Characterization of okra (*Abelmoschus esculentus* (L.) Moench) genotypes based on morphological and phenological traits

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By

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CERTIFICATE – I

This is to certify that the thesis entitled **“Characterization of okra (*Abelmoschus esculentus* (L.) Moench) genotypes based on morphological and phenological traits”** submitted in partial fulfillment of the requirement for the degree of **Master of Science in Horticulture (Vegetable Science)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Pappu Singh Waskel** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published / published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been fully acknowledged by him.

Place : Jabalpur
Dated : …../…./….

(R.K. Shrivastava)
Chairman Advisory Committee

THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

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CERTIFICATE – II

This is to certify that the thesis entitled **"Characterization of okra (*Abelmoschus esculentus* (L.) Moench) genotypes based on morphological and phenological traits"** submitted by **Mr. Pappu Singh Waskel** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of "**MASTER OF SCIENCE IN HORTICULTURE (VEGETABLE SCIENCE)**" in the Department of HORTICULTURE has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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Director of Instruction (Dr. O.P. Veda) ………………………………….

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Place : Jabalpur

Date : ***(Pappu Singh Waskel)***

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INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] has captured a prominent position among the vegetables; it is amongst the choicest fruit vegetable grown extensively in the tropical, subtropical and warm area of the world like India, Africa, Turkey and other neighbouring countries. In India, okra is one of the most important vegetable crops grown for its tender green fruits during summer and rainy seasons.

It was probably domesticated in the Ethiopian region (Vavilov) but according to Murdoc it is a native of West Africa. Okra is a polyploid, belonging to the family Malvaceae with 2n = 8x =72,144 chromosome, it is an often cross pollinated crop, with occurrence of out crossing to an extent of 4 – 19 per cent with the maximum of 42.2 per cent is noticed with insect assisted pollination. Tender green fruits are cooked in curry and soup, while crop has not adapted in India as leafy vegetable as in for eastern countries. In India, among fresh vegetables, sixty per cent share of export goes to okra Okra is known by many local names in different parts of the world. It is called lady's finger in England, Gumbo in U.S.A. and Bhindi in India. Okra is widely cultivated in plains of India with acreage of 452.5 thousand ha. and production of 4803 thousand mt. (2009-10). In Madhya Pradesh okra is grown in 8800 ha area and 52800 tonnes production with 6.00 tonnes productivity.

Edible fresh and mature fruits contain eighty eight per cent moisture and large number of chemical components including Vit. A 88 IU, B 63 IU and C 13 mg/100 gm. Unripe okra fruits contain 3100 calorie energy, 1.8gm. Protein, 90 mg. Calcium and 1.0 mg iron. It has herbal medical properties. Its leaves are used for preparing a medicament to reduce inflammation. It is an excellent source of Iodine for control of goiter.

It is a warm season hardy crop and can be grow with considerable success on a wide range of soils and under variable environmental conditions. In India it is grown twice in a year as a summer and Kharif crop for getting regular supply.

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

The foremost challenge to the existence of mankind has always been to produce adequate quantity of food from the available acreage to meet the requirements of ever expending world population. The rate of yield gain in crop improvement programme must match the rate of population growth so, as to mitigate the problems of malnutrition and hunger.

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

Attempts have been made to determine the magnitude of heritable and non-heritable components and genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance as percentage of mean in quantitative characters of okra. Characterization of okra genotypes was performed based on various parameters like morphological characters of plant based on seed traits and quality parameters. Distinguishing genotypes on the basis of morphological characters is one of the most common criteria.

The estimates of correlation coefficient analysis will be more useful in the estimation of inter-relationship among the yield contributing components and onward. Estimation of path coefficient analysis gives the indication of the nature and extent of direct and indirect effect themselves yield contributing components.

In view of the above facts, the present studies in okra entitled "Characterization of okra genotypes based on morphological and phenological traits." has been carried out with the following objectives:

Objective of investigation:

1. To estimate mean performance of the genotypes.
2. To estimate genetic parameters genetic variance, heritability and genetic advance.
3. To estimate correlation and path coefficient analysis.
4. Characterization of okra genotypes based on morphological and phenological traits and identification of putative lines.

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REVIEW OF LITERATURE

The relevant literature related to the various aspects of the present investigation “Characterization of okra (*Abelmoschus esculentus* (L.) Moench) genotypes based on morphological and phenological traits” has been discussed under the following heads:

2.1 Genetic variability, heritability and genetic advance.

2.2 Correlation coefficients analysis

2.3 Path coefficient analysis

2.4 Characterization of genotypes.

2.1 Genetic variability, heritability and genetic advance.

It is a known fact that genotypes within the species exhibit variation in different metric traits and components of yield. The genetic variation can only be useful for crop improvement with the help of partitioning of variances. Plant breeders are able to determine the relative importance of genetic and environmental variances. Heritability (broad sense) is an index of transmitting a character from the parents to the offspring. It is of great importance for both breeders and geneticists. Lush (1940) defined the broad sense heritability as the ratio of the total genotypic variance to the total phenotypic variance which provides a measure of the overall importance of hereditary determination of a trait.

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

Reddy *et al.* (1985) reported high heritability and genetic advance for fruit yield per plant in okra while Gulshan Lal (1986) studied that the greatest genetic advance for fruit yield, was predicted to occur through selection of characters, like number of primary branches per plant, 100seed weight and number of nodes on the main stem. However Singh (1986) found higher heritability estimate in F_2 than F_1 for characters like days to flowering in okra genotypes. Whereas, Patil and Dalal (1992) reported high heritability estimates for yield and its components in seven *Abelmoschus esculentus* genotypes and their F_1 hybrids. Fruit attributes were found to have moderate heritability estimate.

Patil *et al.* (1996a) reported that considerable differences were observed for some characters in the two seasons. Number of fruits per plant, weight of good fruits per plant, number of borer infested fruits and weight of borer infested fruits per plant showed seasonal differences; in general, genotypic and phenotypic variance were higher in the kharif than rabi season. Estimates of PCV and GCV values ranged from 14.7per cent for days to flowering to 71.6 per cent for weight of borer infested fruits during kharif season. Relatively high genetic advance was observed for characters such as plant height, number of good fruits per plant and weight of good fruits per plant, indicative of the likely effectiveness of selection for such characters. While, Patil *et al.* (1996 b) reported that there was considerable variation of fruit borer resistance among genotypes, ranging between 0 to 80.8 per cent and 0 to 63.4 per cent for infested and weight loss, respectively. Ten genotypes recorded no infestation and no weight loss. Among these, PI 82009 and PI 378630 had high marketable yields (1095 and 1037 g/plant, respectively), followed by PI 489817 (745 g/plant) and PI 21729 (634 g/plant). The highest yielding genotypes PI 482025 (1880 g/plant) also had low fruit borer infestation (5.7%) and weight loss (7.1%).

Chandra *et al.* (1996) reported that the estimates of heritability and genetic advance for fruit yield, plant height and number of seeds per fruit were high in magnitude. While, Panda and Singh (1997) reported high heritability estimates coupled with high genetic advance for plant height, number of fruits and total fruit yield per plant and suggested to improve these traits though selection.

Sood (1999) reported that marketable fruit yield per plant varied from 154 to 467 g and yield was highest in genotypes IC-39135, IC-9856 and Punjab Padmini. IC-39135 also had the highest number of nodes per plant. LC-12 had the highest fruit weight (22.22g), followed by Perfect Long Green (21.60g), LC-26 (21.54g), LC-11 (20.86g) and LC-16 (20.79g). Days to fifty per cent flowering varied from 44.33 to 71.00 days and IC-45791 was the earliest to flower among the genotypes. IC-14026 and IC-45796 had the highest duration of availability of edible fruits (66 days).

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

Bendale *et al.* (2003) showed a wide range of genetic variability for yield and yield-contributing characters viz., first flowering node, days to first harvest, fruit length, fruit weight, plant height, nodes per plant, internodal length, number of branches per plant, moisture content in fruit, fruiting period, seeds per fruit, 100 seed weight, number of fruits per plant and yield per plant. The phenotypic variance (PCV) for all the fifteen characters was higher than the genotypic variance (GCV). The number of branches per plant, yield per plant and number of fruits per plant showed high

GCV and PCV estimates. All the characters recorded medium to high and high heritability.

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

Naidu *et al.* (2007) High degree of variability was observed for plant height, number of fruits per plant, fruit weight and fruit yield per plant. High estimate of heritability and genetic advance were obtained in number of nodes to first flower, number of fruits per plant, number of seeds per fruit and fruit yield per plant. These characters are governed by additive gene action. However Tandeker (2010) reported that low heritability and genetic advance for days to 50 per cent flowering indicated that this character was highly influence by environment.

Shanthakumar and Salimath (2010) in a study of phenotypic and genotypic coefficients of variation, heritability and genetic advance in three double crosses and four single crosses in F_2 population of okra. The analysis of variance revealed highly significant differences for the populations under study for the characters. The estimates of phenotypic and genotypic coefficients of variation were moderate to high for all the characters except days to first flowering, stem diameter fruit length and 100 seed weight. Heritability and genetic advance were also high for all the characters indicating the involvement of additive type of gene action in controlling these characters, hence, selection could be effective.

Nagre *et al.* (2011) reported that the highest genotypic and phenotypic coefficient of variation was observed for leaf area followed by number of nodes per plant, length of fruit, number of leaves per plant, yield per plant, internodal length and chlorophyll content of leaves. Highest estimate of heritability was recorded for leaf area followed by number of leaves per plant, yield per plant, length of fruit, number of nodes per plant, chlorophyll content of leaves and number of fruits per plant. Highest genetic advance was also observed for the characters leaf area followed by yield per plant, plant height and number of leaves per plant.

Chaukhande *et al.* (2011) revealed that the highest genotypic coefficient of variation as well as phenotypic coefficient of variation was observed for incidence of yellow vein mosaic virus. The maximum difference between GCV and PCV was noted for internodal length. Character plant height exhibited high heritability (broad sense) percentage. Highest genetic advance was recorded for yellow vein mosaic virus while lowest for fruit diameter.

2.2 Correlation coefficients analysis:

Correlation studies are of considerable importance in plant breeding programme. The need for coefficient of correlation is to describe the degree of association between two characters of economic importance.

The correlation between yields and its components give an idea for selection pressure, which could profitably be exercised to obtain an increase in yield. As such, it is necessary to estimate the correlation coefficients to aid in estimating the true association due to genetic cause. A brief review related to this aspect is being given as follows.

Singh *et al.* (1975) reported that the moderate to high positive correlation between days to flowering and maturity, plant height with internode length and fruit length with fruit width. While, Ajimal *et al.* (1979) observed positive correlation of yield with number of fruits, number of nodes and length of internode.

Mahajan and Sharma (1979) revealed positive correlation of yield with plant height, number of fruits per plant and fruit length. Similarly Singh and Singh (1979) observed that the fruit yield was positively and significantly correlated with plant height and number of branches per plant, fruit length and number of fruits per plant. While, Chantana Vicharat (1990) reported that yield per plant showed positive correlations with fruit number per plant, plant height at maturity, branches per plant and nodes per plant, but it was negatively correlated with plant height at first flowering.

Shukla (1990) revealed that fruit yield expressed positive correlation with number of fruits per plant, number of nodes per plant and fruit length. Similarly Mandal and Dana (1994) reported that fruit yield was significantly and positively associated with number of fruits per plant and fruit length, whereas fruit yield showed negative association with days to 50 per cent flowering.

Gondane *et al.* (1995) results indicate that number of fruits per plant, weight per edible fruit, stem thickness and plant height were significantly and positively correlated with fruit yield per plant, however length of fruit showed negative correlation with number of leaves per plant, days to 50 per cent flowering, nodes to first fruit and number of branches per plant.

Sood *et al.* (1995) observed correlation among all combinations of twelve characters and found that nodes per plant, duration of edible fruits, plant height and fruit length had strong positive correlation with yield. While, Dash and Mishra (1995) reported that fruit yield per plant was positively correlated with number of branches per plant, fruit length, fruit girth, fruit weight, number of seeds per fruit and seed weight per fruit.

Yadav (1996) found positive correlation between yield per plant and number of fruits per plant. Days to first fruiting and plant height showed positive correlation with fruit length and width.Whereas, Rajani and Manju (1997) reported that nodes per plant, duration of availability of edible fruits, plant height and fruit length had strong positive correlation with yield. Similarly Paiva *et al.* (1998) observed that number of fruiting nodes on main stem, plant height, number of fruits and earliness were highly correlated with yield.

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

Niranjan and Mishra (2003) and Sureshbabu *et al.* (2004) revealed that in general, the genotypic correlations were higher than the corresponding phenotypic correlation for all the character combinations. Fruit yield was positively correlated with edibility period of fruits, number of fruits per plant, fruit length, number of seeds per fruit, fruit weight, plant height and number of branches per plant at both genotypic and phenotypic level where as it was at genotypic level only between edibility period of fruits and number of branches per plant. All characters had positive and significant association among each other at both level.

Bendale *et al.* (2003) reported that the fruit length, fruit weight, plant height, nodes per plant and number of fruits per plant were positively correlated with the yield. Similarly Duzyaman *et al.* (2003) observed that fruit weight and diameter were positively correlated with total yield, towards early flowering was negatively correlated with total yield. Fruit weight and fruit number per plant were highly associated with flowering behavior and fruit composition on the first year. Fruit weight per plant was associated with average fruit weight, fruit width and flesh thickness, whereas fruit number per plant was correlated with dry matter content only. Significant positive or negative correlation was observed among fruit weight, fruit width and flesh thickness.

Jaiprakash Narayan and Mulge (2004) reported that total yield per plant was positively correlated with number of fruits per plant, average fruit weight, number of nodes on main stem, fruit length, plant height (at 60 and 100 DAS) and number of leaves (at 45 and 100 DAS), but negatively correlated with number of locules per fruit, number of nodes at first flowering and first fruiting. However observations of Patro and Ravishankar (2004) revealed that fruit yield per plant have significant and positive correlation with number of branches per plant, fruit length and fruit weight. Negative correlation of fruit yield per plant was recorded with plant height and number of days taken to first fruit setting.

Subrata *et al.* (2004) Results revealed fruit yield had significant positive correlation with number of fruits per plant and fruit weight while Bhalekar *et al.* (2005) and Ghosh (2005) observed that fruit length, internodal length, number of fruits per plant and number of branches per plant had strong positive correlation with fruit yield. Similarly Pawar (2005) observed that the yield per plant expressed positive correlation with number of fruits per plant, fruit weight, fruit length and fruit girth.

