GENETIC EVALUATION OF LOCAL GENOTYPES OF OKRA (*Abelmoschus esculentus* (L.) Moench) UNDER LOW HILL CONDITIONS OF H.P.

Thesis

by

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CERTIFICATE - I

This is to certify that the thesis titled **“**Genetic evaluation of local genotypes of okra (*Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P.” submitted in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) VEGETABLE SCIENCE** in the discipline of **VEGETABLE SCIENCE** of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) – 173230 is a bonafide research work carried out by **Ms. PRATIBHA SHARMA (NH-2017-24-M)** daughter of Sh. Rajesh Kumar under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation has been fully acknowledged.

Dr. B.S. Dogra
Chairman
Advisory committee

Place: Neri, Hamirpur
Dated: 28/08/19

CERTIFICATE - II

This is to certify that thesis titled **"**Genetic evaluation of local genotypes of okra (*Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P." submitted by **Ms. PRATIBHA SHARMA (NH-2017-24-M)** daughter of Sh. Rajesh Kumar to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)-173230 India in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE) VEGETABLE SCIENCE** in the discipline of **VEGETABLE SCIENCE** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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ABBREVIATIONS USED

S. No.	Abbreviation	Meaning
1	@	At the rate of
2	&	And
3	ANOVA	Analysis of Variance
4	cm	Centimeter
5	C.D.	Critical difference
6	D.F.	Degrees of Freedom
7	*et al*.	And others or co-workers
8	m	Meter
9	Fig.	Figure
10	GA	Genetic Advance
11	GCV	Genotypic coefficient of variation
12	g	Gram
13	Ha	Hectare
14	Kg	Kilogram
15	Max.	Maximum
16	Min.	Minimum
17	M.S.S.	Mean Sum of Squares
18	No.	Number
19	PCV	Phenotypic coefficient of variation
20	Sem(±)	Standard error of mean
21	YVMV	Yellow Vein Mosaic Virus

INTRODUCTION

CHAPTER-1

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), also known as bhindi, lady's finger and ochro, is one of the widely grown vegetable in subtropical as well as tropical regions of the world (Tattanakorn and Prabhat, 2004; Phathiz we and Ekpo, 2011). The crop is said to be the native of Ethiopia but according to recent reports, it is considered of African or Asiatic origin (Markose and Peter, 1990). It belongs to the class dicotyledonae, order Malvales, family Malvaceae and genus *Abelmoschus* (syn. *Hibiscus*) having chromosome number 2n=130 (Joshi and Hardas, 1953; Schippers, 2000).

Okra has captured a prominent position among all the vegetables as it is not strictly season-bound and available almost throughout the year. The tender green mucilaginous fruits of okra are a good source of vitamins, proteins, carbohydrates, minerals, iron and iodine (Jha and Dubey, 1998). 100 gm of edible pods contains 88 % of moisture, Vitamin A (88 IU), Vitamin B (63 IU) and Vitamin C (13 mg), 3100 calorie energy, 1.8g protein, 90 mg calcium and 1.0 mg iron (Aykroyd, 1941). The fruits of okra have good medicinal value with its antispaspodic, demulcent, diaphoretic, diuretic, emollient, stimulant and vulnery properties (Nandkarni, 1927).

Okra is a medium-duration crop and fits well under sequential cropping systems either as a sole crop or an intercrop due to its quick growing habit and drought as well as heat tolerance (Reddy, 2010). Plant is a herbaceous annual with bisexual flowers and erect vegetative growth with or without branches. Unripe green finger-like seed capsule of okra, usually called "pod" are processed and consumed as stews, salads, soups, sliced, boiled and fried vegetables (Akanbi et al., 2010; Daniela *et al*., 2012). The potential of okra as industrial crop has been tested in the developed country with respect to food, nutritional and health security.

Okra is a hardy crop and can grow with considerable success on a wide range of soils and under variable environmental conditions. In North Eastern India, the crop is grown during both summer (February-March) and rainy seasons (May-July). Longer harvesting period and lesser incidence of yellow vein mosaic virus make this crop more suitable for cultivation in mid and low hill conditions. Okra is a potential export earner, which accounts for thirty percent of the foreign exchange among fresh vegetables (Bose and Ranjan, 1988). India has leading position for area and production of okra as it is widely cultivated in plains of India with acreage of 528.37 thousand ha and production of 6145.97 thousand MT. (Anonymus, 2017-18). Uttar Pradesh, Bihar, Orissa, West

Bengal, Andhra Pradesh, Karnataka and Assam are some of the major okra growing states.

The improvement in any crop is directly proportional to the magnitude of its genetic variability present in the germplasm (Dhankhar and Dhankhar, 2002).While determining the most approximate breeding procedures, the knowledge of pattern of inheritance of various characters is must as the phenotype is often not true indicator of its genotype. Besides, estimation of the genetic parameters such as genotypic and phenotypic coefficient of variation, correlation and path analysis, heritability and genetic advance as percentage of mean in some of the quantitative characters is must.

Genetic variability for yield and yield components is an important tool in the base population for successful crop improvement (Allard, 1960). The knowledge of association between yield and its components obtainable through estimation of genotypic and phenotypic correlation is useful in order to determine suitable selection criteria as outlined by Miller *et al.* (1958). Genetic parameters such as genotypic and phenotypic coefficient of variation (GCV and PCV) are useful in determining the amount of variability present in the available genotypes.

The productivity as well as the yield of okra is low due to lack of location specific varieties tolerant to pests and diseases such as fruit and shoot borer and yellow vein mosaic virus disease (Thirupathi *et al.*, 2012). Hence, the first step in okra improvement should involve evaluation of the germplasm to assess the existing genetic variability for yield and yield related traits. The knowledge on nature and magnitude of variation existing in available breeding materials would help in choosing traits for effective selection of potential parents for further use in crop improvement programme.

Heritability is an attributing index of transmissibility of a character from parents to their off springs. The study of genetic advance coupled with heritability are more useful in predicting the resultant effect of selection as heritability alone does not give true picture of genetic improvement through selection (Johnson *et al.*,1955). Genetic advance shows the improvement in the mean genotypic values of selected families over base population and thus helps the plant breeder in the selection of the progenies in the earlier generation itself. Also, genetic advance reveals the additive nature of gene action.

In plant breeding programme, evolvement of high yielding varieties is the main objective for a breeder. Since the fruit yield per plant is a complex quantitative trait as it is controlled by polygenes, therefore, environmental factors have great influence on performance. Various component traits of fruit yield per plant *viz.*, plant height, internodal length, fruit length, fruit diameter, fruit weight, number of seeds per plants and many more exhibits varying degree of associations with fruit yield per plant as well as among each other. A study of correlation alone is not enough to generate an exact view of direct and indirect influences of yield component traits on fruit or seed yield. In this context, path coefficient analysis splits the total correlation coefficients into direct and indirect effects of independent variables on dependent variable i.e. fruit yield per plant.

In view of the above points, the investigated study entitled “Genetic evaluation of local genotypes of okra (*Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P.” including twenty genotypes was, therefore carried out with the following objectives:

Objectives

1. To assess the performance and the extent of genetic variability in various okra genotypes.
2. To work out heritability and genetic advance.
3. To work out correlation and path analysis in okra genotypes.
4. To identify most suitable and best performing genotypes of okra for cultivation in low hill conditions of Himachal Pradesh.

REVIEW OF LITERATURE

CHAPTER-2

REVIEW OF LITERATURE

The selection of right material and its skillful management is a most important attribute for success of any crop improvement programme. In okra, substantial contribution has been made to the literature, regarding its genetics and breeding in the past few years. The literature pertaining to various aspects of the present investigation entitled **"Genetic evaluation of local genotypes of okra *(Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P."** has been reviewed under the following heads:

2.1. Genetic variability

2.2. Heritability and genetic advance

2.3. Correlation and path coefficient analysis

2.4. Coefficient of variation

2.1. Genetic variability

Genetic variability is the most important attribute in crop improvement programme (Oppong-Sekyere *et al.* 2011). It is a pre-requisite for any breeding programme (Azam *et al.,* 2013). Characterized genotypes of okra showed broad variation for most traits which allows identification of promising accessions for crop improvement (Oppong-Sekyere *et al.*, 2011). The effectiveness of the selection is mainly depends upon the existence of genetic variability within or among the population (Dixit *et al.*, 1971; Swami Rao, 1972; Tikka *et al.,* 1974; Patnaik and Tak, 1974). Therefore information on genetic variability and inter-relationship among different traits is necessary to improve the yield and other quantitative characters.

Martin *et al.* (1981) evaluated the variability among twenty-nine traits of about five hundred varieties of okra and reported that seventeen West African genotypes could be distinguished from all others on the basis of five discriminating characteristics. Patil *et al.* reported the traits *viz.,* pod weight, number of pods per plant and number of borer infested pods per plant presented season variability during kharif season as comparison to rabi season.

Hazra *et al.* (2000) estimated a wide range of variability and the general mean *viz.,* plant height (80.8 cm), days to first flower (49.9), nodes per plant (14.9), fruit weight (15 g), fruits per plant (10), number of seeds per fruit (53.3), fruit yield per plant (155.7g). While moderate variability for primary branches per plant (2.9) and fruit length (12.9 cm) whereas low variability for first flowering node (4.8), locules per fruit (5.1) and average dry weight of fruit (1.5 g). Primary branches per plant presented a moderate range of variation (35.5%).

Bendale *et al.* (2003) reported a wide range of genetic variability for yield and yield-contributing traits *viz.*, internodal length, number of branches per plant, first flowering node, pod length, pod weight, plant height, nodes per plant, fruiting period, number of pods per plant and yield per plant. The Phenotypic coefficient of variation for all the fifteen characters was higher than the genotypic coefficient of variance. The number of branches per plant, yield per plant and number of pods per plant showed high variability among various genotypes.

Duzyaman *et al.* (2003) evaluated numerous okra genotypes of American, Indian, European, African and Turkish origin for their pod properties as well as nutritive contents. Pod thickness was comparatively high in the germplasm from Africa (2.84 cm in diameter) than from line 1051 of Togo. However, pods from USA and India had a more attractive appearance with diameters varying between 1.15-1.50 cm. The improved cultivars of USA showed slow fibre development. Three lines from Turkey had highest protein content upto 4.55, 4.43 and 4.41 % in the case of Bati Trakya, Akkoy and Denizli, respectively.

Mehta *et al.* (2006) evaluated genetic variability in twenty-two diverse genotypes of okra for fruit yield and its component characters. The genotypic coefficient of variation, heritability and genetic advance as percentage of mean were higher for fruit yield, average fruit weight, plant height and fruit length which might be attributed to additive gene action resulting their inheritance. Simultaneously variations were noticed for number of primary branches per plant showing maximum variability among the different okra genotypes.

Naidu *et al*. (2007) reported highly significant differences between different okra genotypes for all the traits. The results revealed that maximum fruit yield was observed in genotype JAE-14 (221.0g/plant) followed by genotype JAE-18 (199.5g/plant). Maximum range of mean value was observed for yield per plant whereas minimum range of mean value was reported for number of ridges per fruit. High degree of variability was observed for plant height, number of fruits per plant, fruit weight and fruit yield per plant.

Akotkar *et al.* (2010) observed genetic variability of some yield contributing characters of about fifty genotypes of okra. The relative contribution of different characters towards the expression of genetic divergence showed that plant height contributed the maximum (19.59%)

followed by number of nodes on main stem (17.71%), number of locules per fruit (16.82%) and number of fruiting nodes (13.14%).

Senapati *et al.* (2011) presented that the analysis of variance exhibits a wide spectrum of variability among the characters of the hybrids. The maximum variability was recorded in fruit yield (58.163- 125.077 q/ha) followed by plant height (138.800 -182.267 cm). Yadav *et al.* (2013) observed fourty genotypes of okra for estimating the genetic variability as well as genetic divergence. Moderate variability for plant height, internodal length, number of branches per plant, number of fruits per plant, number of seeds per fruit, test weight and fruit yield per plant indicated sufficient genetic variability present among the genotypes for these characters.

Duggi *et al.* (2013) observed thirty-one genotypes of okra for yield and yield attributing characters. All the characters under presented a wide range of variation. The phenotypic variation was higher than that of corresponding genotypic variation for all the characters under study. However, both phenotypic and genotypic variations were in very close association for most of the traits which showed less environmental influence on the expression of the characters under study. High variability were observed for the traits such as number of primary branches and number of fruits per plant which indicated the presence of substantial variability for these characters thus suggesting good scope for improvement through selection.

Yonas *et al.* (2014) presented that analysis of variance showed significant differences ($p<0.01$) among the genotypes for all quantitative traits measured. The estimated values of phenotypic and genotypic coefficients of variations indicated the presence of variability among the genotypes for the majority of the yield contributing characters.

Ijaj *et al.* (2014) observed twenty-five okra genotypes to evaluate the genetic variability for ten yield and quality related characters. Minor difference between genotypic and phenotypic variance presented low environmental variance. All the characters were positively correlated with yield per plant except for photosynthetic active radiation and carbohydrate percentage which showed a negative association.

Badiger *et al.* (2018) recorded mean values on five random plants for fifteen characters. The genetic divergence in the experimental material was accessed. The results revealed that the cluster 3 showed the highest mean values for characters like total yield per plant (160.1g), marketable yield per plant (131.56g), marketable yield per ha (15.55t), average fruit weight (19.28g) and plant height (118.87cm) and lowest mean values for earliness characters like days to fifty percent flowering (39.89), days to first harvest (43.33) and node at first flower appeared (3.15). These five PCs explained 92.06% of total existing variability. PC-1 (42.50%) contributed more than PC-2 (22.68%), PC3 (10.30%), PC4 (8.76%) and PC5 (7.82%). First 3 PCs contributed 75.48 % of the total variation.

