013) and number of branches per plant (0.048) have negligible direct positive effect also days to first harvest (-0.087) show negligible direct negative effect on yield per plant.

4.6.2 Indirect effect

Indirect effect of the characters is elaborated as under.

4.6.2.1 50 % flowering

It had non significant correlation with fruit yield per plant. According to the path analysis result, it showed negative direct effect on yield. It is because of the negligible positive indirect effect via number of branches per plant (0.019) and fruit length (0.03), whereas negligible negative indirect effect via internodal length (-0.007), Plant height (-0.031), Days to first harvest (-0.072), fruit Diameter (-0.024), fruit weight (-0.079) and number of fruits per plant (-0.018).

4.6.2.2 First fruiting node

First fruiting node (-0.489) is in significant negative correlation with fruit yield per plant and have low negative direct effect. It exhibit high indirect effect via number of fruits per plant (-0.383) and negligible negative indirect effects via 50 per cent flowering (-0.002), plant height (-0.059), Days to first harvest (-0.002), number of branches per plant (-0.011) and also negligible positive indirect effect via fruit length (0.007), fruit diameter (0.032) and fruit weight (0.019).

4.6.2.3 Internodal length

Internodal length had significant positive (0.437) correlation and low negative direct effect on yield per plant. Low positive indirect effect via number fruits per plant (0.145), plant height (0.127), fruit weight (0.139) and negligible positive indirect effect via 50 per cent flowering (0.0006), first fruiting node (0.013), days to first harvest

(0.001), number of branches per plant (0.013), fruit length (0.091) and fruit diameter (0.072).

4.6.2.4 Plant height

Plant height exhibited significant positive association as well as low positive direct effect on yield per plant. It showed high positive indirect effect via number of fruits per plant (0.331), low positive indirect effect via fruit weight (0.154) and negligible positive indirect effect via first fruiting node (0.038), days to first harvest (0.0004), number of branches per plant (0.004), fruit length (0.096) and fruit diameter (0.055). Also low negative indirect effect via internodal length (-0.126) and negligible negative indirect effect via 50 per cent flowering (-0.002).

4.6.2.5 Days to first harvest

It had non significant correlation also negligible negative direct effect on yield per plant. It had low positive indirect effect on via number of fruits per plant (0.130), fruit length and negligible positive indirect effect via 50 per cent flowering(0.011), internodal length (0.0011), number of branches per plant (0.006) and fruit diameter (0.012).Along with it had negligible negative indirect effect via first fruiting node (-0.003), plant height (-0.0007) and fruit weight(-0.018).

4.6.2.6 Number of branches per plant

It had significant positive correlation and also had a negligible positive direct on fruit yield. It had high positive indirect effect via number of fruits per plant (0.395) with moderate positive indirect effect via fruit length (0.273), low positive indirect effect via fruit weight (0.129) and negligible positive indirect effect via 50 per cent flowering (0.005), first fruiting node (0.025), Plant height (0.015) and fruit diameter (0.013). Along with it, it also had negligible negative indirect effect via internodal length (-0.046) and days to first harvest (-0.011).

4.6.2.7 Fruit length

It had significant positive correlation and moderate positive direct effect (0.237) with fruit yield per plant. It had high positive indirect effect via number of fruits per plant (0.395), low positive indirect effect via fruit weight (0.129) and negligible positive indirect effect via 50 per cent flowering(0.002), plant height (0.07), number of

branches per plant (0.014), fruit diameter (0.012). Also negligible negative indirect effect via first fruiting node (-0.003), Internodal length (-0.064), days to first harvest (-0.041).

4.6.2.8 Fruit diameter

It had non significant correlation and had low positive direct effect (0.123) with fruit yield per plant. It had negligible positive indirect via plant height (0.076), number of branches per plant (0.003) and fruit length (0.024). Also it had negligible negative indirect effect via number of fruits per plant (-0.019), days to first harvest (-0.008), internodal length (-0.098), first fruiting node (-0.028) and 50 per cent flowering (-0.003).

4.6.2.9 Fruit weight

It had significant positive correlation and moderate positive direct effect on fruit yield per plant. It had low positive indirect effect via number of fruits per plant (0.164), fruit length (0.132) plant height (0.112) and negligible positive indirect effect via days to first harvest (0.007), number of branches per plant (0.009) and fruit diameter (0.074). It also had low negative indirect effect via internodal length (-0.100) negative negligible indirect effect via 50 per cent flowering (-0.005), first fruiting node (-0.0009).

4.6.2.10 Number of fruits per plant

Number of fruits per plant had significant positive correlation and high positive direct effect (0.565). It had low positive indirect via fruit length and negligible positive indirect effect via first fruiting node (0.0745), plant height (0.0985), number of branches per plant (0.0292) and fruit weight (0.0677). It also had negligible negative indirect effect via 50 per cent flowering (-0.004), internodal length (-0.0429), days to first harvest (-0.0202) and fruit diameter (-0.0041).

Similar to the presented research findings with respect to number of fruits per plant was also observed by Adiger *et al.* (2011), Das *et al.* (2012), Balai *et al.* (2014), Saryam *et al.* (2015), Kerure *et al.* (2017), Prasath *et al.* (2017) Pithia *et al.* (2017), Sayfullah *et al.* (2018), Patra *et al.* (2018), Raval *et al.* (2019), Kumari *et al.* (2019), Pawar *et al.* (2020) and Ranga *et al.* (2021). For 50 per cent flowering similar results were described by Kerure *et al.* (2017), Sayfullah *et al.* (2018), Patra *et al.* (2018), Kumari *et al.* (2019) and Ranga *et al.* (2021).

For first fruiting node negligible negative direct effect was observed by Saryam *et al.* (2015) also high negative direct effect by Ranga *et al.* (2021). Negative negligible direct effect for internodal length was resulted by Saryam *et al.* (2015) and medium negligible direct effect was seen by Kumari *et al.* (2019) and Rynjah *et al.* (2020). Plant height exhibit negligible positive direct effect were observed by Adiger *et al.* (2011), Kerure *et al.* (2017), Pithia *et al.* (2017), Sayfullah *et al.* (2018), Patra *et al.* (2018) whereas medium and high positive direct effect was observed by Pawar *et al.* (2020) and Rynjah *et al.* (2020) respectively.