Sankaran *et al.* (2005) reported that the fruit length (0.977), fruit girth (0.922), fruit weight (0.984), crude fiber (0.973), total sugar (0.875) and acidity (0.993) revealed higher positive correlation with advancement of maturity. Similarly Choudhary (2006) revealed that the yield per plant showed positive association with number of fruits per plant, fruit weight, length of fruit, number of seeds per fruit, plant height, fruiting span, fruit girth and number of branches per plant.

Verma *et al.* (2007) reported that yield per plant exhibited positive correlation with fruits per plant, fruit weight, fruit length, and fruit girth, however negative correlation was noticed in 100 seed weight, days to 50 per cent flowering and days to first flowering with yield per plant. While, Kumar *et al.* (2009) in a study the investigation revealed that the magnitudes of genotypic correlation coefficient were invariably higher than phenotypic correlation coefficient, suggesting therefore a strong inherent trait. The most important trait, no. of flower per plant was positively and correlated with no. of leaves per plant, diameter of stem and no. of days to flower at genotypic and phenotypic levels. The data also revealed that no. of fruits per branch, no. of fruits per plant and no. of days to flower was positively a correlated at both genotypic and phenotypic levels.

Nagre *et al.* (2011) reported that yield per plant was closely associated positively with number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit, leaf area, chlorophyll content of leaves plant height and number of primary branches per plant. While, Chaukhande *et al.* (2011) revealed that the yield per plant exhibit positive correlation with plant height number of flowering nodes on main stem, number of fruits per plant, average weight of fruit.

2.3 Path coefficient analysis:

Correlation studies involves a large numbers of factors and their association becomes more complex under such circumstances, the path coefficient analysis help in removing the complication by measuring the direct and indirect influence of one variable upon the other by partitioning the correlation coefficient into the components of direct and indirect effects. This has also an advantage to point out the true yield determinants for genetic improvement of crop.

Koul *et al.* (1979) observed that the primary branches per plant had greatest direct effect on the seed yield. While, Choudhary and Sharma (1999) revealed that weight of fruit had maximum direct genotypic effect on yield followed by number of branches per plant, plant height and number of fruits per plant. Similarly Niranjan and Mishra (2003) reported 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 contribution towards yield. Fruit weight exerted the highest positive direct effect (0.507) and the highest genotypic correlation value (0.975) on fruit yield per plant. However, Sureshbabu *et al.* (2004) and Akinyele and Osekita (2006) reported that the fruits per plant showed highest positive direct effect on yield followed by 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, while Mehta *et al.* (2006) revealed that fruit girth had the maximum direct effect followed by fruit length towards fruit yield. Thus, the fruit yield in okra can be improved by selecting for higher fruit length, fruit girth and average fruit weight simultaneously.

Adeniji and Aremu (2007) path analysis identified plant height at maturity, ridges per fruit, fruits per plant, mature fruit length and seed per ridge as selection indicators for fruit and seed yield improvement in West African Okra.

Verma *et al.* (2007) revealed that the number of fruits per plant had highest direct positive effect on yield per plant followed by number of nodes to first flower. The indirect effects of most the components towards yield were either negative or low in magnitude except in case of number of nodes to first flower via plant height and fruit length; days to first flowering via days to fifty per cent flowering; days to fifty per cent flowering via fruit length; days to first picking via days to fifty per cent flowering; number of fruits per plant via fruit length and plant height.

Nagre *et al.* (2011a) reported that the number of fruits per plant, weight of fruit, number of leaves per plant, internodal length, number of lobes per leaf, diameter of fruit and node at which first fruit appears showed high positive direct effects as the major yield contributing traits, for enhancing yield of okra. Based on direct and indirect effects of different yield components on yield, it would be rewarding to give stress on the number of fruits per plant, number of nodes per plant, weight of fruit, length of fruit, plant height, chlorophyll content of leaves, number of primary branches per plant and leaf area, node at which first fruit appears, while formulating selection indices for improvement of yield of okra. Similarly Chaukhande *et al.* (2011) revealed that the number of fruits per plant exhibited maximum direct effect on yield per plant followed by average weight of fruit and internodal length. Thus all this characters must be taken into consideration while selecting the genotypes for future breeding programme.

2.4 Characterization of genotypes.

Morphological features of seed and plant parts are the major components of identification of cultivar. However, it is rare for a variety to be identified by the expression of single morphological character. Use of different morphological features in a sequential fashion is useful and convenient to distinguish the varieties. (Singhal and Prakash, 1992).

Farghali *et al.* (1994) reported the cultivar Clemson spineless gave longest fruits, while Balady Assint, Balady Cairo and Balady Green had the shortest fruits. Balady Red had the largest fruit diameter and Green Spineless the least. Balady Red, White Velvet, Clemson Spineless and Gold Coast had the heaviest fruits. Balady Green and Clemson Spineless had the highest dry matter contents. White Velvet fruits had the highest fiber content and Green Velvet the lowest. Whereas Prabhu *et al.* (2007) reported that the cultivated *A. esculentus* types, none was found resistant to YVMV. However, the cultivars Varsha Uphar, Phule Utkarsha and HRB 107-1 were found moderately resistant to the virus.

Stem colour

Saifullah and Rabbani (2009) evaluated one hundred and twenty one okra genotypes collected from different parts of Bangladesh were characterized for different quantitative and qualitative traits. Wide range of variation was also found among the okra genotypes. Qualitative character was classified into different categories. Likewise, the genotypes were grouped into different categories for stem colour i.e. green (35 genotypes), deep green (12 genotypes), green with red patches (72 genotypes) and red (2 genotypes).

Oppong-Sekyere *et al.* (2011) revealed that twenty five accessions of okra collected in Ghana were evaluated and scored as specified by the standard international crop descriptor for okra. In general, all the okra accessions showed relatively wide ranges of variations for all morphological characters observed. Most of the plants showed erect growth habits while leaf and stem colours were predominantly green.

Nwangburuka *et al.* (2011) 29 okra accessions sourced from different agro-ecological regions in Nigeria were evaluated for genetic diversity during rainy season of 2007 at Abeokuta. Wide range of variations for stem colour was observed. Most of the plants showed predominantly green and pigmented.

Leaf blade serration of margin and depth of lobbing

Martin et al. (1981) a study of the variation of 29 characteristics of 585 varieties or seedlings of okra revealed that 17 West African varieties could be distinguished from all others on the basis of 5 discriminating characteristics revealed that the degree of leaf lobbing by simple inheritance (Kalia and Padda 1962 a) and incomplete dominance (Nath and Dutta 1970).

Mahajan et al. (1996) reported that the validity of the technique was confirmed by applying it to a well characterized sample data on a set of 260 accessions of diverse geographical origin utilizing qualitative and quantitative descriptors. the variability was observed and classified into different categories leaf lobbing (number of lobes above the sixth node) and lamina margin (1 - deeply incised, 2 - narrowly incised, 3 - serrate).

Veins colour and fruit colour

Mahajan et al. (1996) the validity of the technique was confirmed by applying it to a well characterized sample data set of 260 accessions of diverse geographical origin utilizing qualitative and quantitative descriptors. The variability in leaf colour as classified into green, green with red veins and red.

Saifullah and Rabbani (2009) reported that the genotypes were grouped into different categories for leaf and petal colour.

Nwangburuka et al. (2011) 29 okra accessions sourced from different agro-ecological regions in Nigeria and grown during the rainy season of 2007 at Abeokuta were evaluated for genetic diversity and reported that Leaf vein pigmentation as green and pigmented.

Oppong-Sekyere *et al.* (2011) observed that petal or flower colour was mostly golden yellow among the okra, whereas fruit orientation was largely intermediate for all accession studied. Majority of the fruits produced green and smooth fruits. The results showed that fruit colour displayed five distinct variations, 72% of the accessions produced green fruits while 8% displayed green-with-red-spotted fruits, dark green to black fruits and green to yellow-fruits. A small portion (4%) of the accessions had tinged purple fruits. Variety GH3801 Pora had a unique purplish pigmented fruit colour.

Fruit pubescence

Martin et al. (1981) in a study of African varieties could be distinguished from all others on the basis of 5 discriminating characteristics revealed that the Degree of fruit pubescence by complex (Miller and Wilson 1938), simple inheritance by (Kalia and Padda 1962a) and incomplete dominance by (Nath and Dutta 1970). The variability for fruit pubescence was visually observed and classified into different categories as smooth and pubescent.

Ariyo (1993) revealed that the fruit characteristics such as fruit pubescence, position on the main stem and weight of 100 seeds had moderate communalities.

Saifullah and Rabbani (2009) reported that the genotypes were grouped into different categories for fruit pubescence.

Oppong-Sekyere *et al.* (2011) fruit pubescence showed wide variation among the okra accessions. Sixty-four percentages of okra accessions showed fruits with no hairs, while the rest had rough, downy or little hairs on their fruits representing 4, 12 and 20% occurrences, respectively. From these results, one can conclude that the okra genotypes had no pubescence on fruits.

Nwangburuka et al. (2011) among the 29 okra accessions studied in Nigeria during the rainy season of 2007 at Abeokuta were evaluated for genetic diversity and reported that in fruit pubescence as classified into ‘3’-downy, ‘5’- slightly rough and ‘7’- prickly

Fruit shape

Kalia and Padda (1962a) revealed that the degree of fruit shape is governed by two genes and (Miller and Wilson 1938) for several genes.

Oppong-Sekyere *et al.* (2011) fruit shape showed the greatest diversity among the okra accessions; from short and triangular to long straight or long curved. From the results in eight per cent of total accessions bore fruits with shape scores of 1, 3, 4, and 15, respectively. Twenty percent accessions bore fruits with a shape score of 2, while four per cent bore fruit with shape scores 6, 7, 13 and 14. Fruit shape scores 5, 9, 10, 11 and 12, did not show any occurrence (zero percentages) while shape score of type 8 recorded the highest occurrence of 32 per cent of the okra accessions.

Incidence of Yellow Vein Mosaic Virus

Saifullah and Rabbani (2009) evaluated one hundred and twenty one okra genotypes during summer season, 2004. In respect of qualitative characters, wide range of variation was also observed among 121 okra genotypes. Majority of the genotypes were susceptible to yellow vein mosaic virus. Some genotypes were also found to be high yielding and also tolerant to yellow vein mosaic virus.

MATERIALS AND METHODS

This chapter comprises the details about the materials used and the methods adopted during the course of present investigation entitled “Characterization of okra genotypes based on morphological and phenological traits. [*Abelmoschus esculentus* (L.) Moench]” was carried out in Kharif season during the year 2010-11.

3.1 Experimental site

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

3.1.1 Soil

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

3.1.2 Climate and weather conditions

Jabalpur is situated on ‘Kymore Plateau and satpura hills’ agro-climatic zone of Madhya Pradesh at 23.91^0 North latitude, 79.5^0 East longitudes and at an altitude of 411.78 meters above the mean sea level. The tropic of cancer passes through the middle of the district. The climate of region is typically semi arid and sub tropical having extreme winter and summer. The average annual rainfall is 1350 mm, which is mostly received during June to October form South-west monsoon. The average maximum temperature is 46^0c and minimum temperature 6.8^0c. The average annual relative humidity is seventy four per cent.

The meteorological parameter were recorded at JNKVV Meteorological observatory, Jabalpur during the crop season on parameters viz., minimum and maximum temperature, sunshine hours, rainfall in mm, number of rainy days and relative humidity are presented in Table 1.

Table 1. Week wise Meteorological information during entire *kharif* season of the year 2010-11 at Jabalpur. (July-Nov)

Meterological. Week.	Temperature (oC)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days	Sun shine (hrs.)
	Max.	Min.	Mor.	Evn.			
32	31.9	23.1	88	63	102.5	2	4.2
33	33.3	23.3	85	64	128.0	4	4.2
34	32.9	23.7	86	73	24.0	2	4.6
35	33.5	23.6	84	70	95.0	5	5.1
36	33.0	23.3	93	70	312.7	6	2.7
37	31.9	23.6	90	69	80.0	2	5.0
38	30.4	22.5	93	69	118.5	5	4.3
39	32.0	20.6	88	47	0.0	0	8.7
40	32.3	20.8	89	51	0.0	0	8.4
41	32.7	19.7	86	45	0.0	0	7.4
42	31.8	19.8	94	60	79.4	4	4.3
43	30.9	18.1	92	42	0.0	0	8.2
44	29.3	15.3	91	42	0.4	0	7.6
45	30.3	16.3	91	48	0.0	0	7.3
46	31.5	19.4	92	58	1.4	0	4.7
47	29.7	14.5	90	38	0.0	0	7.5
48	29.2	16.3	91	55	0.0	0	6.3

3.2 Experimental material

The experimental material for this study comprised of 65 genotypes inclusive of five checks (Phule Utkarsh, Hisar Unnat, VRO - 5, VRO - 6 and Pusa A-4) collected from NBPGR, New Delhi. Genotypes and Commercial checks are presented in Table 2.

Table 2. Details of genotypes and checks used in the study

S. No.	Name of genotype	S. No.	Name of genotype	S. No.	Name of genotype	S. No.	Name of genotype
1	IC018975	21	IC033340	41	IC039133		**Checks**
2	IC043736	22	IC113904	42	EC169342	1	Phule Utkarsh
3	IC117224	23	IC105643	43	IC093914	2	Hisar Unnat
4	IC112501	24	IC039132	44	IC058704	3	VRO - 5
5	IC117231	25	EC169356	45	IC045727	4	VRO - 6
6	IC007452	26	IC305644	46	IC018537	5	Pusa A-4
7	IC003753	27	IC033345	47	IC022283		
8	IC117032	28	IC093734	48	IC015027		
9	EC305628	29	IC093737	49	IC103913		
10	IC045796	30	IC018544	50	IC048281		
11	IC111515	31	IC111500	51	IC111477		
12	EC169511	32	IC111547-A	52	IC117212		
13	IC117216	33	IC111499	53	IC046018		
14	EC169462	34	IC111540	54	IC090284		
15	IC043732	35	IC043743	55	IC044190-C		
16	EC169341	36	IC117089	56	IC117078		
17	IC117132	37	IC043744	57	IC043748		
18	IC043737	38	IC090185	58	IC117214		
19	IC027874	39	IC011533	59	IC089876		
20	IC117024	40	IC112494	60	IC052321		

3.3 Experimental details

3.3.1 Design of experiment

The experiment was laidout in Augmented Randomized Block Design (ARBD) with 65 treatments (60genotypes + 5 checks) in three blocks. The experimental details are as follows:-

Design	:	ARBD
Block	:	Three
Genotypes	:	Sixty five genotypes
Row length	:	3.0 m
Spacing	:	60 X30 cm
Number of row/ accession	:	2
Gross area of experimental field	:	178 sq.m
Number of plants for observation per plot	:	5
Distance between blocks	:	1 m
Season	:	Kharif 2010
Date of sowing	:	27th July 2010
Manures	:	20 tonnes FYM/ha
Fertilizer dose (N:P:K)	:	100:50:50 kg/ha

3.3.2 Field preparation and sowing

In order to get good tilth of the soil for sowing one cross cultivation was done by tractor drawn cultivator followed by two harrowing and one planking before sowing of seed.