Vishnu *et al.* (2018) analyzed genetic variability on 29 genotypes of okra revealed high magnitude of genetic variability and high degree of transmission of majority of the growth, earliness and yield associated traits under study. High magnitude of genotypic coefficient of variation (>20%) for number of marketable fruits per plant, marketable yield per plant and yellow vein mosaic virus infestation indicated high degree of genetic variability offering great scope for selection of these characters.

Mahamadi *et al.* (2018) reported mean expected heterozygosity and Shannon diversity index were 0.46 and 0.77, respectively among fifty genotypes of okra. The diversity obtained could be exploited in the program of selection as well as crop improvement of okra. The final result presented a low genetic diversity of cultivated species of okra from West African origins.

Patra *et al.* (2018) reported fourteen genotypes along with three checks (Arka Abhay, Arka Anamika and VRO-6). The coefficient of variation presented low variability of less than 5% for parameter *viz.,* Plant height (4.84 cm), fruit girth (2.86 cm), Plant girth (2.62 cm) and leaf length (2.40 cm). High variability of about >10% was observed for fruit length (10.68), total yield (kg plot-1) (17.63), incidence of YVMV at 30, 45, 60, 75 and 90 DAS (48.01, 34.70, 36.28 and 34.12%).

More *et al.* (2018) evaluated fifty-five okra accessions were tested for stability in three different environments. The mean squares due to genotypes were highly significant for all the traits when tested against pooled error and pooled deviation which indicated the presence of considerable genetic variability in the materials. Highly significant differences were also observed amongst environments for all the traits when tested against pooled error and pooled deviation which indicated the presence of considerable environmental differences for all the traits.

2.2. Heritability and genetic advance

Heritability is an index of transmitting a character from the parents to the offspring. Lush (1940) defined heritability as the ratio of the total genotypic variance to the total phenotypic variance which provides a measure of the overall importance of hereditary determination of a trait.

Vijay and Manohar (1990) estimated high heritability for plant height, fruit weight, number of branches per plant and low genetic advance was observed for fruit length and fruit girth. Jeypandi and Balakrishnan (1990) noticed that heritability coupled with genetic advance were highest for yield per plant and plant height. Patel and Dalal (1992) reported high heritability estimates for yield and it's components in seven okra genotypes and their F1 hybrids. Pod attributes were found to have moderate heritability estimate. Sood *et al.* (1995) observed high heritability values coupled with high to moderate genetic advance for node at first fruit set, plant height and nodes per plant.

Chandra *et al.* (1996) observed high estimates of heritability and genetic advance for pod yield, plant height and number of seeds per pod. Patil *et al.* (1996) observed relatively high genetic advance for plant height, number of pods per plant and weight of pods per plant, indicative of the likely effectiveness of selection for such characters.

Hazra and Basu (2000) revealed that the plant height, fruit weight, ridges per fruit and seeds per fruit, were highly heritable while primary branches per plant, leaves per plant, days to first flower, fruit length, fruits per plant and fruit yield per plant were moderately heritable. Indurani and Veerargavathatham (2005) noticed high heritability coupled with high genetic advance for characters such as plant height at first flower bud appearance, number of fruits per plant and yield per plant.

Singh and Singh (2006) observed high heritability for days to first flowering, first fruiting node and fruit length, whereas high heritability coupled with high genetic advance was observed for first fruiting node length, number of branches per plant, tapering length and fruit yield per plant.

Singh *et al.* (2006) revealed that number of seeds/pod, internodal length, number of branches/plant, fruit yield/plant, number of fruits/plant, plant height and 100-seed weight exhibited high heritability along with high genetic advance which indicated that there was more number of additive factors and, therefore, further improvement could be brought about by selection.

Naidu *et al.* (2007) estimates high heritability and genetic advance in number of nodes to first flower, number of fruits per plant, number of seeds per fruit and fruit yield per plant. These characters are governed by additive gene action. Singh *et al.* (2007) recorded high values of heritability for plant height, number of fruits per plant, fruit yield, fruit length, fruit girth and number of branches per plant. High heritability coupled with moderate genetic advance was recorded for all the characters except for nodes at first flower appear indicating that additive gene affects were more important for these characters.

Akotkar *et al.* (2010) observed high heritability and genetic advance (% of mean) for number of fruiting nodes, number of ridges per fruit, plant height and number of fruiting nodes indicated these characters might be controlled by additive genes. Pal *et al.* (2010) revealed high heritability estimates for edible fruit yield per plant, plant height, number of fruits per plant, days to flowering and length of first fruiting node. The genetic advance as percent of mean was high for plant height and edible fruit yield per plant.

Ramanjinappa *et al.* (2011) observed that the characters *viz.*, plant height, number of branches per plant, number of nodes per plant, internodal length, number of fruits per plant, number of seeds per fruit, harvest index and total yield per plant exhibited high heritability coupled with high genetic advance over mean. Adiger *et al.* (2011) reported that the heritability and genetic advance as percentage of mean were higher for plant height, fruit yield per plant, fruit weight and days to 50 per cent flowering which might be attributed to additive gene action of inheritance.

Senapati *et al.* (2011) investigated that the high heritability estimates were obtained in Yellow vein mosaic virus disease incidence (98.02%), fruit yield (93.92%), edible maturity (90.98%) and days to 50% flowering (89.02%) indicating that these characters might be heritable and less influenced by environment. Das *et al.* (2012) recorded the genetic advance as percentage of mean which was high for fruit yield per plant, numbers of fruit per plant, plant height at flowering and fruit weight.

Nwangburuka *et al.* (2012) reported high heritability traits such as plant height (90.7%), fresh pod length (98.5%), fresh pod width (98.5%), mature pod length (98.5%), branching per plant (82.3%) and pod weight per plant (90.0%).Chandra *et al.* (2014) recorded the highest heritability estimates coupled with high genetic advance for fruit yield per plant and fruit yield per hectare indicating that these characters are under additive gene effects and are more reliable for effective selection.

Ijaj *et al*. (2014) reported high heritability in broad sense for all traits studied *viz.*, number of pods/plant, pod weight, PAR, net photosynthesis, transpiration, stomatal conductance, fibre content, protein content, carbohydrate and yield per plant. High genotypic variance along with high heritability in photosynthetic active radiation, net photosynthesis, stomatal conductance, and pod yield per plant, indicated high variability for traits and selection in early segregating generations on a phenotypic basis would be beneficial for improvement using these traits.

Mihretu *et al.* (2014) evaluated genetic variability among 25 okra accessions. High heritability

(96.76% and 96.50%) coupled with high genetic advance as percent of mean (106.32% and 97.25%) were recorded for internodes length and plant height, respectively.

Reddy and Sridevi (2014) obtained high estimates of heritability coupled with high genetic advance for fruit yield per plant indicating presence of additive gene effects which give high response of selection for these traits. Presence of high heritability coupled with low genetic advance for average fruit weight, plant height and fruit diameter revealed that straight selection has limited scope for further improving these traits.

Ahamed *et al*. (2015) reported high heritability estimates along with high or moderate degree of genetic advance in plant height (99.82 % and 205.06%), number of leaves per plant (99.57% and 204.4), number of seeds per fruit and number of fruits per plant (99.53% and 203.63).

Kerure *et al.* (2017) revealed that high heritability coupled with high genetic advance as percentage of mean were observed for almost all the characters studied *viz.*, plant height, stem girth, number of branches per plant, first fruit producing node, fruit length, fruit diameter, number of fruits per plant, average fruit weight, number of seeds per fruit, 100 seed weight and yield per plant, except days to 50% flowering and days to 80 % maturity which shows low heritability with low genetic advance as percentage of mean. The yield per plant, plant height and number of seeds per fruit showed high genetic advance that helped in effective and reliable selection through these characters for crop improvement.

Bashir and Aminu (2017) evaluated heritability and genetic advance for eight characters of okra. The heritability estimates in broad sense ranged from 25.84 % for the number of capsules per plant to 93.84 % for fresh capsule yield per plant. High heritability and genetic advance were observed for all the characters *viz.*, number of primary branches/plant, fresh capsule yield/plant, number of capsules per plant, fruit capsule length, plant height at harvest, fruit capsule diameter, fresh mass per capsule except days to anthesis and fresh capsule diameter.

2.3. Correlation and path coefficient analysis

The analysis of correlation coefficient showed the association of different traits. But as it is complex and does not provide any information on cause and effects, the path coefficient analysis help in removing the complication by measuring the direct and indirect influence of one variable upon the other by partitioning correlation coefficient into the components of direct and indirect effects.

Choudhary and Sharma (1999) revealed that the fruit weight, number of seeds per fruit, fruit length, number of fruits per plant and number of branches per plant had high direct effect on yield. Fruit weight exhibited the highest positive direct effect (0.507) and the highest genotypic correlation coefficient value (0.975) on fruit yield per plant. Sureshbabu *et al.* (2004) reported that the fruits per plant showed the highest positive direct effect on yield followed plant height, days to flower, fruit length, fruit girth, and fruits per plant. Pawar (2005) reported that the number of fruits per plant and number of seeds per fruit were found to be contributory characters on yield per plant owing to their high direct and indirect effects for all the characters.

Verma *et al.* (2007) reported that yield per plant exhibited positive and significant correlation with fruits per plant, fruit weight, fruit length, and fruit girth while negative correlation was reported in 100 seed weight, days to 50% flowering and days to first flowering with yield per plant.The number of fruits per plant had highest direct positive effect towards yield per plant followed by number of nodes to first flower. The indirect effects of most of the components towards yield were either negative or low in magnitude.

Magar *et al.* (2009) revealed that number of fruits per plant had maximum direct contribution towards total yield followed by fruit weight, plant height and days to first flowering. These important characters may be viewed in selection programme for the further improvement of okra.

Shashank *et al.* (2009) revealed that the single fruit weight (P = 0.720, G = 0.826) exerted highest positive significant correlation followed by number of fruits per plant (P = 0.642, G = 0.722) with number of seeds per fruit and number of seeds per fruit (P = 0.634, G = 0.772) with fruit yield per plant. However, the highest negative significant correlation was found in number of nodes per plant (P = -0.777, G = -0.818) with internodal length.

Saifullah *et al.* (2010) observed that plant height showed medium direct positive effect on fruit yield per plant. This trait had also indirect positive effect with number of fruits per plant and number of seeds per plant. Primary branches per plant had negative direct effect on yield and indirect positive effect with plant height, length of fruit, diameter of fruit, number of fruits per plant, fruit weight, number of seeds per fruit and fruit yield per plant. Number of internodes per plant also showed direct negative effect on fruit yield. While number of fruits per plant, average fruit weight, plant height, fruit length, days to first flowering, number of seeds per fruit and diameter of fruit showed positive direct effect on fruit yield per plant.

Sharma and Prasad (2010) reported that days to 50% flowering exhibited a positive significant correlation with days to first harvest, number of pod per plant with pod yield per plant and negative correlation was observed for pod weight with number of pod per plant. Nasti *et al.* (2010) revealed that fruit length and ten fruit weight had direct positive contribution with yield. The number of fruits per plant had maximum positive indirect contribution via fruit length and ten fruit weight with yield. Fruit shape index was found negatively correlated with fruit yield but showed high direct effect towards yield.

Adiger *et al.* (2011) evaluated 163 genotypes including 43 parents and 120 crosses of okra to determine the genetic variability, nature of association among different yield attributes and their direct and indirect contribution towards yield. The result of path coefficient analysis revealed that fruit weight had maximum direct contribution (0.884) towards fruit yield followed by number of fruits per plant (0.852), plant height (0.024 cm) and number of branches per plant (0.020). However, days to 50 per cent flowering exhibited highest negative direct effect (-0.013) followed by test weight (-0.009) and fruit diameter (-0.003).

Koundinya *et al.* (2013) studied 30 genotypes of okra for determination of correlation coefficient. The result revealed that seed yield per plant had significant positive association with plant height (0.210), fruits per plant (0.631), fruit yield per plant (0.606) and seeds per fruit (0.596), whereas it exhibited significant negative association with days to 50% flowering (-0.308). Fruit yield per plant was having significant positive association with plant height (0.365), fruits per plant (0.912) and fruit weight (0.328) while it had significant negative association with days to 50% flowering (-0.271).

Reddy *et al*. (2013) examined correlation and path coefficient analyses and revealed that fruit weight, total number of fruits per plant and number of marketable fruits per plant not only had positively significant association with marketable pod yield per plant, but also had positively high direct effect on marketable pod yield per plant and are regarded as the main determinants of marketable pod yield per plant.

Simon *et al.* (2013) studied path coefficient analysis and revealed that seed size had positive and highly significant genotypic association with seed yield (0.709**). Number of seeds per pod had the highest significant correlation effect on seed yield (0.846**) as well as highest negative direct effect with seed yield (-1.00) indicating that selection of genotype on the basis of number of seeds per pod will increase seed yield. This suggests that the two attributes have a strong influence on seed yield.

Ahiakpa *et al*. (2013) showed a strong positive correlation between total fruit production and first fruiting node (r =0.76); first fruiting node (r=0.79); and number of fruits per plant and stem diameter at base (r=0.88). The result showed 50% germination had positive and significant correlations ($P \leq 0.05$) with maximum number of internode (r = 0.68), maximum plant height (r = 0.55); stem diameter at base (r = 0.55); but negatively correlated with major yield determining traits such as total fruit production (r = -0.62) and first fruit producing node (r = -0.58).