Balai *et al.* (2014) and Pawar *et al.* (2020) also estimated same result as for the days to first harvest. Kumari *et al.* (2019) observed low negative direct effect of days to first harvest. For fruit diameter, the estimated result was similar to Saryam *et al.* (2015) Pithia *et al.* (2017) and Pawar *et al.* (2020). Negligible positive effect was estimated by Balai *et al.* (2014) and Kerure *et al.* (2017). For fruit length, Adiger *et al.* (2011), Patra *et al.* (2018), Raval *et al.* (2019) and Kumari *et al.* (2019) resulted negligible, Kerure *et al.* (2017) resulted medium, Pawar *et al.* (2020) exhibit low, whereas Rynjah *et al.* (2020) and Ranga *et al.* (2021) exhibit high positive direct effect on fruit yield per plant.

With respect to inter nodal length, Saryam *et al.* (2015), Show negligible negative direct effect, Kumari *et al.* (2019) and Rynjah *et al.* (2019) show medium negative direct effect on yield. The result obtained for number of branches per plant was in accordance with Adiger *et al.* (2011) and Pithia *et al.* (2017) while Saryam *et al.* (2017) and Pawar *et al.* (2020) resulted low positive direct effect and Rynjah *et al.* (2020) had medium positive direct effect on yield. For fruit weight, Adiger *et al.* (2011), Das *et al.* (2012), Balai *et al.* (2014), Kerure *et al.* (2017), Sayfullah *et al.* (2018) Raval *et al.* (2019). Pawar *et al.* (2020) and Rynjah *et al.* (2020) showed high positive effect on yield

The residual effect ($R=0.1242$) was found low suggesting that the studied characters were sufficient to explain the variability in the dependent variables.

Table 4.6. Estimates of Genotypic direct (Diagonal) and indirect effects (above and below diagonal) of various yield and yield components

Sr. No.	Characters	50 % flowering	First fruiting node	Internodal length (cm)	Plant height (cm)	Days to first harvest	Number of branches/plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of fruits/plant	Correlation value of fruit yield/plant at genotypic level
1	50 % flowering	0.013	0.014	-0.007	-0.031	-0.072	0.019	0.03	-0.023	-0.079	-0.018	-0.154
2	First fruiting node	-0.002	-0.11	0.019	-0.059	-0.002	-0.011	0.007	0.032	0.019	-0.383	-0.489**
3	Internodal length (cm)	0.001	0.012	-0.166	0.127	0.001	0.013	0.091	0.073	0.139	0.145	0.437**
4	Plant height (cm)	-0.002	0.038	-0.126	0.168	0.0004	0.004	0.096	0.055	0.154	0.331	0.719**
5	Days to first harvest	0.011	-0.003	0.001	-0.001	-0.088	0.006	0.109	0.012	-0.018	0.130	0.159
6	Number of branches/plant	0.005	0.025	-0.045	0.016	-0.011	0.048	0.27	0.012	0.129	0.395	0.504**
7	Fruit length (cm)	0.001	-0.003	-0.064	0.07	-0.041	0.014	0.237	0.012	0.129	0.395	0.749*
8	Fruit Diameter (cm)	-0.002	-0.028	-0.098	0.076	-0.008	0.003	0.024	0.122	0.141	-0.019	0.209
9	Fruit weight (cm)	-0.004	-0.009	-0.100	0.112	0.007	0.009	0.132	0.074	0.233	0.164	0.617*
10	Number of fruits/plant	-0.0004	0.074	-0.042	0.098	-0.020	0.029	0.165	-0.004	0.068	0.565	0.933**

Residual effect : -0.1242

4.7 Divergence

Divergence to be present in the genotypes is one of the essential qualities when selecting as a parent in hybridization programme. Using such parents in breeding programme guarantees successful development of new improved cultivars having high heterotic effect. Hence to measure the divergence among the genotypes D^2 Statistics developed by Mahalanobis is popularly used.

In the presented study, the divergence is studied among thirty-two genotypes of okra with the help of Mahalanobis D^2 Statistics considering yield and yield contributing characters.

4.7.1. Mahalanobis D^2 Values

Using Mahalanobis D^2 , the thirty two genotypes including the standard check (Phule Vimukta) were assessed for the genetic diversity present in them. The mean values of thirty two genotypes $[(X_1)(X_2)]$ were converted into unstandardised in correlated mean values $[(Y_1)(Y_2)]$. The values of D^2 were calculated for all the possible combinations i.e. $32(32-1)/2$, is equal to 496 pairs of genotypes.

4.7.2 Test with Wilk's Criterion and Analysis of Variance for Dispersion of Genotypes

Significant differences between genotypes based on the pooled effects of all the traits were tested by Wilk's ' λ ' (Statistics) criterion. The significance of ' λ ' (Statistics) values was tested by ' χ^2 ' at 320 degrees of freedom. The ' λ ' (Statistics) value was 594.19**, suggesting that the genotypes differed significantly when all characters were considered simultaneously. The ANOVA of dispersion of thirty three genotypes is presented in Table 4.7.

Table 4.7. Analysis of variance for dispersion in thirty two okra genotypes

Source of variation	Degree of freedom (df)	Mean sum of squares
Genotype	31	2.9022E04**
Error	30	8.7889E-03
Total	61	1.4749E04

** Significant at 1% level

V statistics at 320 df = 594.19

4.7.3 Cluster Pattern

All the thirty-two genotypes were clustered into six groups which was done using Tocher's method, as suggested by Rao (1952). The clusters I, II, III, IV, V and VII and the genotypes includes in it are presented in the Table 4. The source of all the genotypes is AICRP on Vegetables, MPKV, Rahuri. The Cluster I was the largest consisting of twenty-one genotypes followed by Cluster III having seven genotypes. Rest of the clusters i.e. II, IV, V and VI are monogenotypic in nature.

In the research findings of Patro and Ravishankar (2004) forty-one genotypes were clustered into eight group, Akotkar *et al.* (2010) clustered fifty genotypes into five groups. Prakash and Pitchaimuthu (2010) grouped forty four genotypes into twelve clusters, Kaundinya *et al.* (2013) grouped forty genotypes into nine clusters, Umrao *et al.* (2014) grouped fifty genotypes into into eight clusters, Amoatey *et al.* (2015) grouped twenty-nine genotypes into two clusters which are further categorized into four sub clusters. Asare *et al.* (2016) grouped twenty-one okra genotypes into three clusters, Shivaramgowda *et al.* (2016) grouped thirty six accessions into four clusters, Patra *et al.* (2018) grouped fourteen genotypes into four clusters and Syfullah *et al.* (2018) clustered genotypes into five clusters.