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

3.3.3 Irrigation

One irrigation was given at 45th meteorological weak to irrigate long spell of drought.

3.3.4 Intercultural operations

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

3.3.5 Fertilizer application

A dose of 100kg N, 50kg P_2O_5 and 50kg K_2O/ha along with 20 tonnes FYM/ha was applied. One third nitrogen and entire quantity of P, K and FYM was applied prior to sowing. Remaining dose of nitrogen was applied in two splits at 30 and 60 days after sowing.

3.3.6 Sampling

Sampling was done at 30 days to harvest time for growth analysis. Five compete plants were randomly selected from each genotype for the study. Average of five plants was recorded as treatment mean

3.4 Observation

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

(A) Morphological characters

3.4.1 Plant height (cm)

Height of plant was recorded in cm. from the base just above the soil surface to growing point of the plant at final harvest.

3.4.2. Number of branches per plant

Number of branches per plant was recorded at final harvest.

3.4.3 Length of internodes (cm)

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

3.4.4 Stem diameter (cm)

The diameter of stem was measured from randomly selected five plants from every genotype with the help of Vernier calipers and then average was recorded.

3.4.5 Leaf blade length (cm)

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

3.4.6 Leaf blade width (cm)

The width of leaf blade was measured from randomly selected five leaves from every genotype with the help of scale and then average was recorded.

3.4.7 Petiole length (cm)

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

3.4.8 Fruit length (cm)

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

3.4.9 Fruit diameter (cm)

The diameters of the randomly selected fruits were recorded with different position such as at base, at middle and at top with the help of Vernier calipers and average was worked out.

3.4.10 Stem colour

The colour of the stem was recorded in following categories.

Dark green /Green / Light green / Red

3.4.8 Stem intensity of green colour

The intensity of green colour of the stem was recorded in following categories.

- Dark green
- Medium green
- Light green

3.4.9 Leaf blade serration of margin

The serration of margin of the leaf blade was recorded in following categories.

- Strong
- Medium
- Weak

3.4.10 Leaf blade depth of lobbing

The depth of lobbing of the leaf blade was recorded on seventh leaf in following categories.

- Shallow
- Medium
- Deep

3.4.11 Leaf blade colour between veins

The leaf blade colour between veins was recorded in following categories.

- Green
- Red
- Green to red

3.4.12 Vein colour

The leaf blade colour between veins was recorded in following categories.

- Green
- Red
- Green to red
- Purple

3.4.13 Fruits colour

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

- Dark green
- Green
- Light green
- Red
- Light red
- Purple

3.4.14 Fruit surface between ridges

The fruit surface between ridges was recorded at marketable stage in following categories.

- Flat
- Concave
- Convex

3.4.15 Fruit constriction at basal part

The constriction of basal part of the fruit was recorded at marketable stage in following categories.

- Strong
- Medium
- Weak
- Absent

3.4.16 Fruit pubescence

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

- Strong
- Medium
- Weak
- Absent

3.4.17 Fruit shape on apex

The fruit shape on apex was recorded at marketable stage in following categories.

- Acute
- Narrow acute
- Blunt

3.4.18 Number of locules

Number of locules per fruit on observational plants was recorded.

3.4.19 Number of ridges on fruit

Number of ridges per fruit on observational plants was recorded.

3.4.20 Fruit weight (g)

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

3.4.21 Number of seeds per fruit

The number of seeds in five randomly selected fruits from observational plants counted and average seeds per fruit were calculated.

(B) Phenological characters

3.4.22 Days to 50 percent flowering

Number of days required to 50% of the plant to flower in each genotype was recorded separately.

3.4.23 Number of nodes to first flowering

Numbers of nodes were counted at the time of first flowering.

3.4.24 Days to maturity

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

(C) Yield parameters

3.4.25 Number of fruits per plants

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

3.4.26 Yield per plant (g)

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

3.4.27 Incidence of yellow vein mosaic virus:

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

3.5 Statistical methodology

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

3.5.1 Mean: It was calculated by using following formula.

$$\text{Mea} \quad \frac{\sum x}{n}$$

Where,

Σx = The sum of all the observation

n = Number of observation

3.5.2 Analysis of variance

The data based on the mean of individual plants selected for observation were statistically analysed to find out overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out analysis of variance to test the significance of differences among the populations. The analysis of variance was carried out as per methods suggested by Panse and Sukhatme (1967). The skeleton of analysis of variance used was as follows:

Table 3. ANOVA for Augmented randomized block design

Source of variation	df	Sum of square	Mean sum of square	F value calculated	F 5% , 1% reference
Blocks	b-1	bSS	bMS	bMS/EMS	-
Entries	e-1	eSS	eMS	eMS/EMS	
Checks	c-1	cSS	cMS	cMS/EMS	
Genotype	g-1	gSS	gMS	gMS/EMS	-
Genotypes Vs checks	1	gcSS	gcMS	gcMS/EMS	
Error	c(b-1)	ESS	EMS	-	-
Total	**N-1**	**TSS**	**-**	**-**	**-**

Where,

b = Number of blocks

e = Number of entries

c = Number of checks

g = Number of genotypes

df = Degree of freedom

bSS = Blocks sum of square

eSS = Entries sum of square

cSS = Checks sum of square

gSS = Genotype sum of square

gcSS = Genotypes Vs checks sum of square

ESS = Error sum of square

TSS =Total sum of square

bMS = Blocks mean sum of square

eMS = Entries mean sum of square

cMS = Checks mean sum of square

gMS = Genotype mean sum of square

gcMS = Genotypes Vs checks mean sum of square

EMS = Error mean sum of square

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

$$\text{C.V.} = \sqrt{\frac{EMS}{GM}} \times 100$$

Between any two check means

$$\text{SEm}\pm = \sqrt{\frac{EMS}{b}}$$

$$\text{SEdiff} = \sqrt{\frac{2EMS}{b}}$$

CD 5% = SE diff x $t_{5\%}$

Between any two test genotypes in the same means

$$SEm \pm = \sqrt{EMS}$$

$$\text{SEdiff} = \sqrt{2EMS}$$

CD 5% = SE diff x $t_{5\%}$

Between any two test genotypes not in the same means

$$SEm \pm = \sqrt{EMS\ (1+1/c)}$$

$$SEdiff = \sqrt{2EMS(1+1/c)}$$

CD at 5% = SE diff x $t_{5\%}$

Between mean of a check and a test genotypes

$$SEm \pm = \sqrt{\text{EMS}\,(1+1/\text{b}+1/\text{c}+1/\text{bc})}$$

$$SEdiff = \sqrt{2EMS(1+1/b+1/c+1/bc)}$$

CD at 5% = SE diff x $t_{5\%}$

Where,

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

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

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

$$Mean = \frac{\sum Xi}{n}$$

Where,

Σx_i = The sum of all the observation for i^{th} character.

n = Number of observations.

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

The component of variance was calculated as follows:-

S. No.	**Source**	**M.S.S.**	**Expected M.S.S.**
1.	Block	-	-
2.	Genotypes	M_i	$\pm\ {}^{2}e\ i + r.\ \pm\ {}^{2}g\ i$
3.	Error	E_i	$\pm\ {}^{2}e\ i$

$$\pm\ {}^{2}g_i = M_I - E_i$$

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

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

Where,

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

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

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

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

$$GCV = \sqrt{\frac{\pm^{2} gi}{\overline{Xi}}} x100$$

Phenotypic coefficient of variation (PCV)

$$PCV = \sqrt{\frac{\pm^{2} pi}{\overline{Xi}}} x100$$

Where,

x_i = General mean of the i^{th} character under consideration.

$\pm\ {}^{2}g_{I}$ And $\pm\ {}^{2}p_{i}$ = Genotypic and phenotypic standard deviation of the i^{th} character respectively.

Heritability and genetic advance

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

$$h^{2}(BS) = \frac{\pm^{2} gi}{\pm^{2} pi} x100$$

$$\text{Or } h^{2}\text{ (BS)} = \frac{\text{Genotypic variance of the } i^{th} \text{ character}}{\text{Phenotypic variance of the } i^{th} \text{ character}}$$

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

Genetic advance (GA) = K± . P_i .h^2_i

Genetic advance as percentage of mean was calculated as follows:

$$\frac{\text{Genetic advance}}{\bar{X}} \times 100$$

Where,

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

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

h^2_i= Broad sence heritability (fraction) of the i^{th} character.

X_i = General mean of the i^{th} character under consideration.

Correlation coefficients

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

$$r = \frac{\sum xy - \frac{\sum xi . \sum yi}{n}}{\sqrt{\left\{\sum xi^2 - \frac{(\sum xi)^2}{n}\right\} X \left\{\sum yi^2 - \frac{(\sum yi)^2}{n}\right\}}}$$

Where,)

r	=	Correlation coefficient
n	=	Number of treatments
X and Y	=	Character under study

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

$$r_G(XiXj) = \frac{G\sum xiyj - \frac{\sum xi . \sum yj}{n}}{\sqrt{\left\{\sum xi^2 - \frac{(\sum xi)^2}{n}\right\} X \left\{\sum yj^2 - \frac{(\sum yj)^2}{n}\right\}}}$$

$$r_P(XiXj) = \frac{G\sum xiyj - \frac{\sum xi . \sum yj}{n}}{\sqrt{\left\{\sum xi^2 - \frac{(\sum xi)^2}{n}\right\} X \left\{\sum yj^2 - \frac{(\sum yj)^2}{n}\right\}}}$$

$$r_E(XiXj) = \frac{G\sum xiyi - \frac{\sum xi . \sum yj}{n}}{\sqrt{\left\{\sum xi^2 - \frac{(\sum xi)^2}{n}\right\} X \left\{\sum yj^2 - \frac{(\sum yj)^2}{n}\right\}}}$$

Testing of correlations:

The phenotypic correlations are tested for their significance by following formula based on "t" test:

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

Where,

N= Number of treatments.

r = phenotypic correlations coefficient.

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

Path coefficients analysis:

Path coefficients analysis was worked out to show the cause and effect relationship between yield and various yield components and to partition the total correlation coefficient into direct and indirect effects. This procedure was developed by Wright (1921) and modified by Dewey and Lu (1959).

Path coefficients are the standardized partial regression coefficients and as such measure the direct influence of one variable upon another variable and permits partition of correlation coefficient into components of direct and indirect effects. The sum of the direct and all possible indirect effects via all other traits must be equal to correlation coefficient of dependent traits with independent characters under consideration.

Path coefficients were obtained by setting simultaneous equation which express basic relationship between correlation and path coefficient analysis.

1. $r_{1,y} = P_{1,y} + r_{1,2} P_{2,y} + r_{1,2} P_{1yt} + \ldots\ldots + r_{1,10} P_{10,y}$
2. $r_{2,y} = P_{2,y} + r_{2,1} P_{1,y} + r_{2,2} P_{3yt} + \ldots\ldots + r_{2,10} P_{10,y}$

n. $r_{n,y} = P_{10,y} + r_{n,1} P_{1,y} + r_{n,2} P_{3yt} + \ldots\ldots + r_{n,9} P_{9,y}$

Where,

1, 2, ……. n are the component characters and y is dependent upon which direct and indirect effects are studied.

Unexplained variation of the residual effect was obtained from the following equation:

$$R = \sqrt{1 - \sum dirij}$$

Where,

R = Residual effect.

di = Direct effect of the i^{th} character.

rij = Correlation coefficient between the i^{th} character and j^{th} dependent character.

Direct and indirect effects of yield per plant was calculated at both genotypic and phenotypic levels.

RESULTS

The results obtained from the present investigation "Characterization of okra (*Abelmoschus esuleutus* (L) Moench) genotypes based on morphological and phonological traits" are presented under the following hands

4.1 Analysis of variance

4.2 Genetic Variability

4.2.1Mean Performance of the genotypes

4.2.2 Genotypic and phenotypic coefficient of variation

4.2.3 Heritability and Genetic advance

4.3 Correlation Coefficient analysis

4.4 Path coefficient analysis

4.5 Characterization of okra genotypes based on Morphological traits

4.6 Incidence of yellow vein mosaic virus

4.1 Analysis of Variance

The analysis of variance for all the characters studied has been presented in Table 4.1. The mean differences due to genotypes were highly significant for all the characters except for days to 50 per cent flowering and days to maturity indicating that the presence of genetic diversity in the material.

4.2 Genetic variability

4.2.1 Mean performance of the genotypes.

Range maximum and minimum and mean performance of the sixty five genotypes for all the seventeen characters are presented in Table 4.2.

Plant height

Plant height ranged from 56.20 to 150.20 cm, with mean values of 108.88 cm. The maximum plant height was recorded in genotypes IC 043732 and minimum plant height was observed in IC 058704.

Table 4.1. Analysis of variance for different characters in okra (Mean square)

Source of variation	d.f.	Plant height (cm)	Branches /plant	Internodal length (cm)	Stem diameter (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (cm)	Nodes to first flower	Days to 50% flowering
Blocks	2	594.52	0.061	1.435	0.017	3.963	2.809	31.395	0.124	0.662
Entries	14	2177.13	0.995	18.673	0.486	31.342	18.491	63.764	1.572	9.131
Checks	4	894.12**	0.866**	26.331**	0.139**	15.252**	4.772**	48.482**	0.450*	6.072**
Genotypes	59	441.29**	0.170**	2.640**	0.106**	6.377**	3.735**	12.084**	0.324*	1.732
Check vs genotypes	1	866.85	0.337	0.320	0.002	1.530	19.412	5.802	1.082	1.329
Error	74	0.319	0.018	0.260	0.007	1.556	0.314	0.306	0.066	0.623

Source of variation	d.f.	Days to maturity	Fruits / plant	Fruit length (cm)	Fruit diameter (cm)	Locules / fruit	Fruit weight (gm)	Seeds /fruit	Fruit yield /plant (gm)
Blocks	2	9.853	11.514	1.993	0.140	0.97	118.920	85.34	17931.65
Entries	14	42.681	42.392	48.668	0.785	2.85	234.253	656.42	42616.02
Checks	4	20.066	6.529**	20.544**	.0.413**	0.07	32.766**	165.95**	14306.32**
Genotypes	59	8.694	9.053**	9.090**	0.154**	0.66**	50.104**	102.64**	8671.86**
Check vs genotypes	1	4.280	33.215	62.864	0.215	0.62	192.296	2470.34	27759.44
Error	74	5.416	0.227	0.301	0.010	0.07	0.266	0.19	18.958

Stem diameter

Stem diameter varied from 1.50 to 3.50 cm with an overall mean performance of 2.51 cm. The maximum stem diameter was observed in EC 305628 (3.50 cm) and it was minimum in IC 112494 (1.50 cm).