Ahemad *et al*. (2015) recorded the highest positive correlation between number of fruits per plant and yield per plant (r = 0.99) and between number of fruits per plant and 100-seed weight (r = 0.44**). Results also showed the significantly positive correlation between 100-seed weight and yield per plant (r = 0.44).

Sharma and Prasad (2015) evaluated twenty okra genotypes were evaluated for correlation and path coefficient for yield and its contributing attributes. The result revealed that number of branches (NB) showed positive indirect effect via number of fruits per plant (0.7655) and plant height (0.2728) and negative indirect effect via fruit weight (-0.2830). The estimated residual effect found was 0.0118 indicated about 98.82% of variability in fruit yield was contributed by studied yield affecting characters.

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

Umrao *et al*. (2015) studied phenotypic correlation and path coefficient analysis was worked out for eleven important characters in fifty genotypes of okra. Fruit yield per plant (g) showed positive and significant correlation with number of first fruiting nodes / plant, final plant height (cm), no. of fruiting nodes /plant, length of fruit (cm), weight per fruit (g), and number of fruits per plant. The path coefficient analysis revealed that the magnitude of direct effect were higher for weight per fruit (0.506) followed by number of fruits per plant(0.326), length of fruit (0.2) and no. of first fruiting nodes /plant (0.190) while the magnitude of rest of the characters in all the environments were moderate to low.

Doddanakatte *et al.* (2016) evaluated 36 okra germplasm. In results, the crop duration was highly significantly correlated with plant height (r=0.57 at *P*=0.01) and days to first flowering (r=0.28 at *P*=0.28). The number of fruits per plant had positive significant correlation with number of primary branches (r=0.36 at *P*=0.01) and vice- versa. The association between fruit weight was linearly correlated with number of fruits per plant at *P*=0.05 with correlation value of r=0.25. There was positive significant correlation among fruit length and fruit weight (r=0.48 at *P*=0.01).

Tesfa *et al.* (2016) evaluated fifty accessions of okra germplasm. The results showed a strong positive correlation between total fruit number and yield per plant (r = 0.84); first fruit producing node and plant height (r = 0.39); and number of seeds per fruit and the length of commercial fruit (r = 0.44). The observed variability in the traits studied strongly indicate the possibility of selecting plants with suitable morphology when considering integration into any improvement program towards preservation and conservation of okra genetic diversity.

Ishfaq *et al*. (2016) reported 25 genotypes of okra in order to understand the direct and indirect contributions of plant traits with pod yield per plant which may help to develop high yielding okra varieties. In results, the path analysis revealed that pod weight per plant, number of pods per plant, plant height at maturity and 100 seed weight contributed largely to okra pod yield and maximum emphasis would be given to these traits for selection focused at development of high yielding okra varieties.

Dwivedi *et al*. (2017) investigated 20 genotypes of okra. The result showed that significant and positive correlation of plant height at 30 DAS was observed with plant height at 60 DAS (0.66), plant height at 90 DAS (0.58), fruiting span (0.56), number of branches per plant at 60 DAS (0.479), length of internode (0.39), yield per plant and number of branches per plant at 30 DAS (0.34), number of leaves per plant (0.31) and number of fruits per plant (0.26). However, significant and negative association was observed with days to first picking (-0.53), days to 50% flowering (-0.44) and number of seeds per fruit (-0.39).

Prasath *et al*. (2017) reported 30 germplasm lines of okra. The result stated that number of fruits per plant showed positive and significant correlation with number of seeds per fruit, 100 seed weight, number pickings and ascorbic acid content. Number of seeds per fruit showed positive and significant correlation with 100 seed weight, number pickings and iodine content. Number pickings showed positive and significant correlation with ascorbic acid content and iodine content.

Mishra *et al.* (2018) studied direct and indirect effects of thirteen quantitative traits of okra. The results revealed the highest positive direct effect of days to first flowering on yield per plant. Days to first flowering, duration of fruiting, fruit weight, number of nodes per plant and plant height also had positive indirect effects indicating their importance in selection of high yielding genotypes of okra.

Singh *et al*. (2018) evaluated eighty genotypes of okra. The fruit yield has significantly positive correlation with number of fruits per plant, plant height, average fruit weight, number of seeds per fruit, fruit length, first flower producing node, first fruit producing node, 50 percent flowering and stem diameter respectively, indicating mutual association of these traits. The path coefficient analysis revealed that fruit width (1.431) had maximum direct contribution towards fruit yield followed by number of fruits per plant (0.834), first fruit producing node (0.221) and average fruit weight (0.145). However, 100 seed weight exhibited highest negative direct effect (-1.732) followed by first flower producing node (-0.222), 50 per cent flowering (-0.097) and intermodal length (-0.062) plant height at 45 days after sowing (-0.065) and days to first flowering (-0.040).

2.4. Coefficient of variation

Vijay and Manohar (1990) estimated high genotypic coefficient of variation for days to 50% flowering, number of effective nodes, number of branches per plant, fruit yield per plant and low genotypic coefficient of variation observed for first fruiting nodes in okra. High phenotypic coefficient of variation was observed for internodal length. Deo *et al.* (1996) reported high genotypic coefficient of variation for plant height, fruit yield per plant, number of branches per plant, while high phenotypic coefficient of variation was recorded for number of branches per plant in okra and plant height in okra.

Bindu *et al.* (1997) reported high genotypic coefficient of variation for plant height, fruit weight, number of effective nodes, fruit yield per plant, number of branches per plant, whereas high phenotypic coefficient of variation was observed for number of effective nodes number of branches per plant and plant height in okra. Dhall *et al.* (2001) recorded high phenotypic coefficient of variation and genotypic coefficient of variation for total yield per plant, number of fruits per plant, virus incidence, marketable yield per plant and plant height.

Bendale *et al.* (2003) observed that phenotypic variance was higher for all the fifteen characters than the genotypic variance (genotypic coefficient of variation). The number of branches per plant and yield per plant showed high genotypic coefficient of variation and phenotypic coefficient of variation estimates. Singh and singh (2006) observed high genotypic coefficient of variation and phenotypic coefficient of variation for number of branches per plant, fruit yield per plant, tapering length, plant height and fruit length. Bali *et al.* (2004) evaluated 31 diverse genotypes of okra for yield and combining characters and noticed high phenotypic coefficient of variation as well as high genotypic coefficient of variation for seed yield per plant, number of branches per plant, internodal length and fruit yield per plant. Sureshbabu *et al.* (2004) reported high value of genotypic coefficient of variation for the characters like fruits per plant, yield per plant, number of ribs on the fruit and height of the plant.

Singh and Singh (2006) observed high genotypic coefficient of variation and phenotypic coefficient of variation for number of branches per plant, fruit yield per plant, tapering length, plant height and fruit length. Narayan *et al.* (2006) observed high genotypic and phenotypic coefficient of variation for plant height at 100 days after sowing, number of branches per plant and internodal length. Moderate genotypic and phenotypic coefficient of variation was observed for number of nodes on main stem, number of nodes at first flowering and number of leaves at 100 days after sowing. Low genotypic coefficient of variation and phenotypic coefficient of variation was exhibited by days to first flowering and days to 50% flowering.

Singh *et al.* (2007) observed high magnitude of phenotypic coefficient of variation and genotypic coefficient of variation for number of branches per plant, plant height, number of branches per plant, fruit yield, fruit length and number of fruits per plant. Phenotypic coefficient of variation was higher than corresponding genotypic coefficient of variation.

Magar *et al.* (2009) reported that genotypic coefficient of variation and phenotypic coefficient of variation were of higher magnitude for fruit yield per plant followed by number of fruits per plant, node at which first flower appear, plant height and fruit weight. The magnitudinal difference between phenotypic coefficient of variation and genotypic coefficient of variation estimate was maximum for node at which first flower appear and number of fruits per plant indicating influence of environment on these characters.

Prakash and Pitchaimuthu (2010) observed high phenotypic as well as genotypic coefficients of variation for plant height, inter-nodal length, first flowering and first fruiting node, average fruit weight and number of seeds per fruit.

Das *et al.* (2012) recorded high phenotypic coefficient of variation and genotypic coefficient of variation values for fruit yield per plant, number of fruits per plant and plant height during both seasons (rainy and summer). The remaining traits *viz.*, fruit length and dry fruit weight recorded moderate to low phenotypic coefficient of variation and genotypic coefficient of variation estimates.

Morey *et al.* (2012) found significant differences among the genotypes for different morphological characters. The high values of genotypic coefficient of variation and phenotypic coefficient of variation were observed for moisture content, yellow vein mosaic incidence, fruit borer incidence, chlorophyll content, diameter of fruit, number of fruits per plant, and fruit yield per plant.

Nwangburuka *et al.* (2012) reported high genotypic coefficient of variability for traits such as plant height (26.2%), fresh pod length (23.9%), fresh pod width (23.9%), mature pod length (28.6%), branches per plant (29.3%) and pod weight per plant (33.9%) on twenty nine okra accessions during rainy and summer seasons.

Morey *et al.* (2012) reported the higher value of genotypic coefficient of variation was found for the characters, yellow vein mosaic incidence (46.81%), fruit borer incidence (31.63%), protein content (28.76%) and chlorophyll content (28.35%), diameter of fruit (26.45%), number of fruits per plant (23.93%) and yield per plant (22.29%). The higher values of phenotypic coefficient of variation was recorded for the characters, yellow vein mosaic incidence (56.16%), fruit borer incidence (34.41%), number of primary branches per plant (32.68%), chlorophyll content (28.93%), protein content (28.78%), diameter of fruit (27.35%), number of fruits per plant (25.73%), yield per plant (22.93%) and number of nodes on main stem (22.43%).

Duggi *et al.* (2013) evaluated 31 okra genotypes on yield and yield attributing traits. The results revealed the highest phenotypic coefficient of variation for number of primary branches (39.56%) was followed by yield per plant (24.36%) and number of fruits (22.51%) while low phenotypic coefficient of variation was shown by fruit girth (6.96%) and days to 50% flowering (9.90%).

Simon *et al.* (2013) evaluated 10 different cultivars of okra and revealed that the phenotypic coefficient of variation was greater in values than the genotypic coefficient of variation The results revealed higher phenotypic coefficient of variation values in pod yield (35.41%), number of pods per plant (29.04%), seed yield (28.63%), pod length (18.29%) and number of leaves per plant (18.29%). While very low phenotypic coefficient of variation was observed for internodes distance (0.310%).

Yadav *et al.* (2013) evaluated fourty genotypes of okra for estimating the genetic variability. Moderate phenotypic coefficient of variation and genotypic coefficient of variation values for plant height, internodal length, branches/plant, fruits/plant, seeds/fruit, test weight and fruit yield/plant indicated sufficient genetic variability present among the genotypes for these characters. The forty lines were grouped into nine clusters based on d2 values.

Ahamed *et al.* (2015) recorded the highest range of variation for fruit weight (18.25-25.41g), followed by yield per plant (98.90 – 1650.00g). The highest genotypic coefficient of variation (46.70 %) and phenotypic coefficient of variation (47.72 %) were recorded for fruit yield per plant while both were lowest for days to maturity (8.07 % and 8.25 %).

Kerure *et al.* (2017) estimated 52 okra genotypes and the result showed that the variance due to treatments (genotypes) was significant (at p=0.05) for all the traits studied. These results indicated that the phenotypic coefficient of variation ranged from 1.02 % for days to 80 % maturity to 34.13 % for total yield per plant (g).

MATERIALS AND METHODS

CHAPTER–3

MATERIALS AND METHODS

This chapter comprises the details about the materials used and the methods adopted during the course of present investigation entitled “Genetic evaluation of local genotypes of okra *(Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P.” which was carried out during Rainy season in the year 2018.

3.1. SITE OF EXPERIMENT

3.1.1. Location

The present experiment was laid out in the field of Experimental Farm of Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur (H.P.). It is located at an altitude of about 650 m above mean sea level, lying between 31°41’47.6” N latitude and 72°28’6.3” E longitude under low hill zones of Himachal Pradesh, India.

3.1.2. Climate

The place experiences hot summers and mild winters. Maximum rainfall takes place during the month of July-August. The meteorological parameter during the crop season such as temperature, relative humidity and rainfall were taken at the Meteorological observatory, College of Horticulture and Forestry, Neri, Hamirpur (H.P.) are presented in Table 3.1.

Table 3.1. Agro-meteorological data during cropping period

S. No.	MONTH	TEMPERATURE (ºC)	RELATIVE HUMIDITY (%)	RAINFALL (mm)
1	June	29.49	49.87	127.60
2	July	27.56	72.51	325.40
3	August	26.54	76.43	407.80
4	September	24.65	75.67	291.60
5	October	21.36	58.87	11.40
6	November	17.03	62.59	20.00

Source: Department of soil science and watermanagement, COHF, Neri, *Hamirpur*,H.P. (177001)

3.1.3. Soil

The soil of the experimental block was sandy loam having good drainage system and uniform soil texture.

3.2. EXPERIMENTAL MATERIALS

The experimental materials for the present investigation comprised to twenty genotypes of okra (*Abelmoschus esculentus* L.) including two checks (Palam Komal and P-8). These genotypes were selected from the germplasm collected from low hill zone of H.P. and maintained at the experimental farm, Neri. The genotypes under study has been enlisted in Table 3.2.