4.7.4 Intra-cluster and inter cluster distances

The intra and inter cluster distances were worked out by D^2 statistics. The mean D^2 values of cluster elements were used as a measure of intra and inter cluster distances which is given in Table 4.8.

The maximum intra cluster distance were found in cluster III ($D^2=44.76$) followed by cluster I ($D^2 =25.07$). The clusters II, IV, V, VI are monogenotypic and recorded as the least values ($D^2 =0$).

The maximum inter cluster distance is between cluster II and cluster IV ($D^2=190.72$) followed by cluster II and cluster V ($D^2 = 172.66$).the cluster I had maximum inter cluster distance with cluster VI ($D^2= 91.20$). Cluster III had maximum inter cluster distances with cluster V ($D^2= 91.58$). Cluster IV had maximum inter cluster distance with cluster VI ($D^2=114.49$) and cluster V and cluster VI had maximum inter cluster distance ($D^2= 109.83$).

Table 4.8. Distribution of thirty- two genotypes of Okra into different clusters

Sr. No.	Cluster	Number of Genotypes	Source	Genotype
1	I	21	AICRP on Vegetables, MPKV, Rahuri	RHROK20 , RHROK29 , RHROK 16 , RHROK15, RHROK 06, RHROK 14 , RHROK 33, RHROK 23 , RHROK 24, RHROK 04, RHROK19 , RHROK 01, RHROK 08 , RHROK 35, RHROK 17 , RHROK 22, RHROK 30 , RHROK 25 , RHROK 13, RHROK 2, RHROK 18
2	II	1	AICRP on Vegetables, MPKV, Rahuri	RHROK 11
3	III	7	AICRP on Vegetables, MPKV, Rahuri	RHROK 09, Phule Vimukta, RHROK 32, RHROK 12, RHROK 03, RHROK 31, RHROK 05
4	IV	1	AICRP on Vegetables, MPKV, Rahuri	RHROK 07
5	V	1	AICRP on Vegetables, MPKV, Rahuri	RHROK 26
6	VI	1	AICRP on Vegetables, MPKV, Rahuri	RHROK 02
	Total	32		

Table 4.9. Average intra (Bold) and inter cluster distance D and D² values six clusters in thirty-two genotypes (diagonal : Intraccluster distance and above diagonal : intercluster D and D² values)

	I	II	III	IV	V	VI
I	5.07 (25.07)	7.53 (56.70)	7.98 (63.68)	9.54 (91.01)	7.14 (50.98)	9.55 (91.20)
II		0.00	10.3 (106.09)	13.81 (190.72)	11.3 (127.69)	13.14 (172.66)
III			6.69 (44.76)	9.24 (85.38)	9.57 (91.58)	8.07 (65.12)
IV				0.00	6.03 (36.36)	10.7 (114.49)

V					0.00	10.48 (109.83)
VI						0.00

4.7.5 Cluster Means

The cluster means for all the eleven characters presented in the Table 4.9.

4.7.5.1 50 per cent flowering

Minimum days to 50 per cent flowering was shown by cluster II (42.5 DAS) and cluster IV (42.5 DAS) followed by cluster I whereas cluster V and cluster IV took maximum days for 50 percent flowering.

4.7.5.2 First fruiting node

The mean performance of node at which the first fruit appear ranges from 5.6 (Cluster IV) to 6.7 (Cluster II) Cluster IV (5.3) had nodes at the lowest level followed by Cluster III (5.44), Cluster I (5.6) and Cluster VI (5.7).

4.7.5.3 Internodal length

Lowest cluster mean value of internodal length was for cluster I followed by cluster V (6.13) and Cluster II (6.13) while cluster mean value of internodal length is highest for Cluster IV and Cluster III.

4.7.5.4 Plant height

The cluster having highest mean height is cluster VI (134.03 cm) followed by cluster IV (130.89) and cluster III (129.36 cm). Cluster having lowest height is cluster V (100.6 cm).

4.7.5.5 Days to first harvest

The cluster mean for days to first harvest ranges from 49 DAS (Cluster IV) to 50.93 DAS (Cluster I).

4.7.5.6 Number of branches per plant

Cluster IV (5.9) had highest mean number of branches followed by Cluster V (5.3) and cluster III (3.1). Lowest cluster mean value of number of branches per plant was seen in cluster II (2.5) followed by cluster VI and I (2.9)

4.7.5.7 Fruit length

The cluster means value estimated was maximum for cluster V (11.22 cm) followed by Cluster VI, cluster III and minimum for Cluster IV (10.7).

4.7.5.8 Fruit diameter

Cluster III (1.57cm) had highest value of cluster mean of fruit diameter followed by Cluster V (1.54 cm) and cluster II. Lowest mean value for fruit diameter was for Cluster IV (1.47 cm)

4.7.5.9 Number of fruits per plant

Cluster VI (21.49) recorded highest cluster mean value followed by Cluster IV (19.75), Cluster V (17.47) and Cluster III (16.97). lowest number of fruits per plant was observed for Cluster II (12.07)

4.7.5.10 Fruit yield per plant

Cluster VI (255.42 g) recorded highest cluster mean value followed by Cluster IV (215.8 g), Cluster III (205.01 g) and cluster V (199.13 g). lowest number of fruits per plant was observed for Cluster II (127.96 g).

Table 4.10. Cluster mean performance of various characters of okra

	50 % flowering	First fruiting node	Internodal length (cm)	Plant height (cm)	Days to first harvest	Number of branches /plant	fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of fruits/ plant	Fruit yield/ plant (g)
I	45.88	5.6	6.2	107.61	50.93	2.99	10.85	1.49	10.78	16.29	179.37
II	42.5	6.7	6.13	105.21	50.5	2.5	10.44	1.52	10.6	12.07	127.96
III	45.07	5.44	7.04	129.36	51.29	3.1	11.16	1.57	12.03	16.97	205.01
IV	46.5	5.3	7.71	130.89	49	5.9	10.7	1.47	10.8	19.75	215.8
V	48.5	5.8	6.13	100.6	50	5.3	11.22	1.54	11.6	17.47	199.13
VI	42.5	5.7	6.97	134.03	50.5	2.9	11.21	1.38	11.8	21.49	255.42

4.7.6 Per cent Contribution of eleven Characters for Divergence

The utility of D^2 analysis, which is a potent tool to quantify the extent of divergence in biological populations at genetic level, is further enhanced by its applicability to estimate the relative contribution of the various plant characters to genetic divergence. The per cent contribution of ten characters towards genetic divergence is presented in Table 4.10.