Node to first flowering

This trait revealed a range of 4.20 to 6.20 with an average of 5.21. The maximum nodes to first flowering was noted in IC 117078 (6.20) while, it was observed minimum in IC 043743 (4.20).

Branches per plant

The branches per plant varied from 1.10 to 3.0 branches with average of 1.65. The genotype IC 117132 recorded maximum branches per plant, while, genotype IC 112501 exhibited 1.10 branches per plant was the least.

Internodal length

Internodal length ranged between 4.50 to 12.60 cm and average was calculated to be 9.33 cm. the shortest internodal length was observed in genotype IC 090284 (4.50 cm), while, it was maximum in genotype IC 093914 (12.60 cm).

Leaf blade length

Leaf blade length ranged between 14.20 to 23.60 cm. The mean for all genotypes was 18.75 cm. Genotypes IC 089876 recorded considerably long (23.60 cm) leaf blade, while genotype IC 113904 expressed smallest (14.20 cm) leaf blade.

Leaf blade width

It ranged from 18.50 to 27.80 cm with an average of 24.00 cm. Leaf blade width was found to be highest in IC 093734 (27.80 cm) and it was recorded to be lowest in IC 117024 (18.50 cm).

Petiole length

The mean for petiole length was 23.16 cm and it ranged from 16.40 to 28.60 cm. Maximum petiole length was noted in IC 090284 (28.60 cm), while, genotype IC 043743 (16.40 cm) revealed smallest petiole length.

Table 4.2: mean performance of different genotypes of okra.

S. No.	Genotypes	Pl. Ht.	St. dia	Nodes to 1st flowering	Bran.	inter	Lbl	Lbw.	PL.	F.Int	F.dia	F. n.l	F/pt	F. wt	S/Ft	50 % F	DMu	Y/pt
1.	IC018975	124.5	2.5	4.2	2.1	10.2	18.5	24.5	25.2	15.2	1.7	5	10.5	30	44.5	41.5	87	350.2
2.	IC043736	130.2	2.6	5.1	1.2	9.5	16.8	26.3	28.5	6.5	**3.2**	6	11.2	25	**20.6**	42.6	90	360.2
3.	IC117224	125.6	2.7	4.8	1.8	10.4	18.5	24.5	18.2	15.4	1.5	6	12.0	25	34.5	44.5	89	340.5
4.	IC112501	110.5	2.5	4.8	**1.1**	11.2	17.6	24.6	17.6	8.2	1.5	6	12.8	30	29.2	43.2	88	345.2
5.	IC117231	102.6	2.7	4.4	2.1	7.2	19.5	26.8	25.2	**17.1**	**1.5**	**6**	**20.5**	**40**	**51.2**	**40.6**	**92**	**630.5**
6.	IC007452	**150.2**	2.5	5.2	1.9	8.5	22.5	27.2	26.4	15.5	1.5	6	12.0	25	38.5	41.2	87	342.6
7.	IC003753	120.3	2.5	4.8	1.2	9.8	21.8	25.5	22.5	8.5	1.7	6	16.5	**15**	34.6	40.5	95	312.5
8.	IC117032	106.8	2.4	4.2	1.6	11.5	20.9	26.4	23.8	14.8	1.5	6	**12.6**	**40**	45.6	43.8	95	**455.8**
9.	EC305628	132.2	**3.5**	4.6	1.2	10.2	23.1	24.6	28.4	12.5	1.9	6	10.5	**15**	38.5	41.8	93	425.3
10.	IC045796	95.6	2.6	5.2	1.8	11.5	20.5	24.2	26.8	15.8	1.8	6	7.2	35	35.2	40.9	94	320.5
11.	IC111515	115.4	2.5	5.4	1.5	7.5	18.6	24.5	25.3	15.7	1.5	**8**	**6.1**	30	52.4	42.5	95	245.6
12.	EC169511	101.5	2.2	5.6	1.3	8.2	19.5	23.6	21.5	17.5	2.5	5	12.6	**40**	44.5	41.8	92	430.5
13.	IC117216	110.6	2.5	6.0	1.8	9.5	16.8	25.6	24.5	12.5	1.5	5	13.5	30	55.8	42.2	90	425.8
14.	EC169462	125.4	2.9	5.8	1.9	10.3	14.9	21.5	23.6	16.5	1.8	5	9.2	25	28.5	**45.2**	94	365.2
15.	IC043732	150.2	2.8	5.8	1.6	9.2	19.5	23.6	26.4	16.2	1.5	5	11.8	25	42.5	42.6	93	512.5

16.	EC169341	130.6	2.6	5.2	1.6	9.5	18.6	24.5	24.3	10.4	1.6	5	11.2	20	22.0	43.5	95	370.2
17.	IC117132	105.2	1.9	6.0	**3.0**	7.5	16.7	23.1	23.5	13.2	1.5	5	12.6	25	44.5	41.5	**96**	350.6
18.	IC043737	104.3	1.8	5.4	2.5	7.9	16.5	22.8	23.6	12.3	1.3	5	12.4	25	44.1	41.5	92	345.3
19.	IC027874	106.8	2.5	5.2	1.9	11.6	22.5	27.5	26.5	15.2	1.5	5	13.8	39	30.5	**40.2**	94	375.4
20.	IC117024	70.5	2.5	5.2	1.5	10.2	15.8	**18.5**	21.3	12.5	2.1	6	11.2	30	28.5	42.3	90	350.2
21.	IC033340	94.8	2.4	6.2	1.6	8.5	15.7	23.4	21.5	14.5	1.5	5	11.4	25	40.2	42.1	89	365.2
22.	IC113904	114.5	2.5	6.2	1.5	9.2	**14.2**	21.6	16.5	12.5	1.3	5	10.5	35	35.6	43.5	92	345.3
23.	IC105643	92.6	2.8	5.8	1.7	8.6	16.8	22.5	22.3	15.6	1.9	5	12.6	**40**	34.8	42.5	90	420.5
24.	IC039132	72.5	2.6	6.0	1.6	7.8	22.0	24.6	19.4	12.4	1.4	5	13.4	30	30.2	42.6	95	435.2
25.	EC169356	120.6	2.4	5.3	1.5	5.4	18.2	27.1	28.5	**16.5**	**1.5**	**5**	**18.5**	**39**	**50.2**	**43.5**	**88**	**620.2**
26.	IC305644	119.8	2.5	5.8	1.8	10.2	19.1	24.2	20.0	8.5	1.3	6	12.6	33	25.6	44.5	93	420.5
27.	IC033345	80.5	2.3	5.4	1.1	11.5	16.5	24.6	19.4	9.7	1.5	5	11.3	**15**	24.6	42.8	89	365.2
28.	IC093734	106.8	2.5	5.2	1.9	11.6	19.5	**27.8**	25.6	14.5	1.5	**6**	16.5	**25**	60.5	**40.2**	94	465.2
29.	IC093737	122.5	2.8	4.4	1.3	10.5	22.5	24.7	26.8	11.2	1.5	6	16.2	25	24.5	42.9	89	435.8
30.	IC018544	116.4	2.5	4.9	1.2	12.5	21.9	22.9	25.7	18.5	1.9	5	20.3	40	52.3	41.6	92	620.7
31.	IC111500	95.4	2.4	4.8	1.1	8.6	17.6	22.5	24.3	11.2	1.5	5	14.6	30	30.2	44.2	94	465.2
32.	IC111547-A	125.4	2.3	5.2	2.6	10.2	19.8	24.3	22.6	12.1	2.1	5	9.2	35	54.2	43.5	90	280.7
33.	IC111499	92.6	2.5	4.2	1.9	7.8	15.9	23.7	20.5	14.6	1.5	5	12.3	25	34.2	40.8	93	375.2

34.	IC111547	87.9	2.4	5.9	2.5	9.2	16.8	21.5	22.6	15.2	1.5	5	11.6	25	42.6	44.1	87	380.5
35.	IC043743	115.2	2.5	4.2	1.6	9.5	14.2	20.9	16.4	13.5	1.3	5	11.7	35	44.6	43.5	91	370.5
36.	IC117089	93.5	2.8	5.8	1.8	7.6	19.5	21.4	21.5	15.7	1.7	6	10.5	40	30.2	41.5	94	345.2
37.	IC043744	120.5	3.1	4.9	1.1	9.2	16.5	20.7	16.8	16.8	2.5	5	15.6	40	50.7	42.1	89	510.8
38.	IC090185	102.5	2.5	5.1	1.3	10.2	17.4	24.3	26.3	12.2	1.5	5	12.3	30	41.6	40.2	93	420.5
39.	IC011533	119.4	2.5	5.8	1.8	10.8	18.5	24.5	18.5	8.5	1.3	6	14.5	33	42.7	44.8	89	525.1
40.	IC112494	86.5	1.5	5.2	1.7	10.5	17.5	25.1	16.7	12.3	1.5	5	14.2	40	38.8	42.9	95	510.2
41.	IC039133	102.6	2.2	6.2	1.6	7.6	19.6	25.3	26.8	10.5	1.5	5	12.5	28	36.7	41.8	92	380.5
42.	EC169342	118.5	2.3	4.4	1.5	11.5	22.8	24.8	26.4	14.2	1.9	5	14.8	**40**	62.5	42.6	**80**	450.2
43.	IC093914	116.8	2.5	5.2	1.2	**12.6**	21.5	26.7	22.5	11.2	1.8	6	12.8	25	38.2	44.2	94	412.3
44.	IC058704	**56.2**	2.6	5.8	1.8	8.5	22.6	23.6	26.5	**22.5**	1.6	5	**20.5**	**42**	**65.4**	41.5	89	**650.2**
45.	IC045727	125.3	2.2	5.0	1.8	9.5	21.2	24.5	19.4	10.5	1.3	5	11.2	25	52.3	41.2	93	350.6
46.	IC018537	95.8	2.5	5.2	2.4	8.4	19.0	23.8	26.4	13.5	1.5	8	13.2	30	42.5	42.9	89	380.5
47.	IC022283	85.6	2.6	4.4	1.2	9.5	20.9	20.9	24.3	16.5	**1.1**	8	10.2	25	38.9	42.8	92	310.5
48.	IC015027	81.2	2.5	6.0	1.5	9.4	16.6	21.4	24.1	15.8	1.5	5	10.6	25	23.5	40.6	89	320.5
49.	IC103913	93.5	2.3	5.2	1.6	7.5	15.8	24.3	21.5	15.1	1.5	5	11.2	25	43.6	41.5	93	350.4
50.	IC048281	96.4	2.5	5.0	1.1	6.8	15.7	20.1	16.5	10.5	1.5	**6**	10.8	25	39.4	42.7	95	355.6
51.	IC111477	72.5	2.6	4.6	1.5	7.5	15.0	24.5	19.4	11.6	1.4	5	10.2	30	34.5	42.6	92	310.5

52.	IC117212	130.2	2.6	5.3	2.5	8.6	19.6	25.7	21.6	**6.2**	3.2	5	18.2	25	52.1	42.1	94	560.5
53.	IC046018	125.1	2.4	5.2	1.6	9.5	14.8	22.1	23.5	16.1	1.8	8	10.3	25	43.5	**45.2**	88	320.5
54.	IC090284	122.3	1.6	5.3	1.3	**4.5**	17.6	25.9	**28.6**	11.2	1.5	5	11.6	20	38.5	43.6	94	340.6
55.	IC044190-C	120.1	2.2	5.2	1.5	10.6	18.5	24.3	18.5	10.2	1.3	6	10.2	33	42.5	44.5	90	290.4
56.	IC117078	131.5	3.1	**6.2**	**1.4**	11.2	18.2	25.7	25.4	15.6	1.5	5	6.5	30	38.4	43.2	88	**200.5**
57.	IC043748	145.8	2.9	5.1	1.6	8.5	19.0	23.8	26.3	15.2	1.5	5	10.2	25	28.5	43.5	95	300.4
58.	IC117214	122.5	3.1	5.0	1.3	10.5	21.5	25.1	24.1	10.5	1.5	6	10.5	25	51.3	42.1	90	350.2
59.	IC089876	136.2	2.6	4.2	1.5	8.6	**23.6**	21.9	25.3	13.5	1.2	5	14.6	25	40.1	40.6	94	462.5
60.	IC052321	56.2	2.8	5.3	1.9	8.3	22.5	23.5	28.0	11.3	1.6	5	10.9	15	40.0	40.8	92	321.5
61.	Phule Utkarsh(c)	82.23	2.4	4.5	1.5	8.9	17.8	22.4	22.4	10.2	1.5	5	14.6	39	43.0	43.9	88	454.5
62.	VRO-6 (C)	95.87	2.5	5.4	1.6	7.6	20.8	21.53	21.7	11.5	1.7	5	12.5	30	52.7	44.2	95	395.6
63.	VRO-5 (c)	101.50	2.5	4.7	1.6	7.2	16.6	21.17	17.0	15.9	1.6	5.3	16.3	35	62.0	40.6	89	581.2
64.	Hissar Unnat(c)	121.47	2.3	5.2	1.6	6.5	20.2	23.5	25.8	14.6	2.4	5	14.2	35	59.2	42.3	92	472.2
65.	Pusa A-4(c)	78.00	2.8	4.5	2.8	13.9	15.6	24.1	16.9	16.5	1.8	5	15.6	35	57.6	42.7	90	439.4
	SEm±	0.61	0.09	0.28	0.14	0.55	1.36	0.61	0.60	0.60	0.11	0.28	0.52	0.56	0.47	0.86	2.54	4.76
	CD at 5%	2.01	0.29	0.91	0.48	1.82	4.45	2.00	1.97	1.96	0.36	0.92	1.70	1.84	1.54	2.82	8.31	15.55

Fruit length

Fruit length varied from 6.20 cm to 22.50 cm with an overall mean performance of 13.17 cm. Genotype IC 058704 produced longest fruit (22.50 cm), while, smallest fruit was recorded in IC 117212 (6.20 cm).

Fruit diameter

The maximum (3.20 cm) fruit diameter was exhibited by genotype IC 043736 while, it was minimum in IC 022283 (1.10 cm). The overall average performance was 1.63 cm.