Table 3.2. List of genotypes and their source of collection

S. No.	Genotypes Code Number	Source
1.	LC-1-18	Department of Vegetable Science, UHF, Neri
2.	LC-2-18	Department of Vegetable Science, UHF, Neri
3.	LC-3-18	Department of Vegetable Science, UHF, Neri
4.	LC-4-18	Department of Vegetable Science, UHF, Neri
5.	LC-5-18	Department of Vegetable Science, UHF, Neri
6.	LC-6-18	Department of Vegetable Science, UHF, Neri
7.	LC-7-18	Department of Vegetable Science, UHF, Neri
8.	LC-8-18	Department of Vegetable Science, UHF, Neri
9.	LC-9-18	Department of Vegetable Science, UHF, Neri
10.	LC-10-18	Department of Vegetable Science, UHF, Neri
11.	LC-11-18	Department of Vegetable Science, UHF, Neri
12.	LC-12-18	Department of Vegetable Science, UHF, Neri
13.	LC-13-18	Department of Vegetable Science, UHF, Neri
14.	LC-14-18	Department of Vegetable Science, UHF, Neri
15.	LC-15-18	Department of Vegetable Science, UHF, Neri
16.	LC-16-18	Department of Vegetable Science, UHF, Neri
17.	LC-17-18	Department of Vegetable Science, UHF, Neri
18.	LC-18-18	Department of Vegetable Science, UHF, Neri
19.	Palam Komal	CSKHPKV, Palampur
20.	P-8	PAU, Ludhiana

Source: Department of Vegetable Science, COH&F, Neri, Hamirpur

3.3. SEED SOWING

The seed sowing of all the genotypes was carried out on 29th June, 2018 directly in the field. Recommended cultural practices were followed for raising the healthy crop as per package of practices of vegetable crops to ensure a healthy crop of okra.

3.4. EXPERIMENT DESIGN AND LAYOUT

The details of experimental layout are given below:

Location	:	Experimental Farm of Vegetable Science, Neri
Design	:	Randomized Block Design
Name of Crop	:	Okra (*Abelmoschus esculentus* (L.) Moench)
Season	:	Rainy or Kharif
Year		2018
Date of sowing	:	29 June
No. of genotypes (including checks)	:	20
Plot size	:	1.8m x 1.2m
Replications	:	Three (03)
Row to row distance	:	60 cm
Plant to plant distance	:	20 cm
Total number of plants per plot	:	18
Number of plants for observation per plot	:	5
Number of Check Varieties	:	2 (Palam Komal and P-8)

3.5.OBSERVATIONS TO BE RECORDED

Five representative plants in each plot were selected randomly and tagged for recording data for various plant characters. The data recorded on various parameters during the period of experiment are as follows:

3.5.1. Plant height (cm)

Height of plant was recorded from the base just above the soil surface to growing point of the plant with the help of meterscale.

3.5.2. Days to 50% flowering

Number of days taken from the date of sowing to date of 50% flowering were counted.

3.5.3. Internodal length (cm)

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

3.5.4. Plant habit

The plant habit was recorded as per branching habit under following categories:

i) Spreading

ii) Non-spreading

3.5.5. First fruiting node

The nodes which bear first fruit were recorded among five randomly selected plants and the average was worked out.

3.5.6. Fruit length (cm)

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

3.5.7. Fruit diameter (cm)

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

3.5.8. Fruit color

The color of the fruit as per AVRDC record-sheet was recorded at marketable stage in following categories:

i. Dark Green

ii. Green

iii. Yellow green

iv. Green with red specks

v. Red

3.5.9. Fresh fruit weight (g)

The individual weight of five randomly selected fruits was recorded separately with the help of weighing balance and average was worked out.

3.5.10. Number of fruits per plant

The number of fruits harvested from five randomly selected plants in each genotype were counted after each picking and summed up together. The average number of fruits per plant was calculated.

3.5.11. Number of locules per fruit

Number of locules per fruit was observed for five fruits from randomly tagged plants by counting the number of ridges per fruit and average number of locules per fruit was worked out.

3.5.12. Number of seeds per fruit

Seeds were extracted and counted carefully from the five dried fruits and average number of seeds per fruit was worked out.

3.5.13. 100 seed weight (g)

Seeds from five randomly selected fruits were extracted and hundred seeds were counted and their seed weight was recorded.

3.5.14. Fruit yield per plant (g)

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

3.5.15. Incidence of yellow vein mosaic virus and other disease (if any)

The disease incidence of YVMV was calculated by counting the number of plants affected in each replication and were expressed in percentage.

3.6. STATISTICAL ANALYSIS

Mean of the various observations were subjected to the following statistical analysis for drawing conclusion from the present investigation.

3.6.1. Analysis of variance

The data collected on different quantitative traits were processed for the analysis of variance as suggested by Panse and Sukhatme (1967).

$$Y_{ij} = \mu + g_i + r_j + e_{ij}$$

Where,

Y_{ij} = Phenotypic observation of i^{th} entry grown in j^{th} replication

μ = General population mean

g_i = Effect of i^{th} entry

r_j = Effect of j^{th} replication

e_{ij} = Error component

Source of variation	Degree of freedom	Sum of square	Mean sum of square	Expected mean sum of squares
Replication (r)	r-1	S_r	$S_r/(r-1)=M_r$	$\sigma^2 e+g\sigma^2 r$
Genotypes (g)	g-1	S_g	$S_g/(g-1)=M_g$	$\sigma^2 e+r\sigma^2 g$
Error (e)	(r-1) (g-1)	S_e	$S_e/(r-1)(g-1)= M_e = V_e$	$\sigma^2 e$

Where,

r = Number of replications

g = Number of genotypes

S_r = Sum of squares due to replications

S_g = Sum of squares due to genotypes

S_e = Sum of squares due to error

M_r = Mean sum of squares due to replications

M_g = Mean sum of squares due to genotypes

M_e = Mean sum of squares due to error

$\sigma^2 r$ = Variance due to replications

$\sigma^2 g$ = Variance due to entries

$\sigma^2 e$ = Error variance

The replications and genotypes mean sum of square was tested against error mean squares by 'F' test for (r-1), (r-1) (g-1) and (g-1), (r-1) (g-1) degree of freedom at P = 0.05. The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference were calculated to find out the superiority of one genotype over the other.

The standard error and critical differences were calculated as follows:

SE (m) ± = $\sqrt{M_e/r}$

SE (d) ± = $\sqrt{2\,M_e/r}$

$CD_{0.05}$ = S.E. (d) x $t_{(0.05)}$ (r-1) (g-1) df

Where,

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of difference

$CD_{0.05}$ = Critical difference at 5 per cent level of significance

All the characters which showed significant differences among genotypes were further subjected to analysis for the following parameters.

1. Coefficients of Variability (Genotypic and Phenotypic)
2. Heritability
3. Genetic advance
4. Genetic gain
5. Correlation coefficients
6. Path coefficient analysis

1. Coefficients of variability:

Coefficients of variability were estimated as per formula given by Burton (1952).

a) Phenotypic Coefficient of Variation (PCV)

$$\text{PCV (\%)} = \sqrt{\frac{\text{Phenotypic Variance } (V_p)}{\text{General mean of population } (\mu)}} \times 100$$

b) Genotypic Coefficient of Variation (GCV)

$$\text{GCV (\%)} = \sqrt{\frac{\text{Phenotypic Variance } (V_g)}{\text{General mean of population } (\mu)}} \times 100$$

Where,

V_g = $(M_g - M_e)/r$

V_p = $(V_g + V_e)$

2. Heritability:

Heritability in broad sense was calculated as per formula given by Hanson *et al.* (1956).

$$\text{Heritability (\%)} = \frac{\text{Genotypic Variance } (V_g)}{\text{Phenotypic Variance } (V_p)} \times 100$$

3. Genetic Advance:

The expected genetic advance resulting from selection of five percent superior individuals was calculated as per Johnson *et al.* (1955):

$$GA = K \times \sigma_p \times H$$

Where;

K = 2.06 (Selection differential at 5% selection index)

σ_p = Phenotypic standard deviation

H = Heritability in broad sense

4. **Genetic gain:** It was calculated as follows:

$GG (\%) = (GA/ \mu) \times 100$

Where;

GG = Genetic gain

GA = Genetic advance

μ = General mean of population

For categorizing the magnitude of coefficient of variation, Sivasubramanian and Madhava Menon (1973) suggested the following limits:

PCV and GCV	>20%	High
	10-20%	Moderate
	0-10%	Low

Heritability is categorized as high, medium and low by Robinson (1949) as follows:

Heritability	>60%	High
	30-60%	Moderate
	0-30%	Low

Genetic advance as percentage of mean was classified according to Johnson *et al.*, 1955

Genetic advance as percentage of mean (Genetic gain)	>20%	High
	10-20%	Moderate
	0-10%	Low

5. **Correlation studies:**

The correlation coefficients were calculated as per Al-Jibouri *et al.* (1958) by using analysis of variance and covariance matrix in which total variability was split into replications, genotypes and error. All the components of variance were estimated from the analysis of variance table and those of covariance from the analysis of covariance as given below:

Analysis of Variance and Covariance

Source of variance	**df**	**Mean sum of Squares**		**Mean sum of products**	**Variance**
		X	**Y**		
Replications (r)	r-1				
Genotypes (g)	g-1	$M_g X$	$M_g Y$	$M_g XY = MP_1$	MP_1 / MP_2
Error (e)	(r-1)(g-1)	$M_e X$	$M_e Y$	$M_e XY = MP_2$	

Genotypic, Phenotypic and environmental covariances between X and Y characters were worked out as under:

Environmental covariance (V_eXY) = MP_2 Genotypic

covariance (V_gXY) = $(MP_1 - MP_2)/r$

Phenotypic covariance ($V_p XY$) = $V_g XY + V_eXY$

Coefficients of correlation

The phenotypic and genotypic coefficients of correlation were computed following Al-Jibouri *et al.* (1958).

a) Phenotypic coefficient of Correlation

$r_p = V_p XY / \sqrt{V_p X \times V_p Y}$

where,

$V_p XY$ = Phenotypic covariance between trait X and Y

$V_p X$ = Phenotypic variance of X

$V_p Y$ = Phenotypic variance of Y

b) Genotypic coefficient of correlation

$r_g = V_g XY / \sqrt{V_g X \times V_g Y}$

where,

$V_g XY$ = Genotypic covariance between X and Y

$V_g X$ = Genotypic variance of X

$V_g Y$ = Genotypic variance of Y

The calculated correlation coefficients (r_g and r_p) were compared with tabulated 'r' value as given by Fisher and Yates (1963) at (n-2) degrees of freedom. If the calculated value of correlation coefficients was greater than tabulated value at 5 per cent level of significance, the correlation was considered as significant, otherwise it was non-significant.

6. Path coefficient analysis:

The following formula was used for calculating path coefficient analysis was carried out by Dewy and Lu (1959).

The path coefficient were obtained by the simultaneous selection of following equations, which expressed the basic relationship between genotypic correction (r) and path coefficient (P)

$$r_{14} = P_{14} + r_{12} P_{24} + r_{13} P_{34}$$

$$r_{24} = r_{21} P_{14} + P_{24} + r_{23} P_{34}$$

$$r_{34} = r_{31} P_{14} + P_{32} + r_{24} P_{34}$$

where r_{14} , r_{24} and r_{34} are genotypic correlation of components characters with yield (dependent variable) and r_{13}, r_{23} and r_{24} are genotypic correlations among the component characters (independent variable) and $r_{12} P_{24}$, $r_{13} P_{34}$, $r_{21} P_{14}$, $r_{23} P_{34}$, $r_{31} P_{14}$ and $r_{24} P_{34}$ are indirect effects.

The direct effects are calculated by the following set of equations:

$P_{14}= C_{11}\, r_{14}+ C_{12}\, r_{24}+ C_{13}r_{34}$

$P_{24}= C_{21}\, r_{14} + C_{22}\, r24 + C_{23}\, r_{34}$

$P_{34}= C_{31}\, r_{14} + C_{32}\, r_{32} + C_{24}r_{34}$

where C_{11}, C_{12}, C_{23} and C_{33} are constants derived by using abbreviated Doultittle's technique as explained by Goulden and $P_{14,}$ P_{24} and P_{34} are the estimates of direct effects.

Residual effect:

It measures the role of other possible independent variables which were not included in the study on dependent variable. The residual effect is estimated with the help of direct effect and simple correction coefficient as given below:

$$I=P^2x_4+P^2{}_{14}+P^2{}_{24}+P^2{}_{34}+2P_{14}r_{12}P_{24}+2P_{14}r_{13}P_{34}+2P_{24}r_{22}P_{34}$$

RESULTS AND DISCUSSION

CHAPTER - 4

RESULTS AND DISCUSSION

The present investigation entitled "Genetic evaluation of local genotypes of okra *(Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P." on twenty genotypes of okra including two checks (Palam Komal and P-8) was carried out during rainy season in the year 2018 with the following objectives:

1. To assess the performance and the extent of genetic variability in various okra genotypes.
2. To work out heritability and genetic advance.
3. To work out correlation and path analysis in okra genotypes.
4. To identify most suitable and best performing genotypes of okra for cultivation in low hill conditions of Himachal Pradesh.