There were maximum contribution by fruit diameter (25 %) followed by plant height (18.75 %) number of branches per plant (17.34 %), number of fruits per plant (12.70 %), fruit weight (6.85 %), Internodal length (4.84 %), fruit yield per plant (4.44 %), 50 per cent flowering (4.03 %), first fruiting node (3.02), days to first harvest (1.61 %) and fruit length (1.41 %).

4.7.7 Identification of Diverse genotypes for future Hybridization

The pattern of group constellation proved the existence of significant amount of variability. Greater is the distance between to clusters, wider is the genetic diversity in the genotype. For hybridization programme the parents are selected by considering the genetic diversity, their *per se* performance and cluster mean for characters.

Based on inter-cluster and intra cluster distance, cluster mean and *per se* performance, the genotypes *viz.*, RHROK 02, RHROK 26, RHROK 07, RHROK 09, RHROK 32, RHROK 12, RHROK 03, RHROK 31 and RHROK 05 are suggested to utilize for future breeding programme.

Table 4.11. Per cent contribution of eleven characters of okra

Sr. No.	Source	Times ranked first	Contribution (%)
1	50 % flowering	20	4.03
2	First fruiting node	15	3.02
3	Internodal length (cm)	24	4.84
4	Plant height (cm)	93	18.75
5	Days to first harvest	8	1.61
6	Number of branches/plant	86	17.34
7	Fruit length (cm)	7	1.41
8	Fruit diameter (cm)	124	25.00
9	Fruit weight (cm)	34	6.85
10	Number of fruits/plant	63	12.70
11	Fruit yield/plant (g)	22	4.44

5. SUMMARY AND CONCLUSION

The research investigation was carried out under the title “Variability Studies in elite type okra (*Abelmoschus esculentus* L. Monech)” while keeping following objectives in mind.

1. To assess the nature and extent of variability present in different okra genotypes.
2. To workout the association of yield with different horticultural traits.
3. To identify most suitable and best performing elite genotypes of okra cultivation.
4. To identify elite genotypes for disease resistance.

The thirty two genotypes studied in this investigation along with the standard check Phule Vimukta were received from AICRP on vegetable crops, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra). These genotypes were assessed in Randomised Block Design with two replication. It was carried out in the season of *Kharif* during the year 2020.

The genotypes were studied for the variability, heritability, genetic advance, association studies, path analysis along with divergence for various growth and yield contributing characters *viz.* 50 per cent flowering (DAS), first fruiting node, internodal length (cm), plant height (cm), Days to first harvest, number of branches per plant, fruit length (cm), fruit diameter (cm), fruit weight (cm), number of fruits per plant and fruit yield per plant (kg/plant) . Also qualitative characters and incidence of disease and pests were studied.

5.1 Qualitative characters

All the thirty two genotypes are categorized into Red, reddish green and green colour with respect to stem and petiole colour. Except for RHROK 32, RHROK 19 and RHROK 11 which had reddish green coloured leaves and yellow corolla with reddish tinge, all the genotypes have green foliage and yellow flowers with red centre. genotypes *viz.* RHROK 24, RHROK 22, Phule Vimukta, RHROK 09, RHROK 18, RHROK 30 had dark green coloured fruits. Genotypes namely RHROK 32, RHROK 19 and RHROK 11 bore reddish green coloured fruits, eleven genotypes bore light green coloured fruits and rest of the other genotypes had green coloured fruits. With respect to pubescence, five genotypes had high pubescence, eighteen genotypes had medium pubescence while nine

genotypes had low pubescence. Amongst all the genotypes, thirteen genotypes having no seediness in the fruits while twelve genotypes had slight seediness present.

5.2 Variability, Heritability and Genetic Advance

There were significant differences among the genotypes for all the eleven characters taken for study had significant differences in the mean sum of squares values. Among all the characters observed, the number of branches per plant had high estimate of GCV and PCV, moderate values of GCV and PCV were observed for Fruit yield per plant, Plant height and number of fruits per plant and rest of the characters such as fruit diameter, first fruiting node, fruit length, Days to first harvest, 50 per cent flowering and fruit weight had low values of coefficient of Variation. In the case of Internodal length, it has moderate PCV value while low GCV value. The magnitude of PCV was slightly higher than GCV for all the characters which indicates the influence of environment. From all these characters, Plant height, followed by 50 per cent flowering and fruit weight had minimum difference between the GCV and PCV values i.e. comparatively less influence of environment on the expression of traits.

High heritability (broad sense) per cent values were observed for plant height, number of branches, fruit yield per plant, internodal length, fruit weight, number of fruits per plant and 50 per cent flowering.

High heritability coupled with genetic advance as per cent mean was observed for the characters namely plant height, number of branches per plant and fruit yield per plant. These characters are suitable for the direct selection in the crop improvement programme due to presence of additive gene action.

5.3 Correlation and Path Analysis

The fruit yield per plant had significant positive association with internodal length (cm), plant height (cm), number of branches per plant, fruit length (cm), fruit weight (g) and number of fruits per plant. Fruit yield per plant had significant negative association with first fruiting node and non significant association with 50 % flowering, first fruiting node and days to first harvest.

The high positive direct effect on fruit yield per plant was shown by number of fruits per plant, while moderate positive direct effect was shown via fruit

length and fruit weight. These characters also had significant positive correlation with the yield.

5.4 Genetic Divergence

Using Tocher's method, as suggested by Rao (1952), all the thirty-two genotypes were clustered into six groups *viz.* clusters I, II, III, IV, V and VII. Cluster I was the largest consisting of twenty-one genotypes followed by Cluster III having seven genotypes. Rest of the clusters i.e. II, IV, V and VI are monogenotypic in nature.

The maximum intra cluster distance were found in cluster III followed by cluster I. The clusters II, IV, V, VI are monogenotypic and recorded as the least values.