Locules per fruit

It varied from 5.0 to 8.0 locules with an average of 5.51. The genotypes IC 111515, IC 018537, IC 022283 and IC 046018 were recorded 8.0 locules per fruit. Whereas, lowest 5.0 locules per fruit was recorded in 38 genotypes.

Fruit per plant

Fruits per plant ranged between 6.10 to 20.50 fruits with an overall mean performance of 12.51. The maximum 20.50 fruits per plant were recorded in genotypes IC 058704 and IC 117032. While, it was least in genotype IC 111515 (6.10).

Fruit weight

Fruit weight ranged between 7.5 to 21.00 gm with an overall average weight of 14.44 gm. The genotype IC 058704 exhibited maximum 21.0 gm fruit weight while, genotypes IC 003753, IC 033345, EC 305628 and IC 052327 recorded minimum 7.5 gm fruit weight.

Seeds per fruit

Seeds per fruit ranged between 20.60 to 65.40 seeds, while, the average, was 40.10. The maximum 65.40 seeds per fruit were observed in IC 058704 and it was found in least (20.60) in IC 043736.

Days to 50 per cent flowering

Days to 50 per cent flowering varied from 40.20 to 45.20 days with an average of 42.26 days. The early (40.20 days) 50 per cent flowering was recorded in genotypes IC 093734, IC 090185 and IC 027874. While, late (45.20 days) 50 per cent flowering were observed in IC 046018 and EC 169462.

Days to maturity

This trait lied between 80.0 to 96.0 days with an overall mean of 91.50 days. Genotype EC 169342 was observed to be earliest in maturity (80.0 days) while genotype IC 117132 was found to be late (96.0 days).

Fruit yield per plant

Highest fruit yield per plant was recorded to be in IC 058704 (650.20 gm) while it was found to be lower in IC 117078 (200.50 gm). It was varied from 200.50 to 650.20 gm with an average 395.85 gm.

4.2.2 Coefficient of variation

Estimation of components of genetic parameters of variation for yield and its contributing characters exhibited a wide range of variation for the characters studied (Table 4.12). Results indicated that the values of phenotypic coefficient of variation were of higher magnitude than that of genotypic coefficient of variations for all the characters showing that the environment had an important role in influencing the expression of the characters.

The highest phenotypic coefficient of variation was observed for seeds per fruit (25.26), followed by branches per plant (24.98) fruit weight (24.50), fruit diameter (24.07), fruits per plant (24.05), fruit yield per plant (23.52), fruit length (22.89), plant height (19.29) and internodal length (17.41). Days to 50 per cent flowering (3.09), days to maturity (3.22) and leaf blade width (8.05) showed the lowest estimate for the same.

Moderate phenotypic coefficient of variation was recorded for petiole length (15.00) followed by locules per fruit (14.74), leaf blade length (13.46), stem diameter (12.97) and nodes to first flowering (10.92).

4.2.3 Heritability (broad sense) and genetic advance

4.2.3.1 Heritability

Heritability (broad sense) was computed for each of the characters by the variance components for estimating their relative magnitudes of genotypic and phenotypic variability contributed through environmental factors. The estimates of heritability (broad sense) for all the characters have been discussed as follows (Table 4.3). It was partitioned as very high (> 90%), high (70-90%) medium (50-70%) and low (<50%). Heritability was ranged from 37.70% for days to maturity to 99.92% for plant height.

The values of heritability (broad sense) was found to be very high for the traits viz., plant height (99.92%), seeds per fruit (99.81%), fruit yield per plant (99.78%), fruit weight (99.46%), fruit per plant (97.49%), petiole length (97.46%), fruit length (96.68%), fruit diameter (93.50%), stem diameter (93.39%), leaf blade width (91.59%) and internodal length (90.15%). However it was recorded to be high for branches per plant (89.41%), locules per fruit (89.39%), nodes to first flowering (79.62%) and leaf blade length (75.59%). Days to 50 per cent flowering (64.03%) exhibited moderate heritability. Low estimates of heritability was recorded for days to maturity (37.70%).

4.2.3.2 Genetic advance

Based on the estimates of heritability (broad sense) expected genetic advance was computed on the hypothetical selection at 5 per cent best individual (K=2.06). Due to masking influence of environment upon characters concerned values of genetic advance exhibited high fluctuation. Therefore, to attain relative comparison of the characters in relation to environment, genetic advance as percentage of mean was calculated to predict the genetic gain (Table 4.3). It was partitioned as high (> 35%), moderate (20-35%) and low (<20%).

The highest estimate of genetic advance as percentage of mean was recorded for seeds per fruit (51.94%) followed by fruit weight (50.21%), fruit yield per plant (48.35%), fruits per plant (48.30%), fruit diameter (46.37%) branches per plant (46.02%) fruit length (45.59%), plant height (39.71%) while, they were substantial moderate for internodal length (32.34%) and petiole length (30.13%). Locules per fruit (27.15%), stem diameter (24.95%), leaf blade length (20.97%), However the estimates were low for nodes to first flowering (17.91%) and leaf blade width (15.19%) showed moderate values, while days to maturity (2.50%) and days to 50% flowering (4.08%) showed the lowest estimate for the same.

Table 4.3: Genetic parameters of different characters in okra.

S. No.	Characters	Mean	Range		PCV	GCV	Heritability (%)	Genetic advance	Genetic advance as % of mean
			Min.	Max.					
1	Plant height(cm)	108.88	56.20	150.20	19.29	19.28	99.92	43.23	39.71
2	Stem diameter(cm)	2.51	1.50	3.50	12.97	12.53	93.39	0.62	24.95
3	Nodes to 1st flowering	5.21	4.20	6.20	10.92	9.74	79.62	0.93	17.91
4	Branches/ plant	1.65	1.10	3.00	24.98	23.62	89.41	0.75	46.02
5	Internodal length (cm)	9.33	4.50	12.60	17.41	16.53	90.15	3.01	32.34
6	Leaf blade length (cm)	18.75	14.20	23.60	13.46	11.71	75.59	3.93	20.97
7	Leaf blade width(cm)	24.00	18.50	27.80	8.05	7.70	91.59	3.64	15.19
8	Petiole length (cm)	23.16	16.40	28.60	15.00	14.81	97.46	6.97	30.13
9	Fruit length(cm)	13.17	6.20	22.50	22.89	22.51	96.68	6.00	45.59
10	Fruit diameter (cm)	1.63	1.10	3.20	24.07	23.28	93.50	0.75	46.37
11	Locules/ Fruit	5.51	5.00	8.00	14.74	13.94	89.39	1.49	27.15
12	Fruit/plant	12.51	6.10	20.50	24.05	23.74	97.49	6.04	48.30
13	Fruit weight (g)	28.88	15.00	42.00	24.50	24.44	99.46	14.50	50.21
14	Seeds /fruit	40.10	20.60	65.40	25.26	25.24	99.81	20.83	51.94
15	Days to 50% flowering	42.46	40.20	45.20	3.09	2.48	64.03	1.73	4.08
16	Days to maturity	91.50	80.00	96.00	3.22	1.97	37.70	2.28	2.50
17	Fruit yield/plant	395.85	200.50	650.20	23.52	23.49	99.78	191.41	48.35

4.3 Correlation coefficient analysis

Coefficient of correlation were worked out for all possible combinations of seventeen characters are presented in (Table 4.4).

Plant height showed highly positive and strorng association with petiole length (0.315) and leaf blade width (0.310). However, association was negative with fruit length (-0.243).

Stem diameter reveled relationship positive with internodal length (0.372).

Nodes to first flowering expressed negative association with fruits per plant (-0.274).

Highly significant and positive association of branches per plant was recorded with seeds per fruit (0.328).

The correlation of internodal length was significant and negative with days to maturity (-0.230).

Correlation coefficient of leaf blade length was positive with petiole length (0.576).

Leaf blade width showed strong positive relationship with petiole length (0.400) and locules per fruit (0.320) while it was negative with fruit length (-0.279).

Petiole length exhibited negative association with fruit weight (-0.232).

Correlation coefficient for fruits per plant was positive with fruit yield per plant (0.801) and seeds per fruit (0.390).

Fruit length expressed a highly significant and positive correlation with seeds per fruit (0.337) and fruit weight (0.235).

Positive correlation of fruit weight with seeds per fruit (0.290) was significant.

Seeds per fruit had positive and significant association with fruit yield per plant (0.437).

Table 4.4: Estimates of phenotypic correlation coefficients among yield and its contributing characters in okra.

S. No.	Plant height (cm)	Stem diameter (cm)	Nodes at 1st flowering	Branches/ plant	Internodal length (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit No. of locules	Fruits /plant	Fruit wt.(g)	Seed/ fruit	Days to 50% flowering	Days to maturity	Yield /plant (g)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1		.088	-.007	-.160	-.048	.205	.310**	.315**	-.243*	.166	.207	-.142	-.062	-0.55	0.107	0.018	-0.089
2			-.086	-.052	.372**	.114	-.106	-.019	.196	.140	.127	-.168	.127	-0.039	-0.037	-0.044	-0.095
3				.076	-.207	-.122	.003	.058	-.079	.009	-.089	-.274*	-.213	-0.180	0.105	0.116	-0.172
4					.185	-.178	.086	-.109	.209	.028	-.147	.080	.089	0.328**	-0.075	-0.002	0.030
5						-.022	.216	-.210	.154	-.041	.157	.083	.159	-0.027	0.094	-0.230*	-0.098
6							.365	.576**	-.106	.045	.175	.162	-.059	0.082	-0.165	0.117	0.083
7								.400**	-.279*	.020	.320**	.108	-.070	-0.057	-0.122	-0.014	0.008
8									.003	.164	.170	-.058	-.232*	-0.106	-0.129	0.006	-0.059
9										-.069	-.212	.123	.235*	0.337**	-0.102	-0.164	0.141
10											-.001	.156	.152	0.181	-0.033	0.008	0.191
11												-.142	.042	-0.127	0.001	0.084	-0.144
12													.094	0.390**	-0.140	-0.060	0.801**
13														0.290*	0.010	-0.069	0.221
14															-0.161	-0.112	0.437**
15																-0.081	-0.164
16																	-0.059

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

4.4 Path coefficient analysis

Path coefficient analysis was carried out taking fruit yield per plant as a dependent character in sixty five genotypes of okra. Path coefficient analysis was used to partition the observed correlation coefficient between fruit yield per plant and its component characters into direct and indirect effects. The estimates of path coefficient are furnished in the Table 4.5.

Direct effect

Path coefficient analysis of different character contributing to words fruits yield per plant showed that fruits per plant (0.8213) had highest positive direct effect followed by fruit weight (0.1575), stem diameter (0.1196), seed per fruit (0.1164), nodes to first flowering (0.0727), petiole length (0.0337) and plant height (0.0259).

Whereas internodal length (-0.2006) expressed highest negative direct effects on fruits yield per plant followed by leaf blade length (-0.0996), branches per plant (-0.0576), days to 50 per cent flowering (-0.0410), days to maturity (-0.0316), fruit length (-0.0259) and fruit diameter (-0.0144).

Indirect effect

Plant Height

Plant Height exhibited highest positive indirect effect via petiole length (0.0106), stem diameter (0.0105), internodal length (0.0096), branches per plant (0.0092) and fruit length (0.0063). However, it exhibited negative indirect effect via fruits per plant (-0.1166), leaf blade length (-0.0204), fruit weight (-0.0098), seeds per fruit (-0.0064), days to 50 per cent flowering (-0.0044) and fruit diameter (-0.0024).

Stem Diameter

Stem Diameter expressed highest indirect effect through fruit weight (0.0200), fruit length (0.0051), branches per plant (0.0030) and plant height (0.0023). It’s negative indirect effect was high via fruits per plants (-0.1380), internodal length (-0.0746), leaf blade length (-0.0114), nodes to first flowering (-0.0062) and seeds per fruits (-0.0045).

Table 4.5: Estimates of path coefficients analysis showing direct and indirect effect on fruit yield per plant in okra.

	Plant height (cm)	Stem diameter (cm)	Node to 1st flower	Branches / plant	Internodal length (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (cm)	Fruit length (cm)	Fruit diameter (cm)	Locules / Fruit	Fruits /plant	Fruit wt. (g)	Seeds/ fruit	Days to 50% flowering	Days to maturity	Yield /plant (g)
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	y
X1	**0.0259**	0.0105	-0.0005	0.0092	0.0096	-0.0204	0.0002	0.0106	0.0063	-0.0024	-0.0003	-0.1166	-0.0098	-0.0064	-0.0044	-0.0006	-0.089
X2	0.0023	**0.1196**	-0.0062	0.0030	-0.0746	-0.0114	-0.0001	-0.0006	0.0051	-0.0020	-0.0002	-0.1380	0.0200	-0.0045	0.0015	0.0014	-0.095
X3	-0.0002	-0.0103	**0.0727**	-0.0044	0.0415	0.0122	0.0000	0.0020	0.0020	-0.0001	0.0001	-0.2250	-0.0336	-0.0210	-0.0043	-0.0037	-0.172
X4	-0.0041	-0.0062	0.0055	**-0.0576**	-0.0371	0.0177	0.0001	-0.0037	-0.0054	-0.0004	0.0002	0.0657	0.0140	0.0382	0.0031	0.0001	0.03
X5	-0.0012	0.0445	-0.0150	-0.0107	**-0.2006**	0.0022	0.0001	0.0071	-0.0040	0.0006	-0.0002	0.0682	0.0250	-0.0031	-0.0038	0.0073	-0.098
X6	0.0053	0.0136	-0.0089	0.0103	0.0044	**-0.0996**	0.0002	0.0194	0.0027	-0.0006	-0.0003	0.1331	-0.0093	0.0098	0.0068	-0.0037	0.083
X7	0.0080	-0.0127	0.0002	-0.0050	-0.0433	-0.0364	**0.0007**	0.0135	0.0072	-0.0003	-0.0005	0.0887	-0.0110	-0.0066	0.0050	0.0004	0.008
X8	0.0082	-0.0023	0.0042	0.0063	0.0421	-0.0574	0.0003	**0.0337**	-0.0001	-0.0024	-0.0003	-0.0476	-0.0365	-0.0123	0.0053	-0.0002	-0.059
X9	-0.0063	0.0234	-0.0057	-0.0120	-0.0309	0.0106	-0.0002	0.0001	**-0.0259**	0.0010	0.0003	0.1010	0.0370	0.0392	0.0042	0.0052	0.141
X10	0.0043	0.0167	0.0007	-0.0016	0.0082	-0.0045	0.0000	0.0055	0.0018	**-0.0144**	0.0000	0.1281	0.0239	0.0211	0.0014	-0.0003	0.191
X11	0.0054	0.0152	-0.0065	0.0085	-0.0315	-0.0174	0.0002	0.0057	0.0055	0.0000	**-0.0016**	-0.1166	0.0066	-0.0148	0.0000	-0.0027	-0.144
X12	-0.0037	-0.0201	-0.0199	-0.0046	-0.0167	-0.0161	0.0001	-0.0002	-0.0032	-0.0022	0.0002	**0.8213**	0.0148	0.0454	0.0057	0.0019	0.801
X13	-0.0016	0.0152	-0.0155	-0.0051	-0.0319	0.0059	0.0000	-0.0078	-0.0061	-0.0022	-0.0001	0.0772	**0.1575**	0.0338	-0.0004	0.0022	0.221
X14	-0.0014	-0.0047	-0.0131	-0.0189	0.0054	-0.0082	0.0000	-0.0036	-0.0087	-0.0026	0.0002	0.3203	0.0457	**0.1164**	0.0066	0.0035	0.437
X15	0.0028	-0.0044	0.0076	0.0043	-0.0189	0.0164	-0.0001	-0.0044	0.0026	0.0005	0.0000	-0.1150	0.0016	-0.0187	**-0.0410**	0.0026	-0.164
X16	0.0005	-0.0053	0.0084	0.0001	0.0461	-0.0117	0.0000	0.0002	0.0042	-0.0001	-0.0001	-0.0493	-0.0109	-0.0130	0.0033	**-0.0316**	-0.059

Residual effect- 0.5235

Nodes to First Flowering

Nodes to First Flowering manifested highest positive indirect effect through internodal length (0.0415), followed by leaf blade length (0.0122). However it expressed high negative indirect effect via fruit per plant (-02250), fruit weight (-0.0336), seeds per fruits (-0.0210), stem diameter (-0.0103), branches per plant (-0.0044), days to 50 per cent flowering (-0.0043) and days to maturity (-0.0037).