The results obtained from the present investigation are presented under following headings:

4.1. Variability studies

4.1.1. Mean performance of genotypes

4.1.2. Parameters of variability

4.1.2.1. Coefficient of variation

4.1.2.2. Heritability

4.1.2.3. Genetic advance

4.2. Correlation studies

4.2.1. Phenotypic correlations

4.2.2. Genotypic correlations

4.3. Path analysis

4.3.1. Direct effects

4.3.2. Indirect effects

4.1. Variability studies

4.1.1. Mean performances of genotypes

The analysis of variance for different characters of okra is depicted in Appendix-I. Mean sum of square due to genotypes was highly significant for all these characters, indicating the presence of high genetic variability in the existing material. The findings of Ario *et al.* (1986), Akotkar *et al.* (2010), Adiger *et al.* (2011), Nwangburuka *et al.* (2012), Das *et al.* (2012), Simon *et al.* (2013), Reddy *et al.* (2013), Duggi *et al.* (2013), Verma *et al.* (2017), Kerure *et al.* (2017), Bashir *et al.* (2017), Dwivedi *et al.* (2017), Mishra *et al.* (2018) and More *et al.* (2018)

Table 4.1: Mean performance of okra genotypes for plant growth contributing characters

S.No.	Genotypes	Plant height (cm)	First fruiting node	Internodal length (cm)	Days to 50% Flowering
1	LC-1-18	132.93	4.83	6.54	46.87
2	LC-2-18	125.47	4.71	6.93	44.54
3	LC-3-18	169.67	5.35	13.37	51.82
4	LC-4-18	179.60	5.96	24.43	53.23
5	LC-5-18	161.93	4.31	14.43	41.42
6	LC-6-18	179.17	5.35	16.92	49.11
7	LC-7-18	125.77	4.60	11.74	43.23
8	LC-8-18	172.13	5.57	18.66	50.92
9	LC-9-18	119.20	4.14	6.93	41.06
10	LC-10-18	158.44	4.33	20.48	42.30
11	LC-11-18	124.73	4.38	17.43	41.52
12	LC-12-18	120.40	4.60	15.17	45.69
13	LC-13-18	117.33	4.87	6.64	46.39
14	LC-14-18	97.65	4.33	12.51	42.06
15	LC-15-18	141.40	4.59	6.19	45.72
16	LC-16-18	122.47	3.41	17.80	40.97
17	LC-17-18	176.03	4.34	14.25	41.91
18	LC-18-18	132.50	5.41	16.26	40.08
19	Palam Komal	171.21	4.41	13.79	43.77
20	P-8	175.12	4.78	14.37	45.15
	SE±(m)	1.22	0.11	1.12	0.75
	C.D.	3.52	0.32	3.23	2.16
	C.V.	`1.46	4.05	14.14	2.90

are similar to that of the present findings.

The mean performance of the twenty genotypes of okra for twelve plant growth, yield and yield contributing characters under the study are presented in Table 4.1, 4.2 and 4.3.

4.1.1.1. Plant height (cm)

A wide range of variability was observed with respect to plant height ranging from 97.65 cm to 179.61 cm with the mean performance of 138.54 cm. The genotype LC-4-18 exhibited maximum plant height (179.60 cm) which was statistically similar with LC-6-18 (179.16 cm). Eight genotypes had more height than check P-8 while nine genotypes had more height than check Palam Komal. The genotypes with more height had also longer internodal length and moreover these genotypes took more number of days for flowering. The minimum plant height was recorded in LC-14-18 (97.653 cm). These findings are in consonance with the findings of Hazara and basu (2000), Naidu *et al*. (2007) and Bendale *et al*. (2003).

4.1.1.2. Days to 50% flowering

Analysis of variance for days to 50% flowering indicated the preponderance of high genetic variability in different okra genotypes ranging from 40.08 to 53.23 days with an average of 46.40 days. Days to 50% flowering is an indicative of earliness of a genotype. LC-18-18 was earliest in flowering (40.08) closely followed by LC-16-18 (40.97), LC-10-18 (41.06), LC-11-18 (41.52) and LC-17-18 (41.90) which was also statistically *at par* with standard check Palam komal (41.42) whereas second check P-8 took 45.71 days and maximum days were recorded for LC-4-18 (53.23) which was at par with LC-3-18 (51.82). Kumar *et al.* (2017), Sravanthi *et al.* (2017), Mishra *et al.* (2018) and More *et al.* (2018) reported the same results.

4.1.1.3. Internodal length (cm)

Internodal length determines the plant height of the genotype. Also, number of nodes per plant gives an indication of number of fruits as well as yield of the genotype. The length of internodes varied from 6.19 to 24.43 cm. The genotype LC-1-18 had lowest internodal length of 6.19 cm which was statistically similar to LC-2-18 (6.93 cm), LC-9-18 (6.93 cm), LC-13-18 (6.64 cm) and also with standard check P-8 (6.24 cm). LC-4-18 gave maximum internodal length of 24.43 cm which was at par with LC-10-18 (21.47 cm). Similar findings were also observed by Hazara and basu (2000), Naidu *et al*. (2007), Bendale *et al*. (2003), Prajana (2015), Senapati*et al.* (2011), Kumar *et al.*(2017) and More *et al.* (2018) with respect to this character.

4.1.1.4. First fruiting node

First fruiting node determines the earliness of the genotype which in general fetches high price in the market. Number of nodes to first fruit ranged from 3.41 to 5.96 with an overall average of 4.69. The lowest node to first fruiting (3.41) was observed in genotype LC-16-18

Table 4.2: Mean performance of okra genotypes for fruit yield contributing characters

S.No.	Genotypes	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of locules per fruit
1	LC-1-18	18.20	1.46	29.15	5.33
2	LC-2-18	19.73	1.41	32.51	7.63
3	LC-3-18	15.66	1.44	20.51	5.00
4	LC-4-18	12.27	1.25	15.54	5.00
5	LC-5-18	15.95	2.18	42.71	5.00
6	LC-6-18	15.75	1.45	19.47	6.70
7	LC-7-18	19.69	1.65	32.77	5.40
8	LC-8-18	15.65	1.27	21.57	5.70
9	LC-9-18	16.16	2.31	43.11	6.93
10	LC-10-18	20.79	1.82	36.15	5.00
11	LC-11-18	22.71	1.86	44.14	5.00
12	LC-12-18	19.96	1.79	32.05	5.00
13	LC-13-18	16.86	1.75	23.41	5.00
14	LC-14-18	21.77	1.60	37.28	5.00
15	LC-15-18	19.95	1.65	37.25	5.00
16	LC-16-18	22.25	1.98	46.57	7.30
17	LC-17-18	21.35	1.67	45.43	5.00
18.	LC-18-18	20.61	1.56	44.36	6.73
19.	Palam Komal	21.97	1.62	36.70	5.00
20.	P-8	18.91	1.45	28.29	5.00
	SE±(m)	0.34	0.08	0.81	0.17
	C.D.	0.98	0.22	2.32	0.50
	C.V.	3.13	7.81	4.18	5.41

which is statistically lower than both the standard checks. The highest node number to first fruiting (5.96) was found in genotype LC-2-18 which was statistically at par with LC-4-18 (5.93). Nawanburuka *et al.* (2011), Das *et al.* (2012), Simon *et al*. (2013), Reddy *et al*. (2013), Duggi *et al.* (2013), Verma *et al.* (2017) reported the same results.

4.1.1.5. Fruit length (cm)

A lot of genetic variability was present with respect to fruit length ranging from 12.27 to 22.71 cm with a population mean of 17.49 cm. Generally medium sized fruits are preferred by the consumers. Although maximum fruit length was recorded in Genotype LC-11-18 (22.71cm) followed by LC-16-18 (22.25 cm), LC-5-18 (21.97cm) and LC-14-18 (21.77 cm). Five genotypes recorded statistically similar fruit length with standard check Palam Komal and six genotypes were stastically similar with standard check P-8. While genotype LC-4-18 produced smallest fruits (12.27 cm) among all other genotypes. The results were in consolance with the findings of Nwangburuka *et al.* (2012), Hazem *et al.* (2013), Amoatey *et al.* (2015) and Doddanakatte *et al.* (2016).

4.1.1.6. Fruit diameter (cm)

A wide range of variability was present among the genotypes for fruit diameter (Table 4.2). Fruit diameter was recorded maximum in LC-9-18 (2.31 cm) which was statistically at par with standard check Palam komal whereas P-8 recorded 1.65 cm of fruit diameter and it was recorded to be minimum in LC-4-18 (1.24cm) which was statistically at par with LC-2-18 (1.41 cm). The results were agreed with the findings of Muluken *et al.* (2016) and Bello *et al.* (2017).

4.1.1.7. Fruit weight (g)

Analysis of variance showed significant difference among all the genotypes (Table 4.2). The mean fruit weight for the twenty genotypes under study was 31.05g. The maximum fruit weight was observed in genotype LC-16-18 (46.57g) which was *at par* with LC-17-18 (45.43g) and LC-18-18 (44.35) whereas it was lightest in genotype LC-4-18 (15.53 g). The results are in close proximate to the findings of Bello *et al.* (2015) and Doddanakatte *et al.* (2016).

4.1.1.8. Number of locules per fruit

Analysis of variance showed that much variability was not present with respect to this character. The 5.0 ridges per fruit were observed in almost all the genotypes which were found similar to both the checks (Palam Komal and P-8). Five genotypes *viz.*, LC-9-18 (7.60), LC-16-19 (7.30), LC-2-18 (6.90), LC-6-18 (6.70) and LC-18-18 (6.70) produced more number of locules than population mean. Similar results were also depicted by Nawangburuka *et al.*

Table 4.3: Mean performance of okra genotypes for fruit and seed yield contributing characters

S.No.	Genotypes	Number of fruits per plant	Number of seeds per fruit	100 seed weight (g)	Fruit yield per plant (g)
1	LC-1-18	8.71	62.68	6.07	257.07
2	LC-2-18	8.88	71.57	6.18	270.65
3	LC-3-18	7.93	54.34	5.74	184.62
4	LC-4-18	8.25	36.52	5.27	159.86
5	LC-5-18	9.25	77.07	6.78	351.85
6	LC-6-18	8.07	47.19	5.74	184.92
7	LC-7-18	9.01	58.32	6.27	287.96
8	LC-8-18	7.13	42.84	5.43	165.96
9	LC-9-18	9.40	72.57	6.80	355.67
10	LC-10-18	10.08	68.06	6.75	348.18
11	LC-11-18	9.58	78.84	6.83	375.84
12	LC-12-18	8.67	67.17	6.19	272.30
13	LC-13-18	9.54	44.60	5.69	247.34
14	LC-14-18	9.86	57.18	6.77	349.26
15	LC-15-18	8.53	52.16	6.32	297.00
16	LC-16-18	11.36	76.21	7.52	384.59
17	LC-17-18	11.32	73.01	6.72	347.36
18.	LC-18-18	9.68	72.92	7.48	382.88
19.	Palam Komal	12.51	63.51	6.57	311.22
20.	P-8	14.09	56.38	6.32	265.71
	SE±(m)	0.26	0.91	0.04	1.37
	C.D.	0.76	2.61	0.12	3.95
	C.V.	4.76	2.55	1.15	0.82

(2011), Das *et al.* (2012) and Simon *et al*. (2013).

4.1.1.9. Number of fruits per plant

The genotypes under study showed wider diversity for this character ranging from 7.13 to 14.09 with an average of 10.61. Maximum number of fruits per plant was observed in genotype LC-15-18 (14.09). While minimum number of fruits per plant was found in genotype LC-8-18 (7.13). Two checks *viz.*, Palam Komal and P-8 gave 9.25 and 8.52 fruits respectively. The findings reported by Dhankar and Dhankar (2002); Verma *et al.* (2004) and Singh *et al.* (2006) matches the finding of above results.

4.1.1.10. Number of seeds per fruit

Analysis of variance revealed that number of seeds per fruit varied significantly among the genotypes with a mean value of 57.68. The number of seeds per fruit is affected by the number of ridges per fruit as well as fruit length. Genotype LC-11-18 was recorded the maximum number of seeds per fruit (78.84) which was statistically at par with LC-16-18 (76.21) and Palam Komal (77.06) whereas minimum number of seeds per fruit was observed in LC-4-18 (36.52). Mohapatra *et al.* (2007) and Jindal *et al.* (2009) reported the same results.

4.1.1.11. 100 seed weight (g)

Analysis of variance showed significant variability among the genotypes for 100 seed weight. The genotype LC-16-18 exhibited maximum 100 seed weight (7.52g) which was statistically at par with LC-18-18 (7.47g) while the minimum 100 seed weight was recorded in LC-3-18 (5.57g) with an overall mean of 6.39g. Both the checks (Palam Komal and P-8) recorded lower values for 100 seed weight *viz.*, 6.78 and 6.32g respectively. Dhankar and Dhankar (2002), Verma *et al.* (2004) and Singh *et al.* (2006) reported the similar findings.

4.1.1.12. Fruit yield per plant (g)

Data presented in Table 4.3 on fruit yield of okra genotypes during indicated significant differences among the genotypes. Highest fruit yield was recorded in genotype LC-16-18 (384.58g) statistically at par with LC-18-18 (382.88g) which was closely followed by LC-11-18 (375.84g) with the average of 272.38g. The genotype LC-4-18 recorded the minimum fruit yield per plant (159.86g). Dhankar and Dhankar (2002),Verma *et al.* (2004), Singh *et al.* (2006), Mohapatra *et al.* (2007), Jindal *et al.* (2009) and Reddy *et al.* (2013) matches the finding of above results.