The maximum inter cluster distance was between cluster II and cluster IV ($D^2=190.72$) followed by cluster II and cluster V ($D^2 = 172.66$). The cluster I had maximum inter cluster distance with cluster VI ($D^2= 91.20$). Cluster III had maximum inter cluster distances with cluster V ($D^2= 91.58$). Cluster IV had maximum inter cluster distance with cluster VI ($D^2=114.49$) and cluster V and cluster VI had maximum inter cluster distance ($D^2= 109.83$).

The maximum contribution in diversity was due to Fruit diameter (25 %) followed by Plant height (18.75 %) number of branches per plant (17.34 %), number of fruits per plant (12.70 %), fruit weight (6.85 %), Internodal length (4.84 %), fruit yield per plant (4.44 %), 50 per cent flowering (4.03 %), first fruiting node (3.02), days to first harvest (1.71 %) and fruit length (1.41 %).

Conclusion:

By taking obtained result into consideration, the conclusion is drawn as follows.

1. As per the analysis of variance, for all the thirty two genotypes the eleven selected characters had significant differences which means there is ample amount of variability present in genotypes and hence these characters should be considered while exploitation.
2. Based on Mean performances of all the yield contributing and growth characters in general, the genotypes *viz.* RHROK 02, RHROK 05, RHROK18 and RHROK 07 were found superior for most of the characters. Also in terms of yield, the estimates for these genotypes are superior to Standard check Phule Vimukta.

3. As for qualitative characters, the genotypes namely RHROK 24, RHROK 22, Phule Vimukta, RHROK 09, RHROK 18, RHROK 30 had dark green coloured fruits which is a desirable character for market and export.
4. The magnitude of phenotypic variance as well as phenotypic coefficient of variation is slightly higher than genotypic variance and coefficient of variation.
5. From all the characters studied in this experiment, number of branches per plant had high whereas fruit yield per plant, plant height and number of fruits per plant had moderate values of PCV and GCV which implies good scope for their improvement via selection procedures.
6. The characters such as plant height, number of branches per plant and fruit yield per plant, high heritability along with high genetic advance as per cent means was observed which means these characters are predominantly governed by additive gene action and it would be more effective to select these traits for genetic improvement.
7. The characters such as internodal length, plant height, number of branches per plant, fruit length, fruit weight and number of fruit per plant had significant positive correlation with yield per plant at both genotypic and phenotypic levels.
8. In the Path analysis study, the highest positive direct effect on fruit yield per plant was shown by number of fruits per plant. Moderate positive direct effect was shown via fruit length and fruit weight. The characters such as plant height and fruit diameter exhibit low positive direct effect whereas first fruiting node and internodal length exhibit low negative direct effect on fruit yield per plant. Rest of the characters namely 50 per cent flowering and number of branches per plant have negligible direct positive effect also days to first harvest show negligible direct negative effect on yield per plant.
9. The thirty two genotypes were grouped into six clusters. From which cluster I is the largest followed by cluster III and the smallest ones are II, IV, V and VI which are solitary.
10. The per cent contribution of fruit diameter in divergence was maximum followed by plant height, number of branches per plant and number of fruits per plant. Based inter-cluster, cluster mean and *per se* performance, the genotypes viz.,

RHROK 02, RHROK 26, RHROK 07, RHROK 09, RHROK 32, RHROK 12, RHROK 03, RHROK 31 and RHROK 05 are suggested to utilize for future breeding programme.

11. The genotypes from the above conclusion, viz. RHROK 26, RHROK 07, RHROK 32 and RHROK 05 were highly resistant yellow vein mosaic virus and rest of all the genotypes had negligible incidence of it.
12. RHROK 26 had comparatively lower borer incidence hence should be considered for resistance breeding.

6. LITERATURE CITED

- Anonymous, 2020. NHB data, Horticulture at a glance (2020), www.nhb.gov.in, 2nd Advance Estimate of Year 2019-20, Horticulture Statistics Division Department of Agriculture, Cooperation & Farmers' Welfare Ministry of Agriculture & Farmers' Welfare Government of India.
- Ade Oluwa, O.O. and Kehinde, O.B. 2011 Genetic variability studies in West African okra (*Abelmoschus caillei*), *Agriculture Biological Journal of N. American*, **2**(10) : 1326-1335.
- Ali, S., Khan, M., Rasheed, A.H.S., Iftikhar, Y. 2005. Correlation of Environmental Conditions with Okra Yellow Vein Mosaic Virus and *Bemisia tabaci* population density. *International Journal of Agriculture and Biology*. **7**(1) : 142-144.
- Ahiakpa, J.K., Kaledzi, P.D., Adi, E.B., Peprah, S. and Dapaah, H.K. 2013. Genetic diversity, correlation and path analyses of okra (*Abelmoschus spp. (L.) Moench*) germplasm collected in Ghana'. *International of Journal of Development and Sustainability*. **2**(2) : 1396-1415.
- Adiger, S., Shanthkumar, G., Gangashetty, P. I. and Salimath, P.M. 2011, Association studies in okra (*Abelmoschus esculentus* (L.) Moench), *Electronic Journal of Plant Breeding*, **2**(4) : 568-573.
- Ahamed, K.U., Akter, B., Ara, N., Hossain, M.F. and Moniruzzaman, T. 2015. Heritability, Correlation And Path Coefficient Analysis In Fifty Seven Okra Genotypes, *International Journal of Applied Science and Biotechnology*, **3**(1) : 127-133.
- Alam, A.K.M.A. and Hossain, M.M. 2008. Variability of different growth contributing parameters of some okra (*Abelmoschus esculentus* L.) accessions and their interrelation effects on yield. *Journal of Agricultural Rural Development*. **6**(1&2) : 25-35.
- Asare, A.T., Elvis Asare-Bediako, Agyarko F., Kingsley Taah and Edmund O. Osei 2016. Phenotypic traits detect genetic variability in Okra (*Abelmoschus esculentus* L. Moench). *African Journal of Agricultural Research*. **11**(33) : 3169-3177.