Branches per plant

Branches per plant revealed high value of positive indirect effect on fruits yield per plant through fruits per plant (0.0657), seeds per fruit (0.0382), leaf blade length (0.0177), fruit weight (0.0140), nodes to first flowering (0.0055) and days to 50 per cent flowering (0.0031). While it expressed a high negative indirect effect through internodal length (-0.0371), stem diameter (-0.0062), fruit length (-0.0054), plant height (-0.0041) and petiole length (-0.0037).

Internodal Length

Internodal Length recorded to have highest positive indirect effect on fruit yield per plant via fruits per plant (0.0682), stem diameter (0.0445), fruit weight (0.0250), days to maturity (0.0073) and petiole length (0.0071). However negative indirect effects were observed through nodes to first flowering (-0.0150), branches per plant (-0.0107), days to 50 per cent flowering (-0.0038), seeds per fruit (-0.0031) and fruit length (-0.0040).

Leaf Blade Length

Leaf Blade Length manifested high positive indirect effect on fruit yield per plant through fruits per plant (0.1331), petiole length (0.0194), stem diameter (0.0136), branches per plant (0.0103), seeds per fruit (0.0098), days to 50 per cent flowering (0.0068), plant height (0.0053) and internodal length (0.0044). Its indirect effect via fruit weight (-0.0093), nodes to first flowering (-0.0089) and days to maturity (-0.0037) was found to be negative.

Leaf blade width

Leaf blade width was reported to have highest positive indirect effect on fruit yield per plant via fruits per plant (0.0887), petiole length (0.0135), plant height (0.0080), fruit length (0.0072) and days to 50 per cent flowering (0.0050). But it had negative indirect effect via internodal length (-0.0433), leaf blade length (-0.0364), stem diameter (-0.0127), fruit weight (-0.0110), seeds per fruit (-0.0066) and branches per plant (-0.0050).

Petiole length

Indirect effect of Petiole Length was highest and positive on fruit yield per plant via internodal length (0.0421), plant height (0.0082), branches per plant (0.0063), days to 50 per cent flowering (0.0053) and nodes to first flowering (0.0042). Whereas, it was negative via leaf blade length (-0.0574), followed by fruits per plant (-0.0476), fruit weight (-0.0365), seeds per fruit (-0.0123), fruit diameter (-0.0024) and stem diameter (-0.0023).

Fruit length

Fruit length revealed high value of positive indirect effect on fruit yield per plant through fruits per plant (0.1010), seeds per fruit (0.0392), fruit weight (0.0370), stem diameter (0.0234), leaf blade length (0.0106) and days to maturity (0.0052). While, it expressed a highly negative indirect effect through internodal length (-0.0309), followed by branches per plant (-0.0120), plant height (-0.0063) and nodes to first flowering (-0.0057).

Fruit diameter

High positive indirect effect of fruit diameter on fruit yield per plant was recorded via fruits per plant (0.1281), fruit weight (0.0239), seeds per fruit (0.0211), stem diameter (0.0167), petiole length (0.0055), plant height (0.0043), while, remaining characters exhibited lower positive indirect effect except leaf blade length (-0.0045), branches per plant (-0.0016) and days to maturity (-0.0003).

Locules per fruit

Positive Indirect effect of locules per fruit exhibited via stem diameter (0.0152), branches per plant (0.0085), fruit weight (0.0066), petiole length (0.0057), fruit length (0.0055) and plant height (0.0054). Highest negative indirect effect were observed through fruits per plant (-0.1166), internodal length (-0.0315), leaf blade length (-0.0174), seeds per fruit (-0.0148), nodes to first flowering (-0.0065) and days to maturity (-0.0027).

Fruits per plant

High positive indirect effect of fruits per plant on fruit yield per plant was revealed through seeds per fruit (0.0454), fruit weight (0.0148), days to 50 per cent flowering (0.0057) and days to maturity (0.0019). Remaining traits viz., stem diameter (-0.0201), nodes to first flowering (-0.0199), internodal length (-0.0167), leaf blade length (-0.0161), branches per plant (-0.0046), plant height (-0.0037), fruit length (-0.0032) and fruit diameter (-0.0022) were found to be negative indirect effect.

Fruit weight

Fruit weight manifested highest positive indirect effect on fruit yield per plant via fruits per plant (0.0772), seeds per fruit (0.0338), stem diameter (0.0152), leaf blade length (0.0059) and days to maturity (0.0022), however, Its indirect effect was observed via internodal length (-0.0319), nodes to first flowering (-0.0155), petiole length (-0.0078), fruit length (-0.0061), branches per plant (-0.0051) and fruit diameter (-0.0022) were negative.

Seeds per fruit

Indirect effect of seeds per fruit on fruit yield per plant were reported to have highest positive indirect effect via fruits per plant (0.3203), fruit weight (0.0457), days to 50 per cent flowering (0.0066), internodal length (0.0054), and days to maturity (0.0035). But it had negative indirect effect via branches per plant (-0.0189), nodes to first flowering (-0.0131), fruit length (-0.0087), leaf blade length (-0.0082) and stem diameter (-0.0047).

Days to 50 per cent flowering

Days to 50 per cent flowering exhibited highest positive indirect effect via leaf blade length (0.0164), nodes to first flowering (0.0076), branches per plant (0.0043), plant height (0.0028), fruit length (0.0026) and days to maturity (0.0026). It exhibited negative indirect effect via fruits per plant (-0.1150), internodal length (-0.0189), seeds per fruit (-0.0187), stem diameter (-0.0044) and petiole length (-0.0044).

Days to maturity

Days to maturity was observed to highest positive indirect effect as fruit yield per plant via., internodal length (0.0461), nodes to first flowering (0.0084), fruit length (0.0042) and days to 50 per cent flowering (0.0033). Whereas, it negative indirect effect were expressed high for fruits per plant (-0.0493), seeds per fruit (-0.0130), leaf blade length (-0.0117) fruit weight (-0.0109) and stem diameter (-0.0053).

An overall observation of the above results of path coefficient analysis of yield and its components revealed that fruits per plant, fruit weight, stem diameter, seeds per fruit, nodes to first flowering, petiole length, plant height, internodal length, leaf blade length, branches per plant, fruit length and fruit diameter were the most important characters contributing towards fruit yield per plant.

4.5 Characterization of okra genotypes based on morphological traits

Characterization of okra genotypes based on morphological characters of plants are as follows:

4.5.1 Stem colour

Genotypes were categorizes as per descriptor in to four groups based on pigmentation i.e. dark green, green, light green and red. Variation was observed among the genotypes for stem colour pigmentation. All the genotypes exhibited green colour stem except IC 015027 and IC 048281 which were recorded red colour stem.

4.5.2 Intensity of green colour stem

A wide range of variation was exhibited for intensity of green colour stem (Table 4.6) based on intensity of green color stem, okra genotypes were categorized into three groups i.e. light green, medium green and dark green. Thirty seven genotypes were expressed light green stem. Genotypes IC018975, IC117231, IC003753, IC045796, IC043732, IC117024, EC169356, IC305644, IC093734, IC018544, IC111547-A, IC090185, EC169342, IC093914, IC 058704, VRO-5 (c), Hissar Unnat (c) and Pusa A-4 (c) recorded medium green stem, while, genotypes IC 007452, IC117032, EC305628, IC111500, IC112494, IC039133, IC018537, IC 015027 and Phule Utkarsh (c) exhibited dark green stem.

Table 4.6: Categorization of okra genotypes based on stem intensity of green colour.

Light green	Medium green	Dark green
IC043736, IC117224, IC112501, IC111515, EC169511, IC117216, EC169462, EC169341, IC117132, IC027874, IC033340, IC113904, IC105643, IC039132, IC033345, IC093737, IC111499, IC11154, IC043743, IC1170895, IC043744, IC011533, IC045727, IC022283, IC103913, IC048281, IC111477, IC117212, IC046018, IC090284, IC044190-C, IC117078, IC043748, IC117214, IC089876, IC052321, VRO-6 (c)	IC018975, IC117231, IC003753, IC045796, IC043732, IC117024, EC169356, IC305644, IC093734, IC018544, IC111547-A, IC090185, EC169342, IC093914, IC058704, VRO-5 (c), Hissar Unnat (c), Pusa A-4 (c).	IC007452, IC117032, EC305628, IC111500, IC112494, IC039133, IC018537, IC015027,Phule Utkarsh (c)

4.5.3 Leaf blade Serration of margin

Genotypes were classified in to strong, medium and week (Table 4.7). Significant variation was observed among the genotypes for leaf blade serration of margin. Leaf blade serration of margin were observed to be strong in genotypes, IC112501, EC305628, EC169511, EC169462, EC169341, IC113904, IC305644, IC033345, IC018544, IC111547-A, IC11154, IC043744, IC090185, IC112494, IC058704, IC018537, IC015027, IC117212, IC 089876, Phule Utkarsh (c) , VRO-6 (c), VRO-5(c) and Hissar Unnat (c), whereas, IC003753, IC117024, IC105643, IC039132, IC039133, IC046018 and IC 044190-C showed weak serration of margin and medium leaf blade serration of margin was observed in thirty five genotypes.

Table 4.7: Categorization of okra genotypes based on leaf blade serration of margin.

Strong	Medium	Weak
IC112501, EC305628, EC169511, EC169462, EC169341, IC113904, IC305644, IC033345, IC018544, IC111547-A, IC11154, IC043744, IC090185, IC112494, IC058704, IC018537, IC015027, IC117212, IC089876, Phule Utkarsh (c) , VRO-6 (c), VRO-5(c), Hissar Unnat (c).	IC018975, IC043736, IC117224, IC117231, IC007452, IC117032, IC045796, IC111515, IC117216, IC043732, IC117132, IC043737, IC027874, IC033340, EC169356, IC093734, IC093737, IC111500, IC111499, IC043743, IC1170895, IC011533, EC169342, IC093914, IC045727, IC022283, IC103913, IC048281, IC111477, IC090284, IC117078, IC043748, IC117214, IC052321, Pusa A-4 (c).	IC003753, IC117024, IC105643, IC039132, IC039133, IC046018, IC044190-C.

4.5.4 Leaf blade depth of lobbing

Considerable variability was obtained for leaf blade depth lobbing i.e. shallow, medium and deep (Table 4.8). Genotypes IC112501, IC003753, IC117024, IC105643, IC039132, IC039133, IC046018 and IC 044190-C observes sallow depth of lobbing, where as, genotypes IC117224, IC007452, EC305628, EC169462, IC043732, IC117132, IC043737, EC169356, IC033345, IC018544, IC111547-A, IC111499, IC043743, IC1170895, IC043744, IC103913, IC048281, IC 117212, Phule Utkarsh (c) , VRO-5(c), Hissar Unnat (c) and Pusa A-4 (c) had deep depth of lobbing. Thirty six genotypes exhibited medium leaf blade depth of lobbing.

Table 4.8: Categorization of okra genotypes based on leaf blade depth of lobbing.

Shallow	Medium	Deep
IC112501, IC003753, IC117024, IC105643, IC039132, IC039133, IC046018, IC044190-C,	IC018975, IC043736, IC117231, IC117032, IC045796, IC111515, EC169511, IC117216, EC169341, IC043737, IC027874, IC033340, IC113904, IC305644, IC093734, IC093737, IC111500, IC11154, IC090185, IC011533, IC112494, EC169342, IC093914, IC058704, IC045727, IC018537, IC022283, IC015027, IC111477, IC090284, IC117078, IC043748, IC117214, IC089876, IC052321, VRO-6 (c),	IC117224, IC007452, EC305628, EC169462, IC043732, IC117132, *IC043737, EC169356, IC033345, IC018544, IC111547-A, IC111499, IC043743, IC1170895, IC043744, IC103913, IC048281, IC117212, Phule Utkarsh (c), VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).

4.5.5 Veins colour

Genotypes were categorized as green, red, green to red and purple for vein colour (Table 4.9). Purple vein colour was exhibited in two genotypes viz., IC 015027 and IC 048281 and rest of the genotypes expressed green vein colour. None of the genotypes were express to red and green to red group of vein colour.

Table 4.9: Categorization of okra genotypes based on veins colour.