4.1.1.13. Flower color and fruit color

The flower color of all the genotypes was yellow except for LC-16-18 which was reddish yellow in color. While, the fruit colors were observed as dark green, green, yellow

Table 4.4: Characterization of Okra genotypes based on morphological traits

S. No.	Genotypes	Plant Habit	Flower Color	Fruit Color
1	LC-1-18	Non-Spreading	Yellow	Yellow green
2	LC-2-18	Non-Spreading	Yellow	Yellow green
3	LC-3-18	Non-Spreading	Yellow	Dark green
4	LC-4-18	Non-Spreading	Yellow	Dark green
5	LC-5-18	Non-Spreading	Yellow	Dark green
6	LC-6-18	Non-Spreading	Yellow	Green
7	LC-7-18	Non-Spreading	Yellow	Yellow green
8	LC-8-18	Non-Spreading	Yellow	Yellow green
9	LC-9-18	Non-Spreading	Yellow	Yellow green
10	LC-10-18	Non-Spreading	Yellow	Green
11	LC-11-18	Non-Spreading	Yellow	Yellow green
12	LC-12-18	Non-Spreading	Yellow	Yellow green
13	LC-13-18	Non-Spreading	Yellow	Dark green
14	LC-14-18	Non-Spreading	Yellow	Green with Red specks
15	LC-15-18	Non-Spreading	Yellow	Yellow green
16	LC-16-18	Non-Spreading	Reddish Yellow	Red
17	LC-17-18	Non-Spreading	Yellow	Yellow green
18.	LC-18-18	Non-Spreading	Yellow	Yellow green
19.	Palam Komal	Non-Spreading	Yellow	Green
20.	P-8	Non-Spreading	Yellow	Green

green, green with red specks and red as depicted in table 4.4. Bashir *et al.* (2017), Muluken *et al.* (2016) and Tesfa *et al.* (2016) observed the morphological characters in okra.

4.1.1.14. Plant habit

All the genotypes had non-branching type of plant habit. Also both the checks Palam Komal and P-8 also had non-branching habit. Verma *et al.* (2004) and Reddy *et al.* (2013) observed same results.

4.1.1.15. Incidence of YVMV or any other disease

The incidence of YVMV ranged from 0-7.40% with an average of 3.70 %. The minimum 0.0 per cent incidence of yellow vein mosaic virus was found in all genotypes except for genotype LC-16-18 which showed maximum incidence of 7.40 per cent followed by LC-2-18 with 3.70 percent of incidence. Mazumder *et al.* (1996) and RoyChaudhary *et al.* (1997) also concluded the approximate findings.

4.1.2. Parameters of variability

4.1.2.1. Coefficient of variations

The estimation of components of genetic parameters of variation for fruit yield as well as its attributing characters are summarized in Table 4.5.The findings of Mittal *et al.* (1996); Bendale *et al.* (2003) and Senapati *et al.* (2011) also reported the same results.

The phenotypic coefficient of variation ranged between 8.93% (days to 50% flowering) to 38.77 % (internodal length) showed in Table: 4.5. The phenotypic coefficient of variations were high for many characters *viz.*, internodal length (38.77%), fruit weight (28.88%), fruit yield per plant (25.33%) and number of seeds per fruit (20.42%) and. However, it was noted low for characters such as days to 50% flowering (8.93%), and 100 seed weight (9.64%).The rest of the characters exhibited moderate phenotypic coefficient of variations *viz.*, fruit length (15.40%), fruit diameter (17.85%), number of seeds per fruit (15.92%), first fruiting node (12.87%), number of locules per fruit (16.98%) and plant height (18.06%). The similar results are reported by Ahamed *et al.* (2015) for fruit yield per plant; Bendale *et al*. (2003), Verma *et al*. (2004) for fruit yield per plant; Somashekhar *et al*. (2011), Nwangburuka *et al.* (2012) for fruit yield per plant; Katagi *et al.* (2014) and Nagre *et al*. (2011) for fruit yield per plant.

It is revealed from the Table 4.5 that genotypic coefficient of variation varied from 8.44% for days to 50% flowering to 36.11 % for internodal length. High genotypic coefficient of variation was recorded for internodal length (36.11%), fruit weight (28.58%), number of seeds per fruit (20.27%) and yield per plant (25.31%). However, it was exhibited low for characters such as days to 50% flowering (8.44%) and 100 seed weight (9.98%). The rest of the characters exhibited moderate genotypic coefficient of variations *viz.*, plant height (17.99%), first fruiting node (12.87%), number of locules per fruit (16.10%), fruit diameter (16.06 %), number of fruits per plant (16.51%) and fruit length (15.08%). The results are in consolance with the findings of Dhall *et al.* (2001); Reddy *et al.* (2013) which reported high GCV for fruit yield per plant while low GCV were reported by Gandhi *et al.* (2001); Mehta *et al.* (2006), Singh *et al.*(2006), Dakahe *et al.*(2007), Mohapatra *et al.*(2007), Reddy *et al.* (2013) and Doddanakatte *et al.* (2016).

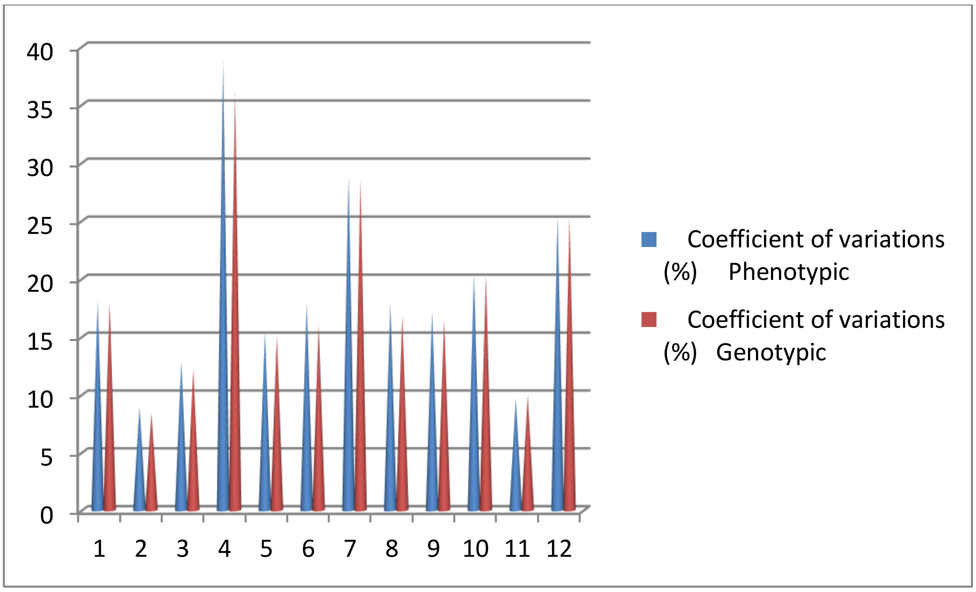

Figure 1: Graphical presentation of genotypic and phenotypic coefficient of variation

4.1.2.2. Heritability (broadsense)

Result indicated that the heritability varied from 80.93% (fruit diameter) to 99.89% (fruit yield per plot). The high heritability recorded for 100 seed weight (97.57%), fruit yield per plant (92.46%), number of fruits per plant (90.95%), number of seeds per fruit (98.45%), fruit length (95.87%), fruit weight (97.90%), plant height (99.35%), first fruiting node (90.11%), days to 50% flowering (89.44%), number of locules per fruit (89.89%) and internodal length (86.69%) whereas low estimation of heritability was not found for any character, however lowest amongst all traits was in fruit diameter (Table 4.3.).

The results were in consolance with the findings of Singh *et al.* (2006) and Mohapatra *et al.* (2007) for days to 50% flowering and fruit length; Hazara and Basu (2000); Chaukhande *et al.* (2011) and Nagre (2011) for fruit length and plant height;Bindu *et al.* (1997) for fruit weight, number of fruits per plant and plant height; Sureshbabu *et al.* (2004); Senapati *et al.* (2011) and Nwangburuka *et al.*(2012) and for fruit yield per plant and plant height; Doddanakatte *et al.* (2016) for plant height, fruit length, fruit weight and fruit yield per plant whereas low estimation of heritability was not found for any trait.

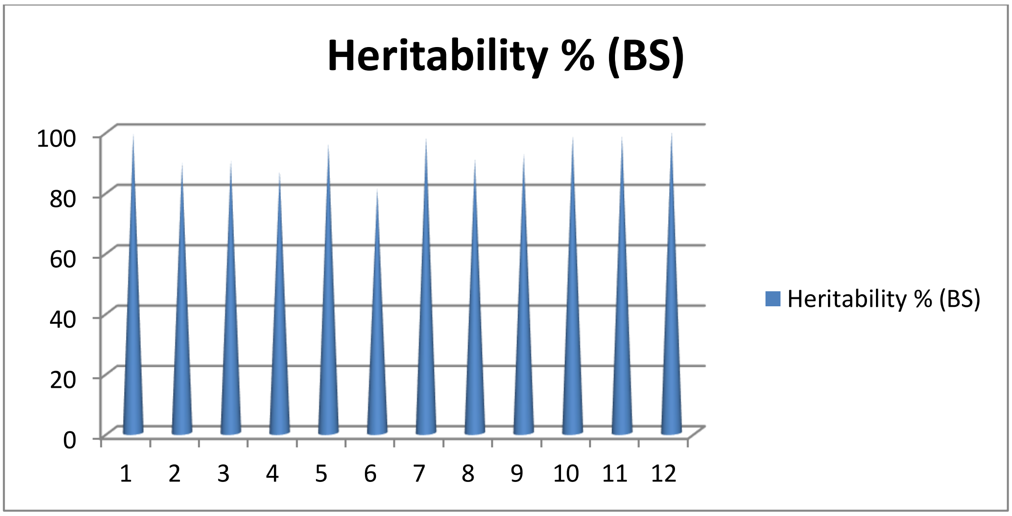

Figure 2: Graphical presentation of heritability in broad sense (%)

4.1.2.3. Genetic advance

It is evident from the estimates (Table 4.5) that genetic advance as *percentage* of mean ranged between 16.45% (days to 50% flowering) to 69.23% (internodal length). Maximum genetic advance as per cent of mean was recorded for internodal length (69.23%), fruit weight (58.25%), fruit yield per plant (52.12%), number of seeds per fruit (41.42%), plant height (36.95%), number of fruits per plant (32.69%), number of locules (31.45%), fruit length (30.42%), fruit diameter (29.77%) and first fruiting node (23.89%). The results were in consolance with the findings of Sarkar *et al.* (2004), Panda and Singh (1997) and Prakash and Pitchaimuthu (2017) for fruit yield per plant, plant height, number of seeds per fruit and number of fruits per plant; Dhankar and Dhankar (2002), Nagre *et al.* (2011), Prakash *et al*. (2017) and Senapati *et al*. (2011) for fruit yield per plant. It was moderate for 100 seed weight (19.90%) and days to fifty percent flowering (16.45%). Similar reports were observed by Dhankar and Dhankar (2002) reported similar results for plant height. Low estimation of heritability was not recorded for any of trait.

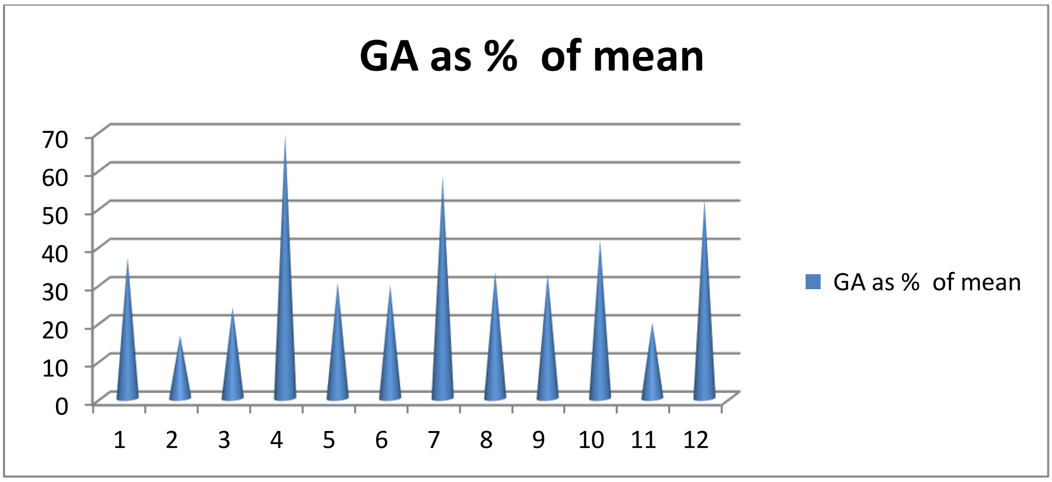

Figure 3: Graphical presentation of genetic advance as percentage of mean (%)

Table 4.5: Estimates of genotypic and phenotypic correlation coefficients among fruit yield and its attributing traits in okra

Characters	Mean	Range		Coefficient of variations (%)		Heritability % (BS)	Genetic Advance (GA)	GA as % of mean
		Min.	Max.	Phenotypic	Genotypic			
Plant height (cm)	145.16	97.65	179.60	18.06	17.99	99.35	53.64	36.95
Days to 50% flowering	44.89	40.08	53.23	08.93	8.44	89.44	7.38	16.45
First fruiting node	4.71	3.41	5.96	12.87	12.22	90.11	1.13	23.89
Internodal length (cm)	13.74	6.19	24.43	38.77	36.11	86.69	9.51	69.23
Fruit length (cm)	18.81	12.27	22.71	15.40	15.08	95.87	5.72	30.42
Fruit diameter (cm)	1.66	1.25	2.31	17.85	16.06	80.93	0.49	29.77
Fruit weight (g)	33.45	15.54	46.57	28.88	28.58	97.90	19.48	58.25
Number of locules per fruit	5.59	5.00	7.63	16.98	16.10	90.87	1.76	31.45
Number of fruits per plant	9.59	7.13	14.09	17.66	17.01	92.46	3.24	33.75
Number of seeds per fruit	61.66	36.52	78.84	20.42	20.27	98.45	25.54	41.42
100 seed weight (g)	6.37	5.27	7.46	09.64	9.57	98.57	1.25	19.57
Fruit yield per plant (g)	290.01	159.86	384.59	25.33	25.31	99.89	151.14	52.12

4.2. Correlation studies

The estimates of phenotypic and genotypic correlation coefficients for different quantitative characters in twenty okra genotypes are depicted in Table 4.6. These findings agreed to Niranjan and Mishra (2003), Kumar *et al*. (2009), Senapati *et al*. (2011) and Saryam *et al.* (2015).