- Akotkar, P.K., De, D.K. and Pal, A.K. (2010) Genetic Variability and Diversity in Okra (*Abelmoschus esculentus* L. Moench). *Electronic Journal of Plant Breeding*, **1**(4) : 393-398.
- Aminu, D., Bello, O.B., Gambo, B.A., Azeez, A.H., Agbolade, O.J., Ali Iliyasu and Abdulhamid, U.A. 2016. Varietal performance and correlation of okra pod yield and yield components; *Acta Universitatis Sapientiae Agricultural and Environment*. **8** : 112-125.
- Amoatey, H.M., Klu, G.Y.P., Quartey, E.K., Doku, H.A., Sossah, F.L., Segbefia, M.M. and Ahiakpa, J.K. 2015. Genetic Diversity Studies in 29 Accessions of Okra (*Abelmoschus esculentus* L.) Using 13 Quantitative Traits; *American Journal of Exp. Agriculture*. **5**(3): 217-225.
- Barche, S., Nair, R., Ramgiri, M. and Jain, P.K. 2014. Genetic Variability In Okra (*Abelmoschus esculentus* L. Moench) *The Ecoscan: An Int. Quart. Journal of Environmental Science*. **VI** : 153-156.
- Balakrishnan, D. and Sreenivasan, E. 2010. Correlation and Path Analysis Studies in Okra [*Abelmoschus esculentus* (L.) Moench]; *Madras Agriculture Journal*. **97**(10-12) : 326-328.
- Balai, T.C., Maurya, I.B., Verma, S. and Kumar, N. 2014. Correlation And Path Analysis In Genotypes Of Okra [*Abelmoschus esculentus* (L.) Moench] *The Bioscan: An Int, Quat. Journal of Life Science*. **9**(2) : 799-802.
- Binepal, I.K., Barche, S., Kaur, M. and Asati, K.P. 2019. Assessment of the Correlation and Path Analysis with Association of Growth and Yield Characteristics in Okra; *International Journal of Current Microbiology Applied Science*. **8**(5) : 2331-2338.
- Burton, G.W. 1952. Quantitative Inheritance in grasses; *Proc. Sixth Inter Grassland Cong.*; **1**: 277-283.
- Burton, G.W. and Devane, E.H. 1953. Estimating heritability fall fescue (*Festuca arundanaceae*) from replicated conial material. *Agronomy Journal*. **45** : 478-481.
- Chandramouli, B., Shrihari, D., Dorajee Rao, A.V.D. and Paratpara Rao, M. 2016. Studies on genetic variability, heritability and genetic advance in okra

- [*Abelmoschus esculentus* (L.) Monech] genotypes. *Plant Archives*, **16**(2) : 679-682.
- Chaurasiya, P.C., Yadav Murlee and Singh, D.B. 2010. Studies on variability in okra (*Abelmoschus esculentus* (L.) Moench). *Journal of Plant Development Science*. **2**(1&2) : 31-33.
- Das, S., Chattopadhyay, A. , Chattopadhyay, S.B., Dutta, S and Hazra, P. 2012. Genetic parameters and path analysis of yield and its components in okra at different sowing dates in the Gangetic plains of eastern India, *African Journal of Biotechnology*. **11**(95) : 16132-16141.
- Dewey, D.R. and Lu, K.H. 1959. A correlation path analysis of components of created wheat grass seed production. *Agronomy Journal*. **51** : 515-518.
- Dhall, R.K., Arora, S.K. and Mamta Rani. 2000. Correlation and path analysis in advanced generations of okra (*Abelmoschus esculentus* (L.) Moench.) *Indian Journal of Horticulture*. **57**(4) : 342-346.
- Duggi, S., Magadum, S., Srinivasraghavan, A., Kishor, D. S. and Oommen, S. K. 2013. Genetic analysis of yield and yield-attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]; *International Journal of Agriculture Environment Biotechnology*. **6**(1) : 45-50.
- Gemedede, H.F., Ratta, N., Haki, G.D. and Woldegiorgis, A.Z. 2014. Nutritional Quality and health benefits of okra(*Abelmoschus esculentus* L. Monech) : A review; *Global Journal of Medicinal Research*. **14**(1) : 29-37.
- Hamim Ashraf, A.T.M., Mizanur Rahman, M., Mofazzal Hossain, M. and Sarker, U. 2020. Study of Correlation and Path Analysis in the Selected Okra Genotypes, *Asian Research Journal of Agriculture*. **12**(4) : 1-11.
- Jindal, S.K., Arora, D. and Ghai, T.R. 2010. Variability studies for yield and its contributing traits in okra; *Electronic Journal of Plant Breeding*, **1**(6) : 1495-1499.
- Johnson, H.W., Robinson, H.E. and Comstock, R.E. (1955) Estimation of genetic and environmental variability in soybean. *Agronomy Journal*, **47**(7): 314-318.
- Kerure, P., Pitchaimuthu, M. and Hosamani, A. 2017. Studies on variability, correlation and path analysis of traits contributing to fruit yield and its components in

- okra (*Abelmoschus esculentus* L. Moench) *Electronic Journal of Plant Breeding*, **8**(1): 134-141.
- Kumari, A., Singh, V.K., Kumari, M. and Kumar, A. 2019. Genetic Variability, Correlation and Path coefficient analysis for Yield and Quality traits in Okra [*Abelmoschus esculentus* (L.) Moench], *International Journal of Current Microbiology Applied Science*. **8**(6) : 918-926.
- Kumar, A., Kumar, M., Sharma, V.R., Kumar Singh, M., Singh, B. and Chand, P. 2019. Genetic Variability, Heritability and Genetic Advance studies in Genotypes of Okra [*Abelmoschus esculentus* (L.) Moench] *Journal of Pharmacognosy and Phytochemistry*; **8**(1) : 1285-1290.
- Kumar, Y., Singh, V.B., Gautam, S.K., Kumar, V. and Singh, V. 2020. Studies on genetic variability, heritability and genetic advance for fruit yield and its contributing traits in okra [*Abelmoschus esculentus* L. Moench.]. *The Pharma Innovation Journal*. **9**(10) : 351-354.
- Khajuria, R.K., Sharma, J.P., Samnotra, R.K., Kumar, S. and Ranjit, K. 2016. Variability studies in Okra (*Abelmoschus esculentus* L. Moench), *Electronic Journal of Plant Breeding*, **7**(2): 226-234.
- Koundinya, A.V.V., Dhankhar, S.K. and Yadav, A.C. 2013. Genetic variability and divergence in okra (*Abelmoschus esculentus* L. Monech), *Indian Journal of Agriculture Science*. **83**(6) : 685–688.
- Lush, J.L. 1949. Heritability of quantitative character in farm animals. *Proc. 8th Int. Cong. Genet. Heredita* (Suppl. 217-367).
- Lenka, D. and Mishra, B. 1973. Path coefficient analysis of yield in rice varieties. *Indian Journal of Agriculture Science*. **43** : 376-379.
- Mahalanobis, P.C. 1936. On the genaralised distance in statistics. *Proceedings of the National Institute of Sciences in India*. **2**(1) : 49-55.
- Mckinney, H.H. 1923. Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum*. *Journal of Agriculture Research*. **26** : 195 - 217.