Green	Red	Green to red	Purple
IC018975, IC043736, IC117224, IC112501, IC117231, IC007452, IC003753, IC117032, EC305628, IC045796, IC111515, EC169511, IC117216, EC169462, IC043732, EC169341, IC117132, IC043737, IC027874, IC117024, IC033340, IC113904, IC105643, IC039132, EC169356, IC305644, IC033345, IC093734, IC093737, IC018544, IC111500, IC111547-A, IC111499, IC11154, IC043743, IC1170895, IC043744, IC090185, IC011533, IC112494, IC039133, EC169342, IC093914, IC058704, IC045727, IC018537, IC022283, IC103913, IC111477, IC117212, IC046018, IC090284, IC044190-C, IC117078, IC043748, IC117214, IC089876, IC052321, Phule Utkarsh (c), VRO-6 (c), VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	_	_	IC015027, IC048281,

4.5.6 Fruit colour

Significant variability was observed for fruit colour viz dark green, green, light green, red, light red and purple. Light green fruit colour was visible in genotypes IC112501, IC007452, IC003753, IC043732, EC169356, IC033345, IC018544, IC 045727 and VRO-6 (c). Genotypes IC018537, IC022283 and IC 111547-A expressed light red colour of fruits, while genotypes IC 015027 and IC 048281 revealed purple fruits. The remaining fifty one genotypes showed green fruit (Table 4.10). None of the genotypes expressed dark green and red colour of fruits.

Table 4.10: Categorization of okra genotypes based on fruit colour.

Dark green	Green	Light green	Red	Light red	Purple
_	IC018975, IC043736, IC117224, IC117231, IC117032, EC305628, IC045796, IC111515, EC169511, IC117216, EC169462, EC169341, IC117132, *IC043737, IC027874, IC117024, IC033340, IC113904, IC105643, IC039132, IC305644, IC093734, IC093737, IC111500, IC111499, IC11154, IC043743, IC1170895, IC043744, IC090185, IC011533, IC112494, IC039133, EC169342, IC093914, IC058704, IC103913, IC111477, IC117212, IC046018, IC090284, IC044190-C, IC117078, IC043748, IC117214, IC089876, IC052321, Phule Utkarsh (c), VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	IC112501, IC007452, IC003753, IC043732, EC169356, IC033345, IC018544, IC045727, VRO-6 (c),	_	IC018537, IC022283. IC111547-A	IC01502, IC04828.

4.5.7 Fruit surface between ridges.

Considerable variability was observed among the genotypes for fruit surface between ridges and genotypes were categorized as flat concave and convex (Table 4.11). Concave fruit surface was observed in genotypes IC043736, IC117024, IC305644, IC093734, IC111500, IC112494, IC093914, IC022283, IC103913, IC043748 and IC 117214. Remaining fifty four genotypes showed flat fruit surface between ridges. However, none of the entries expressed convex fruit surface.

Table 4.11: Categorization of okra genotypes based on fruit surface between ridges.

Flat	Concave	Convex
IC018975, IC117224, IC112501, IC117231, IC007452, IC003753, IC117032, EC305628, IC045796, IC111515, EC169511,IC117216, EC169462, IC043732, EC169341, IC117132, IC043737,IC027874, IC033340, IC113904, IC105643, IC039132, EC169356, IC033345, IC093737, IC018544, IC111547-A, IC111499, IC11154,IC043743, IC1170895, IC043744, IC090185, IC011533, IC039133, EC169342, IC058704, IC045727, IC018537, IC015027, IC048281, IC111477, IC117212, IC046018, IC090284, IC044190-C, IC117078,IC089876, IC052321, Phule Utkarsh (c), VRO-6 (c),VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	IC043736, IC117024, IC305644, IC093734, IC111500, IC112494, IC093914, IC022283, IC103913, IC043748, IC117214.	–

4.5.8 Fruit constriction at basal part

The genotypes have been classified in four groups based on fruit constriction at basal part i.e. strong, medium, weak and absent. The fruits were classified based on visual observation are given in Table 4.12. Strong basal part was visible only in genotype IC 048281, while, absent basal part was recorded in genotypes IC117024, IC105643, IC111499, IC039133, IC022283 and IC044190-C. Remaining 58 genotypes revealed weak basal part. No medium fruit constriction at basal part was observed.

Table 4.12: Categorization of okra genotypes based on fruit constriction at basal part.

Strong	Medium	Weak	Absent
IC048281	_	IC018975, IC043736, IC117224, IC112501, IC117231, IC007452, IC003753, IC117032, EC305628, IC045796, IC111515, EC169511, IC117216, EC169462, IC043732, EC169341, IC117132, IC043737, IC027874, IC033340, IC113904, IC039132, EC169356, IC305644, IC033345, IC093734, IC093737, IC018544, IC111500, IC111547-A, IC11154, IC043743, IC1170895, IC043744, IC090185, IC011533, IC112494, EC169342, IC093914, IC058704, IC045727, IC018537, IC015027, IC103913, IC111477, IC117212, IC046018, IC090284, IC117078, IC043748, IC117214, IC089876, IC052321, Phule Utkarsh (c), VRO-6 (c),VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	IC117024, IC105643, IC111499, IC039133, IC022283, IC044190-C

4.5.9 Fruit pubescence

Considerable variability was observed among the genotypes for fruit pubescence and was categorized as strong, medium, weak and absent (Table 4.8). Genotypes were found to have strong hairs while genotype IC043736, IC045796, IC111515 and IC111547-A had expressed medium hairs. None of genotypes was visible in category absent pubescence. The remaining genotypes showed weak hairy.

Only six genotypes IC117024, IC033340, IC111499, IC018537, IC103913 and IC044190-C expressed strong pubescence. None of the genotypes expressed glabrous fruit surface, while four genotypes viz., IC043736, IC045796, IC111515, IC111547-A expressed medium pubescence. While remaining 55 genotypes observed were revealed weak pubescence.

Table 4.13: Categorization of okra genotypes based on fruit pubescence.

Strong	Medium	Weak	Absent
IC117024, IC033340, IC111499, IC018537, IC103913, IC044190-C	IC043736, IC045796, IC111515, IC111547-A	IC018975, IC117224, IC112501, IC117231, IC007452, IC003753, IC117032, EC305628, EC169511, IC117216, EC169462, IC043732, EC169341, IC117132, IC043737, IC027874, IC113904, IC105643, IC039132, EC169356, IC305644, IC033345, IC093734, IC093737, IC018544, IC111500, IC11154, IC043743, IC1170895, IC043744, IC090185, IC011533, IC112494, IC039133, EC169342, IC093914, IC058704, IC045727, IC022283, IC015027, IC048281, IC111477, IC117212, IC046018, IC090284, IC117078, IC043748, IC117214, IC089876, IC052321, Phule Utkarsh (c), VRO-6 (c),VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	_

4.5.10 Fruit Shape on apex

Fruit shape on apex was classified as acute, narrow acute and blunt (Table 4.14). Genotypes IC117231, IC007452, IC033340, EC169356, IC111499, IC103913, IC090284 and IC043748 showed acute fruit shape, whereas genotypes IC043736, IC117024, IC305644 and IC093914 were found to bear blunt fruit apex. Narrow acute fruit shape on apex was seen in remaining fifty three genotypes.

Table 4.14: Categorization of okra genotypes based on fruit shape on apex.

Acute	Narrow acute	Blunt
IC117231, IC007452, IC033340, EC169356, IC111499, IC103913, IC090284, IC043748,	IC018975, IC117224, IC112501, IC003753, IC117032, EC305628, IC045796, IC111515, EC169511, IC117216, EC169462, IC043732, EC169341, IC117132, IC043737, IC027874, IC113904, IC105643, IC039132, IC033345, IC093734, IC093737, IC018544, IC111500, IC111547-A, IC11154, IC043743, IC1170895, IC043744, IC090185, IC011533, IC112494, IC039133, EC169342, IC058704, IC045727, IC018537, IC022283, IC015027, IC048281, IC111477, IC117212, IC046018, IC044190-C, IC117078, IC117214, IC089876, IC052321, Phule Utkarsh (c), VRO-6 (c),VRO-5(c), Hissar Unnat (c), Pusa A-4 (c).	IC043736, IC117024, IC305644, IC093914,

4.6 Incidence of yellow vein mosaic virus

The incidence of yellow vein mosaic virus recorded as highly susceptible, susceptible, tolerant, moderately tolerant and resistance. The result of incidence of yellow vein mosaic virus is depicted in the table 4.15.

Genotypes EC169511, IC117216, IC043732, IC117132, IC093734, IC1170895, IC058704, IC117078, VRO-5(c) and Hissar Unnat(c) were found to be resistance under field conditions and genotypes IC117032, IC090185, IC093914, IC117214 and Phule Utkarsh (c), were exhibited to tolerance to this disease. However, genotypes IC117224, IC117231, EC305628, EC169356, IC112494, IC018537, IC117212, IC089876 and VRO-6 (c) were observed moderately tolerantly to yellow vein mosaic virus. Seventeen genotypes highly susceptible and twenty four genotypes were recorded susceptible.

Table 4.15: Categorization of okra genotypes based on incidence of yellow vein mosaic virus.

Highly susceptible	Susceptible	Tolerant	Moderately tolerant	Resistant
IC043736, IC112501, IC007452, IC003753, EC169462,IC 027874, IC117024, IC033340, IC113904, IC105643, IC011533, IC022283, IC103913, IC048281, IC046018, IC090284, IC044190-C,	IC018975, IC045796, IC111515, EC169341, EC169342, IC039132, IC305644, IC033345, IC093737, IC018544, IC111500, IC111547-A, IC111499, IC11154, IC043743, IC043744, IC039133, IC043737, IC045727, IC015027, IC111477, IC043748, IC052321, Pusa A-4 (c).	IC117032, IC090185, IC093914, IC117214, Phule Utkarsh (c),	IC117224, IC117231, EC305628, EC169356, IC112494, IC018537, IC117212, IC089876, VRO-6 (c),	EC169511, IC117216, IC043732, IC117132, IC093734, IC1170895 , IC058704, IC117078, VRO-5(c), Hissar Unnat(c)

DISCUSSION

The experimental findings of the present investigation "Characterization of okra (*Abelmoschus esuleutus* (L) Mrench) genotypes based on morphological and phonological traits" have been discussed on the following heads in the light of the available literature.

5.1 Analysis of Variance

5.2 Genetic variability

5.2.1 Mean performance of the genotypes

5.2.2 Genotypic and phenotypic coefficient of variation

5.2.3 Heritability and genetic advance

5.3 Association analysis

5.3.1 Correlation coefficient analysis

5.3.2 Path coefficient analysis

5.4 Characterization of okra genotypes based on morphological traits.

5.5 Incidence of yellow vein mosaic virus

5.6 Identification of putative lines

5.1 Analysis of Variance

The main objective of the present investigation was to study the diversity present in sixty five genotypes of okra. The estimates of mean sum of square due to genotypes were highly significant for all the characters except for days to 50 percent flowering and days to maturity. (Table 4.1) indicates the presence of substantial genetic diversity in the existing material. The findings of Patro and Ravisankar (2004) Naidu *et al*. (2007) and Shantha Kumar and Salimath (2010) are similar to that of the present study.

5.2 Genetic variability

5.2.1 Mean performance of the genotypes

Range maximum and minimum and mean performance of the sixty five genotypes for all the seventeen characters are presented in Table 4.2.

Plant height

The maximum plant height was recorded in genotypes IC 043732 and minimum plant height was observed in IC 058704. The mean values of 108.88 cm and 33 genotypes exhibited above the mean value. The findings were quite similar to as reported by Bendale *et al.* (2003).

Stem diameter

The maximum stem diameter was observed in EC 305628 (3.50 cm) and it was minimum in IC 112494 (1.50 cm). Thirty three genotypes were observed above the mean value (2.51cm).

Node to first flowering

Thirty nine genotypes were recorded above the mean value (5.21). The maximum nodes to first flowering was noted in IC 117078 (6.20) while, it was observed minimum in IC 043743 (4.20). The findings were quite similar to as reported by Bendale *et al.* (2003).

Branches per plant

The genotype IC 117132 recorded maximum branches per plant, while, genotype IC 112501 exhibited 1.10 branches per plant was the least. Twenty five genotypes expressed above the mean value (1.65). The findings were quite similar to as reported by Bendale *et al.* (2003).

Internodal length

The shortest internodal length was observed in genotype IC 090284 (4.50 cm), while, it was maximum in genotype IC 093914 (12.60 cm). Thirty three genotypes were observed above the mean value (9.33cm). The findings were quite similar to as reported by Bendale *et al.* (2003).

Leaf blade length

Genotypes IC 089876 recorded considerably long (23.60 cm) leaf blade, while genotype IC 113904 expressed smallest (14.20 cm) leaf blade. Thirty genotypes revealed above the mean value (18.75cm).

Leaf blade width

Leaf blade width was found to be highest in IC 093734 (27.80 cm) and it was recorded to be lowest in IC 117024 (18.50 cm). Thirty five genotypes were observed above the mean value (24.0cm).

Petiole length

Maximum petiole length was noted in IC 090284 (28.60 cm), while, genotype IC 043743 (16.40 cm) revealed smallest petiole length. Thirty five genotypes were exhibited above the mean value (23.16cm).

Fruit length

Genotype IC 058704 produced longest fruit (22.50 cm), while, smallest fruit was recorded in IC 117212 (6.20 cm). Thirty four genotypes expressed above the mean value (13.17 cm). The findings were quite similar to as reported by Farghali *et al*. (1994), Bendale *et al.* (2003).

Fruit diameter

The maximum (3.20 cm) fruit diameter was exhibited by genotype IC 043736 while, it was minimum in IC 022283 (1.10 cm). Twenty three genotypes expressed above the mean value (1.63 cm). The findings were quite similar to as reported by Farghali *et al*. (1994).

Locules per fruit

The genotypes IC 111515, IC 018537, IC 022283 and IC 046018 were recorded 8.0 locules per fruit. Whereas, lowest 5.0 locules per fruit was recorded in 38 genotypes and twenty three genotypes expressed above the mean value (5.51). The findings were quite similar to as reported by Naidu *et al.* (2007).

Fruit per plant

The maximum 20.50 fruits per plant were recorded in genotypes IC 058704 and IC 117032. While, it was least in genotype IC 111515 (6.10) and thirty genotypes recorded above the mean value (12.51). The findings were quite similar to as reported by Bendale *et al.* (2003).

Fruit weight

Overall average weight of fruit is 28.88 gm. The genotype IC 058704 exhibited maximum 42.0 gm fruit weight, while, genotypes IC 003753, IC 033345, EC 305628 and IC 052327 recorded minimum 15.0 gm fruit weight and thirty four genotypes above the mean value. The findings were quite similar to as reported by Farghali *et al*. (1994), Sood (1999), Bendale *et al.* (2003).

Seeds per fruit

The maximum 65.40 seeds per fruit were observed in IC 058704 and it was found in least (20.60) in IC 043736. The average was 40.10 and thirty four genotypes above the mean value. The findings were quite similar to as reported by Bendale *et al.* (2003).

Days to 50 per cent flowering

The early (40.20 days) 50 per cent flowering was recorded in genotypes IC 093734, IC 090185 and IC 027874. While, late (45.20 days) 50 per cent flowering were observed in IC 046018 and EC 169462. Thirty five genotypes were exhibited above the mean value (42.46 days). The findings were quite similar to as reported by Sood (1999).