4.2.1. Phenotypic correlations

The phenotypic correlation coefficients among different traits showed that fruit yield per plant had positive and significant association with fruit weight (0.959), hundred seed weight (0.949), number of seeds per fruit (0.839), fruit length (0.728), fruit diameter (0.664) and number of fruits per plant (0.487). These findings were in the consolance with the findings of Mandal and Dana (1993), Gondane *et al.* (1995), Yadav *et al.* (1996) for fruit length, fruit diameter, fruit weight, number of seeds per fruit, 100 seed weight and number of fruits per plant; Gandhi *et al*. (2002) and Mishra *et al.* (2015) for number of fruits per plant; Duzyaman *et al.* (2003) for fruit diameter; Choudhary (2006) and Verma *et al.* (2007) for number of fruits per plant and fruit diameter, whereas significant and negative correlation with days to fifty percent flowering (-0.936), first fruiting node (-0.756), plant height (-0.485) and internodal length (-0.111). Similar findings were found by Majumdar *et al.* (1974) for days to fifty percent flowering.

Plant height with 1st fruiting node (0.432), internodal length (0.463) and number of fruits per plant (0.082) exhibited highly significant and positive association. Similar findings are in consonance with Nwangburuka *et al.* (2012) for 100 seed weight in okra; Jayapandi and Balkrishnan (1993) and Chitra *et al.* (1992) for internodal length. Likewise, days to fifty percent flowering showed significant and positive correlation with plant height and first fruiting node. Jayapandi and Balkrishnan (1993) and Chitra *et al.* (1992) reported the similar results for plant height. Fruit length expressed significant and positive correlation with fruit weight (0.703), number of fruits per plant (0.527), number of seeds per fruit (0.616) and 100 seed weight (0.707). Similar results were reported by Sood *et al.* (1993) and Chandra *et al.* (1996). Fruit diameter with fruit weight (0.653), number of seeds per fruit (0.614) and hundred seed weight (0.580) and fruit weight with number of locules per fruit (0.193), number of fruits per plant (0.426), number of seeds per fruit (0.865) and 100 seed weight showed highly significant and positive association (0.923).The findings are in accordance with Sood *et al.* (1993) and Chandra *et al.* (1996). Number of locules per fruit had depicted highly significant and positive correlation with number of seeds per fruit (0.405) and 100 seed weight (0.340). Number of fruits per plant showed positive and significant association with number of seeds per fruit (0.353) and 100 seed weight (0.507).

4.2.2. Genotypic correlations

The genotypic correlation coefficients among different traits showed that fruit yield per plant had positive and significant association with fruit weight (0.969), hundred seed weight (0.957), number of seeds per fruit (0.845), fruit length (0.745), fruit diameter (0.743) and number of fruits per plant (0.506),

Table 4.6: Genotypic and phenotypic correlation coefficients among various traits in okra

		DFPF	PH	FFN	In.L	FL	FD	FW	NOL	NFP	NSF	100 SW	YPP
DFPF	P	1	0.481**	0.719**	0.191	-0.690**	-0.634**	-0.889**	-0.194	-0.485**	-0.809**	-0.883**	-0.936**
	G	1	0.510**	0.807**	0.199	-0.745**	-0.741**	-0.957**	-0.228	-0.511**	-0.845**	-0.940**	-0.988**
PH	P		1	0.452**	0.463**	-0.421**	-0.378**	-0.402**	-0.233	0.093	-0.338**	-0.394**	-0.485**
	G		1	0.470**	0.496**	-0.433**	-0.417**	-0.410**	-0.256*	0.091	-0.343**	-0.399**	-0.487**
FFN	P			1	0.254	-0.641**	-0.684**	-0.743**	-0.106	-0.472**	-0.672**	-0.693**	-0.756**
	G			1	0.276*	-0.689**	-0.795**	-0.795**	-0.147	-0.516**	-0.727**	-0.734**	-0.796**
In.L	P				1	-0.109	-0.171	-0.141	-0.130	0.036	-0.109	-0.024	-0.111
	G				1	-0.112	-0.220	-0.145	-0.129	0.020	-0.111	-0.008	-0.121
FL	P					1	0.229	0.703**	0.037	0.513**	0.616**	0.707**	0.728**
	G					1	0.251	0.724**	0.021	0.532**	0.627**	0.728**	0.745**
FD	P						1	0.653**	0.087	0.181	0.614**	0.580**	0.664**
	G						1	0.729**	0.111	0.207	0.688**	0.648**	0.743**
FW	P							1	0.190**	0.408**	0.865**	0.923**	0.959**
	G							1	0.195	0.429**	0.882**	0.938**	0.969**
NOL	P								1	-0.078	0.277*	0.278*	0.138
	G								1	-0.105	0.291*	0.297*	0.146
NFP	P									1	0.337**	0.490**	0.468**
	G									1	0.352**	0.510**	0.487**
NSF	P										1	0.828**	0.839**
	G										1	0.840**	0.845**
100 SW	P											1	0.949**
	G											1	0.957**

Significant at 5% level=** Significant at 1% level =*

DFPF~Days to 50% flowering,PH~Plant Height (cm),FFN~First fruiting node,In.L~Internodal Length (cm), FL~Fruit length (cm),FD~Fruit Diameter(cm),FW~Fruit Weight (g),NOL~Number of locules,NFP~Number of fruits per plant,NSF~Number of seeds per fruit, 100 SW~100 Seed weight (g), YPP~Yield per plant (g) whereas significant and negative correlation with days to fifty percent flowering (-0.936), first fruiting node (-0.756), plant height (-0.485) and internodal length (-0.111). The highly significant and positive association of traits are same as phenotypically except for fruit diameter which showed positive and significant correlation (0.309) with number of locules genotypically. Jayapandi and Balkrishnan (1992), Gandhi *et al*. (2002) and Mishra *et al.* (2015) reported the similar results.

4.3. Path coefficient analysis

Path coefficient analysis determines the effects of different independent traits individually as well as in combination with other traits on dependent variable i.e. fruit yield per plant. The estimates of path coefficient are furnished in the Table 4.7 representing direct and indirect effects of various horticultural traits over fruit yield per plant.

4.3.1. Direct effects:

The data revealed that the maximum positive direct effect on fruit yield per plant was exhibited by fruit diameter (0.27022) followed by 100 seed weight (0.23841), fruit weight (0.22714), first fruiting node (0.21264), fruit length (0.18405), number of fruits per plant (0.04101) and internodal length (0.02626) whereas maximum negative direct effect was reported by number of seeds per fruit (-0.04220) followed by number of locules per fruit (-0.05303), plant height (-0.05535) and days to fifty percent flowering (-0.38454). Balakrishnan and Sreenivasan (2010) and Chaukhande *et al.* (2011) recorded the same.

4.3.2. Indirect effects:

4.3.2.1. Days to 50% flowering

Days to 50% flowering exhibited maximum positive indirect effect via first fruiting node (0.17150) followed by number of seeds per fruit (0.03566), number of locules per fruit (0.01208) and internodal length (0.00521). The similar results reported by Sood *et al.* (1993), Dhall *et al.* (2000), Chaukhande *et al.* (2011), Das *et al.* (2012) and Adiger *et al.* (2011) for number of fruits per plant, fruit weight and fruit length whereas number of fruits per plant (-0.02094), plant height (-0.02824), fruit length (-0.13717), fruit diameter (-0.20020), fruit weight (-0.21747), 100 seed weight (-0.22409) showed negative association with fruit yield per plant. Alam and Hossain (2006), Adiger *et al.* (2011), Reddy *et al.* (2013) and Yonas *et al.* (2014) reported the same findings.

4.3.2.2. Plant height

Plant height exhibited the maximum positive indirect effects on fruit yield per plant through first fruiting node (0.10005), number of seeds per fruit (0.01448), number of locules per fruit (0.01356), internodal length (0.01303cm) and number of fruits per plant (0.00375). Negative indirect effects were reported through fruit length (-0.07966), fruit weight (-0.09307), 100 seed weight (-

0.09513),fruit diameter (-0.11262) anddays to 50% flowering (-0.19619). Dhankar and Dhankar (2002), Mishra *et al.* (2018), Kumar *et al.* (2019) reported the same findings.

4.3.2.3. First fruiting node

First fruiting node depicted positive indirect effects on fruit yield per plant through number of seeds per fruit (0.03067), number of locules (0.00780) and internodal length (0.00725) whereas all other characters under study showed negative indirect effects on fruit yield. Kumar *et al.* (2019) supported the same findings.

4.3.2.4. Internodal length

Internodal length showed positive indirect effects on fruit yield per plant via first fruiting node (0.05868), number of locules (0.00685), number of seeds per fruit (0.00468) and number of fruits per plant (0.00082). While days to 50% flowering (-0.07635), plant height (-0.02747), fruit length (-0.02066), fruit diameter (-0.05941), fruit weight (-0.03283), and 100 seed weight (-0.00187) showed negative indirect effect on fruit yield.

4.3.2.5. Fruit length

The highest positive indirect effect of fruit length on fruit yield per plant was recorded via days to 50% flowering (0.28658), 100 seed weight (0.17347), fruit weight (0.16434), fruit diameter (0.06788), plant height (0.02395) and number of fruits per plant (0.02181). However, negative indirect effect on fruit yield was observed through number of locules (-0.00110), internodal length (-0.00295).number of seeds per fruit (-0.02644) and first fruiting node (-0.14659).

4.3.2.6. Fruit diameter

Fruit diameter showed the highest positive indirect effect on fruit yield per plant through days to 50% flowering (0.28490), fruit weight (0.16557), 100 seed weight (0.15446), fruit length (0.04624),plant height (0.02307) and number of fruits per plant (0.00848). However, negative indirect effect was exhibited via internodal length (-0.00380), number of locules (-0.00586), number of seeds per fruit (-0.02904) and first fruiting node (-0.16914). Kumar *et al.* (2019) reported the same results.

4.3.2.7. Fruit weight

Weight of fruit revealed positive indirect effect on fruit yield per plant via days to 50 % flowering (0.36818) followed by 100 seed weight (0.22371), fruit diameter (0.19697), fruit length (0.13317),plant height (0.02268) and number of fruits per plant (0.01759). However characters *viz.* first fruiting node (-0.16911), number of seeds per fruit (-0.03723), number of locules per fruit (-0.01037) and internodal length (-0.00380). The findings were in agreement with Alam and Hossain (2006), Adiger *et al.* (2011), Reddy *et al.* (2013) and Yonas *et al.* (2014).

Table 4.7: Estimates of direct and indirect effect of the characters contributing towards fruit yield per plant in okra

	DFPF	PH	FFN	In.L	FL	FD	FW	NOL	NFP	NSF	100 SW	"r" value fruit yield per plant
DFPF	**-0.38454**	-0.02824	0.17150	0.00521	-0.13717	-0.20020	-0.21747	0.01208	-0.02094	0.03566	-0.22409	-0.988**
PH	-0.19619	**-0.05535**	0.10005	0.01303	-0.07966	-0.11262	-0.09307	0.01356	0.00375	0.01448	-0.09513	-0.487**
FFN	-0.31014	-0.02604	**0.21264**	0.00725	-0.12689	-0.21494	-0.18064	0.00780	-0.02115	0.03067	-0.17498	-0.796**
In.L	-0.07635	-0.02747	0.05868	**0.02626**	-0.02066	-0.05941	-0.03283	0.00685	0.00082	0.00468	-0.00187	-0.121
FL	0.28658	0.02395	-0.14659	-0.00295	**0.18405**	0.06788	0.16434	-0.00110	0.02181	-0.02644	0.17347	0.745**
FD	0.28490	0.02307	-0.16914	-0.00577	0.04624	**0.27022**	0.16557	-0.00586	0.00848	-0.02904	0.15446	0.743**
FW	0.36818	0.02268	-0.16911	-0.00380	0.13317	0.19697	**0.22714**	-0.01037	0.01759	-0.03723	0.22371	0.969**
NOL	0.08762	0.01415	-0.03127	-0.00339	0.00382	0.02987	0.04440	**-0.05303**	-0.00431	-0.01229	0.07086	0.146
NFP	0.19640	-0.00506	-0.10969	0.00053	0.09791	0.05586	0.09746	0.00557	**0.04101**	-0.01485	0.12148	0.487**
NSF	0.32491	0.01899	-0.15451	-0.00291	0.11532	0.18595	0.20035	-0.01545	0.01443	**-0.04220**	0.20035	0.845**
100 SW	0.36144	0.02208	-0.15607	-0.00021	0.13392	0.17506	0.21313	-0.01576	0.02089	-0.03547	**0.23841**	0.957**

Residual effect Genotypic = 0.00273

DFPF~Days to 50% flowering,PH~Plant Height (cm),FFN~First fruiting node,In.L~Internodal Length (cm), FL~Fruit length(cm),FD~Fruit Diameter (cm), FW~Fruitweight (g),NOL~Number of locules,NFP~Number of fruits per plant, NSF~Number of seeds per fruit, 100 SW~Hundred Seed weight (g) and YPP~Yield per plant (g).