- Mishra, A., Mishra, H.N., Senapati, N. and Tripathy, P. 2015. Genetic variability and correlation studies in Okra (*Abelmoschus esculentus* (L.) Moench), *Electronic Journal of Plant Breeding*, **6**(3) : 866-869.
- Makhdoomi, M.I., Wani, K. P., Jabeen, N., Nabi, A., Afroza, B., Hussain, K. and Singh, P.K. 2018 Variability analysis in okra (*Abelmoschus esculentus* (L.) Moench). *Journal of Pharmacognosy and Phytochemistry*; **7**(2) : 177-180.
- Nikitha, J., Arya, K. and Darshan, S. 2016. Genetic Variability Studies for Yield and Yield Parameters in Okra [*Abelmoschus esculentus* (L.) Moench] *Advance in Life Science*. **5**(17) : 6539-6541.
- Nwangburuka, C.C., Denton, O.A., Kehinde, O.B., Ojo, D.K. and Popoola, A.R. 2012. Genetic variability and heritability in cultivated okra [*Abelmoschus esculentus* (L.) Moench]. *Span. Journal of Agriculture Research*. **10**(1) : 123-129.
- Narkhede, G.W., Deshmukh, S.B., Mahajan, R.C. and Shinde, S.M. 2015. Correlation coefficient and Path analysis studies in Okra (*Abelmoschus esculentus* L. Moench); *Eco. Env. & Cons.*, **21**(1) : 285-288.
- Patra, N.R., Nayak N.J. and Baisakh, B. 2018. Evaluation of elite genotypes for YVMV resistance in Okra (*Abelmoschus esculentus* (L.) Moench), *Journal of Genetic Mol Biology*. **2**(2) : 7-15.
- Pithiya, P.H., Kulkarni, G.U., Jalu, R.K. and Thumar, D.P. 2017. Correlation and path coefficient analysis of quantitative characters in okra (*Abelmoschus esculentus* (L.) Moench); *Journal of Pharmacognosy and Phytochemistry* **6**(6) : 1487-1493.
- Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. Publication and Information Division, ICAR, New Delhi.
- Patel, J.N. 1983. Variability in okra, M.Sc. (Agri.) Thesis on www.krishikosh.egranth.ac.in submitted to AAU, Anand.
- Prakash, K. and Pitchaimuthu, M. 2010. Nature and magnitude of genetic variability and diversity studies in okra (*Abelmoschus esculentus* L. Moench), *Electronic Journal of Plant Breeding*, **1**(6): 1426-1430.

- Patro Kaun, T.S.K.K. and Ravisankar, C. 2004. Genetic Variability and Multivariate Analysis in Okra (*Abelmoschus esculentus* (L.) Moench), *Tropical Agriculture Research*. **16** : 99-113.
- Prasath, G.K., Ravinder Reddy and Pidigam Saidaiah. 2017. Correlation and Path Coefficient Analysis of Fruits Yield and Yield Attributes in Okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Current Microbiology Applied Science*. **6**(3) : 463-472.
- Pawar, Y., Sarode, S.B., Shaikh, A.B. and Kharad, D.A. 2020. Phenotypic and genotypic path coefficient analysis studies in okra (*Abelmoschus esculentus* (L.) Moench). *Journal of Pharmacognosy and Phytochemistry*; **9**(5) : 488-493.
- Ranga, A.D., Kumar, S. and Darvhankar, M.S. 2021. Variability among different yield and yield contributing traits of Okra (*Abelmoschus esculentus* L. Moench) genotypes, *Electronic Journal of Plant Breeding*, **12**(1) : 74-81.
- Radha Rani, K., Lalitha Kameshwari, P. and Narayanamma, M. 2016. Variability and correlation studies in okra (*Abelmoschus esculentus* L. Moench). *Andhra Pradesh Journal of Agriculture Science*. **2**(1) : 16-21.
- Ramgiry, M., Barholia, A.K. and Mishra, P. 2017. Studies on Genetic Variability, Heritability and Genetic Advance in Okra (*Abelmoschus esculentus* (L.) Monech). *Trends in Biosciences*. **10**(2) : 941-944.
- Rao, C.R. 1952. Advanced statistical methods in biometrical research. John Wiley and Sons, New York.
- Rana, A., Singh, S., Bakshi, M. and Singh, S.K. 2020. Studied on Genetic Variability, Correlation and Path Analysis for Morphological, Yield and Yield Attributed Traits in Okra [*Abelmoschus Esculentus* (L.) Monech] *International Journal of Agriculture Stat. Science*. **16**(1) : 387-394.
- Raval, V., Patel, A.I., Vashi, J.M. and Chaudhari, B.N. 2019. Correlation and path analysis studies in okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Chemical Studies*, **7**(1) : 1230-1233.
- Reddy, M.T., Hari Babu, K., Ganesh, M., Reddy Chandrasekhar, K., Begum, H., Reddy Purushothama, B. and Narshimulu, G. 2012. Genetic variability analysis for the selection of elite genotypes based on pod yield and quality from the

- germplasm of okra (*Abelmoschus esculentus* L. Moench), *Journal of Agriculture Technology*. **8**(2) : 639-655.
- Rynjah, S., Arumugam, T., Ganesan, K.N. and Kamalkumaran, A. 2020. Correlation and path coefficient analysis studies in okra (*Abelmoschus esculentus* (L.) Moench) *Journal of Pharmacognosy and Phytochemistry*; **9**(3) : 1423-1427.
- Sankara, R.K. and Acharyya, P. 2012. Incidence of yellow vein mosaic virus disease of okra [*Abelmoschus esculentus* (L.) Moench] under summer and rainy environments. *International Journal of Current Research*. **4**(5) : 18-21.
- Shuirkar, G., Naidu, A.K., Pandey, B.R., Mehta, A.K., Dwivedi, S.K. and Sharma, H.L. 2018. Correlation coefficient analysis in okra; *The Pharma Innovation Journal*. **7**(6): 644-647.
- Simon, S.Y., Gashua, I. B. and Musa, I. 2013. Genetic Variability and Trait Correlation Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *Agriculture Biology Journal of North America*. **4**(5) : 532-538.
- Sharma, P. K., Mishra, D. P. and Pandey, A. 2016. Genetic variability studies for yield and its contributing traits in okra [*Abelmoschus esculentus* L. Moench]. *Journal of Applied Natural Science*. **8**(3) : 1634-1637.
- Shivaramgowda, K.D., Krishnan, A., Jayaramu, Y.K., Kumar, V., Yashoda and Hee J.K. 2016. Genotypic Variation among Okra (*Abelmoschus esculentus* (L.) Moench). Germplasms in South India; *Plant Breeding Biotechnology*. **2** : 234-241.
- Syfullah, K., Md. Nasir Hossain Sani, Saifullah Omar Nasif, Sohely Parvin, Md. Mahasab Hossain Rony, Mohammad Saiful Islam and Md. Sarowar Hossain. 2018. Genetic Variability, Heritability, Character Association and Morphological Diversity in Okra (*Abelmoschus esculentus* L. Moench). *IJPSS*, **25**(6) : 1-11.
- Saryam, D.K., Mittra, S.K., Mehta, A.K., Prajapati, S. and Kadwey, S. 2015. Correlation and path co-efficient analysis of quantitative traits in okra [*Abelmoschus esculentus* (L.) Moench] *The Bioscan : An International Quarterly Journal of Life Science*. **10**(2) : 735-739.

- Singh, A.K., Singh, D.K., Singh, N.K., Kushwaha, M.L. and Maurya, S.K. 2020. Genetic analysis in okra under tarai region of Uttarakhand, *International Journal of Chemical Study*. **8**(1) : 2767-2770.
- Singh, R.K. and Chaudhary, B.D. 1977. "Biometrical Methods In Quantitative Genetic Analysis " Kalyani Publishers, New Delhi, pp. 1-318.
- Singh, N., Singh, D.K., Sati, U.C. , Rawat, M. and Pandey, P. 2017. Genetic Analysis Studies in Okra [*Abelmoschus esculentus* (L.) Moench], *International Journal of Pure Applied Bioscience*. **5**(4) : 361-367.s
- Sravanthi Ullangula. 2016. Studies on Variability, Heritability and Genetic Advance in Okra [*Abelmoschus esculentus* (L.) Moench.]. *Journal of Agriculture Engineering and Food Technology*. **3**(4) : 281-284.
- Thulasiram, L.B., Bhople, S.R., Srikanth, M. and Ravi Nayak, B. 2017. Genetic Variability and Heritability Studies In Okra (*Abelmoschus esculentus* (L.) Moench), *Plant Archives*; **17**(2) : 907-910.
- Thamburaj, S. and Singh, N. 2005. Text Book of Vegetable Crops, Tubers and Spices; pp 222-223.
- Umrao, V., Sharma, S.K., Kumar, R., Kumar, V. and Sharma A. 2014. Genetic variability and divergence analysis in okra [*Abelmoschus esculentus* (L.) Moench] *HortFlora Research Spectrum*. **3**(2): 127-132.
- Verma, V., Singh, B., Singh, M.K. and Singh, S.K. 2018. Studies on genetic variability, heritability and genetic advance in Okra [*Abelmoschus esculentus* (L.) Moench.]. *Journal of Pharmacognosy and Phytochem*. **7**(4): 1114-1115.
- Vishnu Priyanka, D., Thirupathi Reddy, M., Begum, H., Sunil, N. and Jayaprada, M. 2018. Studies on Genetic Variability, Heritability and Genetic Advance in genotypes of okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Current Microbiology Applied Science*. **7**(5) : 401-411.
- Wilk, S.S. 1932. Certain generalization in the analysis of variance Biometrics., **24** : 471-494.

7. APPENDIX

Appendix-I: Details of Meteorological Data During Experimental Period

Meteorological week	Date	Temperature (°C)		Humidity (%)		Wind speed (km/hr)	Daily rain (mm)	Bright sunshine (hrs)	Open pan evaporation (mm)
		Max.	Min.	RH-I	RH-II				
34	20 Aug - 26 Aug	28.7	23.4	86.6	64.0	4.2	1.9	4.2	4.8
35	27 Aug - 2 Sept	29.5	23.1	86.0	60.1	4.7	0.3	4.3	5.0
36	3 Sept - 9 Sept	32.9	23.8	89.7	56.3	0.9	3.5	6.7	5.2
37	10 Sept - 16 Sept	29.7	23.6	92.3	62.9	1.2	9.1	4.2	3.9
38	17 Sept - 23 Sept	28.4	23.4	93.4	75.0	1.0	40.3	2.5	2.5
39	24 Sept - 30 Sept	30.3	23.1	90.3	56.3	1.6	2.3	5.8	4.2
40	1 Oct - 7 Oct	31.7	23.5	85.1	46.6	1.7	1.3	8.0	5.1
41	8 Oct - 14 Oct	31.5	23.7	89.3	54.0	1.4	1.5	4.5	4.3
42	15 Oct - 21 Oct	29.8	23.1	92.4	62.6	1.9	16.4	4.8	4.7
43	22 Oct - 28 Oct	30.1	21.5	90.0	54.6	0.6	3.1	6.7	4.9
44	29 Oct - 4 Nov	30.9	18.0	87.0	36.9	0.6	0.0	8.9	5.2
45	5 Nov - 11 Nov	29.1	13.9	84.1	33.1	1.1	0.0	9.1	5.3
46	12 Nov - 18 Nov	29.9	18.4	83.0	40.7	1.3	0.0	9.2	5.1
47	19 Nov - 25 Nov	30.6	19.0	89.1	43.7	0.9	0.6	7.8	5.0
48	26 Nov - 2 Dec	28.2	17.5	82.0	43.6	1.7	0.0	8.2	5.2
49	23 Dec - 9 Dec	29.5	12.8	83.6	28.4	1.2	0.0	9.6	4.9
50	10 Dec - 16 Dec	27.7	18.0	83.6	47.4	0.8	0.0	4.1	3.5
51	17 Dec - 23 Dec	28.1	12.3	88.3	35.6	1.0	0.0	8.0	3.0

8. VITAE

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IN

VEGETABLE SCIENCE

2023

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