4.3.2.8. Number of locules per fruit

Number of locules per fruit revealed highest positive indirect effect on fruit yield per plant through days to 50% flowering (0.08762) followed by 100 seed weight (0.07086), fruit weight (0.04440), fruit diameter (0.02987) plant height (0.01415) and fruit length (0.00382) while fruit yield per plant showed negative indirect effect through first fruiting node (-0.03127), number of seeds per fruit (-0.01229), number of fruits per plant (-0.07086) and internodal length (-0.00339).

4.3.2.9. Number of fruits per plant

Number of fruits per plant revealed positive indirect effect on fruit yield per plant through days to 50% flowering (0.19640), 100 seed weight (0.12148), fruit length (0.09791), fruit weight (0.09746), fruit diameter (0.05586), number of locules (0.00557) and internodal length (-0.00053) and negative indirect effect for fruit yield per plant was recorded through plant height (-0.00506), number of seeds per fruit (-0.01485) and first fruiting node (-0.10969).

4.3.2.10. Number of seeds per fruit

Number of seeds per fruit revealed positive indirect effect on fruit yield per plant through days to 50% flowering (0.32491), fruit weight (0.20035), 100 seed weight (0.20035), fruit diameter (0.18595), fruit length (0.11532), plant height (0.01899) and number of fruits per plant (0.01443) and negative indirect effect for fruit yield per plant was recorded through first fruiting node (-0.15451), internodal length (-0.00291) and number of locules per fruit (-0.01545).

4.3.2.11. 100 seed weight

100 seed weight revealed positive indirect effect on fruit yield per plant through days to 50% flowering (0.36144), fruit weight (0.21313), fruit diameter (0.17506), fruit length (0.13392), plant height (0.02208) and number of fruits per plant (0.02089), whereas negative indirect effect for fruit yield per plant was observed through internodal length (-0.00021), number of locules (-0.01576), number of seeds per fruit (-0.03547) and first fruiting node (-0.15607). Sindhumole *et al.* (2006), Akotkar *et al.* (2010), Adiger *et al.* (2011) reported the similar findings.

The residual effect was low (0.00273) for fruit yield indicated that the traits included in the present investigation accounted for the greater part of the variation present in the dependent variable (fruit yield per plant). According to Sengupta and Kataria (1971), this residual effect towards yield in the present study might be due to other characters, which were not studied, environmental factors and sampling errors.

Plate 1: The Experimental block of okra (*Abelmoschus esculentus* L.)

Plate 2: Variability among fruits of different okra genotypes[C1&C2 : Checks (PalamKomal& P-8), 1-18: LC-1-18, LC-2-18 & so on..(Local collections)]

Plate 3: Green stem bearing yellow flowers (LC-1-18)

Plate 4: Red stem bearing reddish yellow flowers (LC-16-18)

SUMMARY AND CONCLUSION

CHAPTER – 5

SUMMARY AND CONCLUSION

The present investigation entitled **"Genetic evaluation of local genotypes of okra *(Abelmoschus esculentus* (L.) Moench) under low hill conditions of H.P."** was carried out at the Experimental Farm, Department of Vegetable Science, College of Horticulture and Forestry, Neri (H.P.) during the *Kharif/Rainy* season 2018.

Twenty genotypes of okra including two checks (Palam Komal and P-8) were grown in Randomized Block Design with three replications. Five competitive plants from each plot were randomly selected and tagged for recording various characters *viz.*, Plant height, days to 50% flowering, first fruiting node, internodal length, fruit length, fruit diameter, fruit weight, number of locules per fruit, number of fruits per plant, plant habit, fruit color, number of seeds per fruit, 100 seed weight, fruit yield per plant and incidence of yellow vein mosaic virus. The values of phenotypic and genotypic coefficient of variation were computed according to Burton *et al.* (1952). The Heritability (Broad Sense) was calculated by Hanson *et al*. (1956) and genetic advance was estimated by Johnson *et al*. (1955). The correlation coefficient was worked out as per method given by Al-Jibouri (1958). Similarly path coefficient analysis was estimated as per procedure outlined by Dewey and Lu (1959). The analysis of variance have been calculated as per procedure suggested by Panse and Sukhatme (1967).

The present investigation revealed that mean sum of squares due to the genotypes was highly significant for all the traits indicating the presence of high genetic diversity in the existing materials. Mean performance revealed that genotypes LC-18-18, LC-16-18 and LC-9-18 took minimum days to 50% flowering while genotype LC-16-18, LC-9-18 and LC-5-18 recorded fruiting at lower node. Shorter internodal length was found in genotype LC-15-18, LC-1-18 and LC-13-18. Maximum plant height was recorded in LC-4-18 followed by LC-6-18 and LC-17-18. The fruit length was found maximum in LC-11-18 followed by LC-16-18 and LC-14-18 which was in close proximate with standard check Palam komal whereas fruit diameter was found maximum in LC-9-18 followed by LC-5-18 and LC-16-18. The heaviest fruits were found in genotypes LC-16-18 followed by LC-17-18 and LC-10-18. Most of the genotypes produced five locules per fruit which was similar to both the checks. Maximum number of fruits per plant were found in LC-15-18 followed by LC-16-18 and LC-5-18 whereas both the checks (P-8 and Palam Komal) produced more number of fruits than other genotypes. Maximum number of seeds per pod was found in LC-11-18, LC-5-18 and LC-16-18 while maximum 100 seed weight was found in LC-16-18, LC-18-18 and LC-11-18. Genotype LC-16-18 gave highest fruit yield per plant followed by LC-18-18 and LC-11-18.

The persual of data indicating that phenotypic coefficient of variation were of higher magnitude as compared to genotypic coefficient of variation for all the traits under study suggesting that the environment has played an important role in influencing the expression of the traits. The highest phenotypic and genotypic coefficient of variation were recorded in internodal length, fruit weight, number of seeds per fruit and fruits yield per plant revealing the presence of substantial desirable variability in the traits and possibilities of improvement through selection. Besides, moderate phenotypic and genotypic coefficient of variation was found in fruit length, fruit diameter, number of seeds per fruit, first fruiting node, number of locules per fruit and plant height, while characters like days to 50% flowering and 100 seed weight observed low genotypic and phenotypic coefficient of variation.

The high heritability recorded for all the traits under study *viz.,*plant height, fruit yield per plant, number of fruits per plant, number of seeds per fruit, hundred seed weight, fruit length, fruit weight, plant height, first fruiting node, days to 50% flowering, number of locules per fruit and internodal length. Whereas low estimation of heritability was not found for any character, however lowest amongst all character was observed in fruit diameter.

Genetic advance as percentage of mean was estimated to be the highest for internodal length followed by fruit weight, fruit yield per plant, number of seeds per fruit, plant height, number of locules per fruit, number of fruits per plant, fruit length, fruit diameter and first fruiting node. While hundred seed weight and days to 50% flowering reported moderate genetic advance as percentage of mean.

High heritability coupled with high genetic advance was observed for plant height, first fruiting node, internodal length, fruit weight, fruit yield per plant, number of seeds per fruit, plant height, number of locules, number of fruits per plant, fruit length, fruit diameter and first fruiting node whereas high heritability with moderate genetic advance was observed for days to 50% flowering and 100 seed weight.

The genotypic and phenotypic correlation coefficient among different characters showed that yield per plant had maximum significant and positive correlation with fruit weight followed by 100 seed weight, number of seeds per fruit, fruit length, fruit diameter and number of fruits per plant. Days to 50% flowering, first fruiting node and plant height had significant and negative correlation with fruit yield per plant.

Path coefficient analysis of different characters contributing towards fruit yield per plant showed that fruit diameter had the highest positive direct effect followed by 100 seed weight, fruit weight, first fruiting node, fruit length, number of fruits per plant and internodal length. Whereas, the maximum negative direct effect was reported by number of seeds per fruit followed by number of locules per fruit, plant height and days to 50% flowering.

Conclusions

a. A wide and significant range of variability was observed for all the characters under study in all the genotypes.

b. From the present investigation it may be inferred that genotypes LC-16-18, LC-18-18 and LC-11-18 gave higher yield compared to rest of the genotypes and also surpases the standard check varieties (P-8 and Palam Komal).

c. High phenotypic and genotypic coefficients of variation were recorded for fruit weight, number of seeds per fruit, internodal length and yield per plant.

d. Moderate phenotypic and genotypic coefficient of variation were recorded for plant height, first fruiting node, fruit length, fruit diameter, number of locules per fruit and number of fruits per plant.

e. High heritability coupled with high genetic gain was recorded for plant height, first fruiting node, internodal length, fruit length, fruit weight, fruit diameter, number of locules, number of fruits per plant, number of seeds per fruit and fruit yield per plant. Hence selection for these traits can prove effective for improvement of yield.

f. A highly positive and significant genotypic correlation of fruit yield per plant was observed with fruit weight, number of fruits per plant, fruit length, fruit diameter and number of seeds per fruit.

g. Maximum positive direct effects towards fruit yield per plant were contributed byfruit diameter followed by hundred seed weight and fruit weight.

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APPENDICES

APPENDIX –I

Analysis of variance for various Horticultural and seed traits in Okra

Characters / Source	df	Mean Sum of Squares*											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Replications	2	1.622	7.167	0.141	3.263	0.368	0.007	5.321	0.026	0.054	5.992	0.021	29.686
Genotypes	19	44.772*	2051.988*	1.030*	77.580*	24.496*	0.230*	276.058*	2.521*	8.196*	470.785*	1.121*	16,171.901*
Error	38	1.696	4.498	0.036	3.777	0.347	0.017	1.958	0.091	0.208	2.465	0.005	5.648

*Significant at 5% level of significance

Where,

1	=	DAYS TO 50% FLOWERING	2	=	PLANT HEIGHT
3	=	FIRST FRUITING NODE	4	=	INTERNODAL LENGTH
5	=	FRUIT LENGTH	6	=	FRUIT DIAMETER
7	=	FRUIT WEIGHT	8	=	NUMBER OF LOCULES PER FRUIT
9	=	NUMBER OF FRUITS PER PLANT	10	=	NUMBER OF SEEDS PER FRUIT
11	=	100 SEED WEIGHT	12	=	FRUIT YIELD PER PLANT

ABSTRACT

DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE AND
FORESTRY, NERI, HAMIRPUR (H.P)
Dr YS PARMAR UNIVERSITY OF HORTICULTURE
AND FORESTRY NAUNI, SOLAN (HP)

Title of Thesis	**:**	**Genetic evaluation of local genotypes of okra (*Abelmoschus esculentus* (L.) Moench.) under low hill conditions of H.P.**
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Degree Awarded	**:**	M.Sc. (Horticulture) Vegetable Science
Number of pages in thesis	**:**	62+i
Number of words in abstract	**:**	324
Year of Award of degree	**:**	2019

ABSTRACT

The present investigation entitled **"Genetic evaluation of local genotypes of okra (*Abelmoschus esculentus* (L.) Moench.) under low hill conditions of H.P."** was conducted at Experimental Farm, Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur (H.P.) during Rainy, 2018 to evaluate genotypes of Okra and to study variability, heritability, correlation and path analysis of different characters. The experiment was laid out in RCBD with three replications and 20 genotypes including two checks 'P-8 and Palam Komal' for studying the extent of genetic variability and performance of each genotype. The present investigated studies revealed a significant difference among genotypes for all the characters studied. Genotypes like LC-16-18, LC-18-18, LC-11-18, LC-9-18 and LC-5-18 were significantly superior over other genotypes and both the respective checks for yield and few other horticultural important traits of vegetable types and can be recommended as such for direct cultivation after multilocational testing in the state. The GCV and PCV were high for traits like internodal length, fruit weight, number of seeds per fruit and fruit yield per plant. High heritability coupled with high genetic advance as percentage of mean was observed for plant height, first fruiting node, internodal length, fruit weight, fruit yield per plant, number of seeds per fruit, number of fruits per plant, number of locules per fruit, fruit length and fruit diameter which indicates their improvement through simple selection method. Correlation analysis revealed that traits like fruit weight, 100 seed weight, number of seeds per fruit, fruit length, fruit diameter and number of fruits per plant had significant positive correlation with fruit yield per plant at both phenotypic and genotypic level. Further, path coefficient analysis suggested that fruit diameter had the highest positive direct effect on fruit yield per plant followed by 100 seed weight, fruit weight, first fruiting node, fruit length, number of fruits per plant and internodal length. Therefore, main emphasis should be given on these characters, while making selection in okra genotypes.

Signature of the Major Advisor **Signature of the Student**

Countersigned

Professor and Head Department of Vegetable Science

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Standard/Degree	**Name of Institute**	**Board/University**	**Year of passing**	**Percentage received (%) or OGPA**
10^{th}	N.C.M. Senior Secondary School, Rahjol,Tal.	H.P.	2011	79.4
12^{th}	S.D. Public School Hamirpur (H.P)	H.P.	2013	84.8
B.Sc. (Horticulture)	College of Horticulture and Forestry, Neri, Hamirpur (H.P.)	Dr. Y.S Parmar University of Horticulture and Forestry, Nauni (Solan)	2017	8.27 out of 10

Whether sponsored by some state/ Central Govt./Univ./SAARC : No

Scholarship/ Stipend/ Fellowship, any other financial assistance received : Scholarship

Visits abroad along with duration and purpose of visit : NA

Any other Information : NA

(Pratibha Sharma)