Days to maturity

Genotype EC 169342 was observed to be earliest in maturity (80.0 days), while genotype IC 117132 was found to be late (96.0 days) and thirty seven genotypes above the mean value (91.50 days). The findings were quite similar to as reported by Sood (1999), Bendale *et al.* (2003).

Fruit yield per plant

Highest fruit yield per plant was recorded to be in IC 058704 (650.20 gm) while it was found to be lower in IC 117078 (200.50 gm). Twenty seven genotypes exhibited above the mean value (395.85 gm). The findings were quite similar to as reported by Patil *et al.* (1996b), Sood (1999), Bendale *et al.* (2003) and Naidu *et al.* (2007).

5.2.2 Coefficient of variation

In the present findings PCV were observed to be more than the corresponding GCV for all the characters studied, however the differences was narrow which implied their relative resistance to environmental variation. It also described that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively on the basis of phenotypic performance. The finding of Bendale *et al.* (2003) is similar to that of the present investigation.

High estimates of phenotypic coefficient of variation were observed for seeds per fruit (25.26) followed by branches per plant (24.98) fruit weight (24.50), fruit diameter (24.07), fruits per plant (24.05), fruit yield per plant (23.52), fruit length (22.89), plant height (19.29) and internodal length (17.41). The findings are in close harmony with the result of Bendale *et al.* (2003) for number of branches per plant, yield per plant and number of fruits per plant, Nagre *et al*. (2011) for fruit length, yield per plant and internodal length and Chaukhande *et al*. (2011) reported that maximum difference between GCV and PCV for internodal length. The high values of GCV suggested greater genotypic variability among the genotypes and responsiveness of the genotypes for making further improvement by selection.

However, low estimates of PCV and GCV were noted characters e.g. days to 50 per cent flowering (3.09), days to maturity (3.22) and leaf blade width (8.05). The finding of Shantha kumar and Salimath (2010) and Patil *et al.* (1996a) for days to flowering were similar to the present finding which indicated that there is limited scope for improvement.

5.2.3 Heritability and Genetic advance

Heritability which denotes the proportion of genetically controlled variability expressed by its phenotype for a particular character or a set of character is very important biometrical tool for guiding plant breeders to choose traits with high degree of inheritance. High heritability in broad sense in helpful in identifying appropriate character for selection and enables the breeder to select superior genotypes on the basis of phenotypic expression of quantitative characters. The estimated values of heritability in broad sense were classified as very high (> 90%), high (between 70-90%), medium (50-70%) and low (< 50%).

Very high estimates of heritability were obtained for majority of the traits viz., plant height, seeds per fruit, fruit yield per plant, fruit weight, fruit per plant, petiole length, fruit length, fruit diameter, stem diameter, leaf blade width and internodal length. The results were in close proximate to that of Reddy *et al*. (1985) for fruit yield per plant, Patil and Dalal (1992) for yield and its components, Chandra *et al*. (1996), Panda and Singh (1997), Dhankar and Dhankar (2002) and Sureshbabu *et al.* (2004) for fruit yield, plant height and seeds per fruit, Naidu *et al.* (2007) for fruit per plant, seeds per fruit and fruit yield per plant, Nagre *et al.* (2011) for yield per plant, fruit length and fruit per plant, and Chaukhande *et al*. (2011) for plant height. Characters like branches per plant, locules per fruit, nodes to first flowering and leaf blade length exhibited high heritability. The findings of Patil and Dalal (1992) were quite similar to that of the present study. High values of broad sense heritability for the above characters revealed that these traits were less influenced by the environment. It reflected that the phenotypes truly represent their genotypes and selection based on phenotypic performance would be reliable.

Estimates of heritability were low for days to maturity. This is indicative of the fact that these characters are rather more influenced by the environment and may not respond much to selection. Days to 50 per cent flowering exhibited moderate heritability which indicated that selection based on phenotypic performance would be considerably rewarding.

Heritability however indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimates along with genetic gains are more effective and reliable in predicting the improvement through selection (Johnson *et al*., 1955). Estimate of genetic advance help to predict the extent of improvement that can be achieved per cycle of selection for improving the different characters. The estimated values of genetic advance as percent of mean were classified as high (> 35%), moderate (20-35%) and low (< 20%).

In the present study, the characters namely seeds per fruit followed by fruit weight, fruit yield per plant, fruits per plant, fruit diameter, branches per plant, fruit length and plant height exhibited higher values of genetic advance as percentage of mean. The results were in consonance with Reddy *et al*. (1985) and Gulshan Lal (1986) for fruit yield per plant, Patil *et al*. (1996a) and Panda and Singh (1997) for plant height, fruits per plant and fruit weight Chandra *et al*. (1996) for plant height, fruits per plant and seeds per fruit, Naidu *et al.* (2007) for fruits per plant, seeds per fruit and fruit yield per plant, Nagre *et al.* (2011) for yield per plant and plant height, Chaukhande *et al*. (2011) for fruit diameter. Whereas, genetic advance was moderate for internodal length, petiole length, locules per fruit, stem diameter and leaf blade length. Moderate genetic advance as percentage of mean was reported by Dhankar and Dhankar (2002). Low genetic advance as percentage of mean was observed for nodes to first flowering, leaf blade width, days to 50 per cent flowering and days to maturity.

High heritability coupled with high genetic advance was observed in traits e.g. plant height, seeds per fruit, fruit yield per plant, fruit weight, fruit per plant, fruit length, fruit diameter and branches per plant. Suggested that the preponderance of additive genes in inheritance of these traits. It also indicated higher response for selection of high yield and associated characters for predominance of additive gene actions. The findings were in agreement to the findings of Reddy *et al*. (1985) for fruit yield per plant, Patil *et al.* (1996a) for plant height, fruit weight and fruit per plant, Chandra *et al*. (1996) for plant height, fruits per plant and seeds per fruit, Panda and Singh (1997) for plant height, fruits per plant and fruit yield per plant, Naidu *et al.* (2007) for fruits per plant, seeds per fruit and fruit yield per plant, Nagre *et al.* (2011) for yield per plant.

High heritability supplemented with moderate genetic advances as percentage of mean were manifested by internodal length followed by petiole length, locules per fruit, stem diameter and leaf blade length which might be due to the action of additive gene controlling expression of traits hence, stratified phenotypic selection for their amenability can be brought about. The findings were in agreement to the findings of Dhankar and Dhankar (2002).

High heritability coupled with low genetic advance as percentage of mean was observed for nodes to first flowering and leaf blade width. This revealed the predominance of non-additive gene action in the expression of these characters. The findings were in agreement to the findings of Dhankar and Dhankar (2002).

Low estimates of heritability coupled with low genetic advances as percentage of mean were displayed by days to maturity that indicated that this character was highly influenced by environmental effects and consequently selection for these traits may not be rewarding. The results were in consonance with Tandekar (2010).

5.3 Association analysis

5.3.1 Correlation coefficient analysis

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

The magnitude of genotypic correlation was higher than the phenotypic correlation for all the traits that indicated inherent association between various characters. The findings were in agreement to Niranjan and Mishra (2003) and Kumar *et al.* (2009).

In the present investigation the highest positive correlation of fruit yield per plant was noted with fruits per plant, followed by seeds per fruit indicating that these characters are the primary yield determinant in okra. These findings corroborated the earlier findings of Ajimal *et al*. (1979), Mahajan and Sharma (1979), Singh and Singh (1979), Chantana Vicharat (1990), Shukla (1990), Mandal and Dana (1994), Gondane *et al*. (1995), Yadav (1996), Paiva *et al*. (1998), Bendale *et al*. (2003), Jaiprakash Narayan and Mulge (2004), Sureshbabu *et al.* (2004), Subrata *et al*. (2004), Bhalekar *et al*. (2005), Pawar (2005), Verma *et al*. (2007), Nagre *et al.* (2011) and Chaukhande *et al*. (2011) for fruits per plant, Dash and Mishra (1995) and Ghosh (2005) for number of seeds per fruit, Niranjan and Mishra (2003) and Choudhary (2006) for fruits per plant and number of seeds per fruit.

Plant height revealed strong positive and significant association with petiole length and leaf blade width. However, its association was negative with fruit length. This indicates the importance of this character in selection. The positive correlation of plant height with petiole length and leaf blade width indicates that allocation and translocation of photosynthates from the source to the sink. These results are not in agreement with the finding of Yadav (1996) reported positive relationship between for plant height and fruit length.

Stem diameter revealed positive relationship with internodal length.

Nodes to first flowering expressed negative association with fruits per plant. These results are in close harmony with the findings of Hazare and Basu (2000), Jaiprakash Narayan and Mulge (2004) and Pawar (2005) for fruits per plant.

Very strong positive association of branches per plant was recorded with seeds per fruit.

The correlation of internodal length was significant and negative with days to maturity.

Correlation coefficient of leaf blade length was positive with petiole length.

Leaf blade width showed strong positive association with petiole length and locules per fruit while it was negative with fruit length.

Petiole length exhibited negative association with fruit weight.

Fruit length expressed a highly significant and positive correlation with seeds per fruit and fruit weight. These results are in close harmony with the findings of Singh et al. (1975) and Pawar (2005) for fruit weight.

Correlation coefficient for fruits per plant was positive with fruit yield per plant and seeds per fruit. The results corroborated the findings of Ajimal *et al*. (1979), Mahajan and Sharma (1979), Singh and Singh (1979), Chantana Vicharat (1990), Shukla (1990), Mondal and Dana (1994), Gondane *et al*. (1995) and Yadav (1996) for yield and seeds per fruit.

Positive correlation of fruit weight with seeds per fruit was significant. The results corroborated the findings of Ghosh (2005) for fruit weight with seeds per fruit.

5.3.2 Path coefficient analysis

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

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

Path coefficient analysis of the different characters revealed that fruits per plant had highest positive direct effect on fruit yield per plant followed by fruit weight, stem diameter, seed per fruit, nodes to first flowering, petiole length and plant height. The results are in propinquity with Gondane *et al*. (1995) for fruit weight and fruits per plant important variables contributing towards yield. Choudhary and Sharma (1999) and Sureshbabu *et al.* (2004) for fruit weight, fruits per plant and plant height, Niranjan and Mishra (2003), Pawar (2005), Nagre *et al.* (2011a) and Chaukhande *et al.* (2011) for fruit weight, fruits per plant and seed per fruit, Adeniji and Aremu (2007) for plant height, fruits per plant and seed per fruit, Verma *et al.* (2007) for fruits per plant. The character fruit per plant expressed correlation coefficient values at par with their direct effect on fruit yield per plant. This indicates true relationships with fruit yield per plant and direct selection for these traits would result in higher breeding efficiency for improving yield. Thus, these traits might be reckoned as the most important component trait for improvement of fruit yield per plant.

Characters viz., internode length expressed highest negative direct effects on fruits yield per plant followed by leaf blade length, branches per plant, days to 50 per cent flowering, days to maturity, fruit length and fruit diameter. But leaf blade length, branches per plant, fruit length and fruit diameter was positively correlated to it. This indicated that the indirect effect was the cause of correlation and thus the indirect causal factors are to be considered simultaneously for selection.

The traits internodal length, days to 50 per cent flowering and days to maturity imparted a negative direct effect on fruit yield per plant, as well as they were negatively correlated to it. Under such circumstance direct selection for these traits should be avoided, instead indirect selection should be followed. However, this may help in selection of early genotypes in the high yield.

Other characters like leaf blade width and locules per fruit did not exhibit, higher direct effect on fruit yield, they expressed higher indirect effect on it through fruits per plant and stem diameter respectively and hence simultaneous selection for these characters can be made for the improvement of yield.

Path coefficient analysis revealed that fruits per plant, fruit weight, stem diameter, seeds per fruit, nodes to first flowering, petiole length, plant height, leaf blade length, branches per plant, fruit length and fruit diameter were the most important characters contributing towards fruit yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of okra. Direct selection of days to 50 per cent flowering and days to maturity should be avoided instead of indirect selection.

5.4 Characterization of okra genotypes based on morphological traits

Characterization of okra genotypes was performed based of various parameters of morphological characters (at seedling and plant traits). Distinguishing genotypes on the basis of morphological characters is one of the most common criteria. On morphological basis characterization was done based on NBPGR descriptor for okra (Anonymous, 2008).

Among the morphological traits observed at pre-flowering stage stem colouration may be considered as distinguishing, uniformity and stability for verification of genotypes. Genotypes were categorized into four groups based on pigmentation on stem i.e. dark green, green, light green and red. Stem pigmentation was observed variation among the genotypes. Plants of all the genotypes were observed green colour stem pigmentation except IC 015027 and IC 048281 which were recorded red colour. The findings are in agreement with the findings of Oppong-Sekyere *et al.* (2011)

A wide range of variation exhibited for intensity of green color stem i.e. dark green, medium green and light green stem. Most of the genotypes had light green stem, while 9 genotypes exhibited dark green and 18 genotypes expressed medium green colour of stem. These observations are in agreement with the result of Saifullah and Rabbani (2009) reported green (35 genotypes), deep green (12 genotypes), green with red patches (72 genotypes) and red (2 genotypes). Nwangburuka *et al.* (2011) most of the plants showed predominantly green and pigmented.

Significant variation was observed among the genotypes for leaf blade serration of margin i.e. strong medium and weak. Weak leaf blade serration is good for photosynthesis because it exhibited more leaf area. Leaf blade serration of margin were observed to be strong in genotypes viz., IC112501, EC305628, EC169511, EC169462, EC169341, IC113904, IC305644, IC033345, IC018544, IC111547-A, IC11154, IC043744, IC090185, IC112494, IC058704, IC018537, IC015027, IC117212, IC089876, Phule Utkarsh (C), VRO-6 (c), VRO-5 (c), and Hissar Unnat (c), where as IC003753, IC117024, IC105643, IC039132, IC039133, IC046018 and IC 044190-C showed weak serration of margin and rest of the genotypes exhibited medium leaf blade serration of margin. The findings are in agreement with the result of Mahajan *et al*. (1996).

Considerable variability was obtained for leaf blade depth of lobbing i.e. shallow, medium and deep. Shallow leaf blade depth of lobbing is good for photosynthesis because it exhibited more leaf area. Genotypes viz., IC112501, IC003753, IC117024, IC105643, IC039132, IC039133, IC046018 and IC 044190-C recorded shallow depth of lobbing, whereas, genotypes IC117224, IC007452, EC305628, EC169462, IC043732, IC117132, IC043737, EC169356, IC033345, IC018544, IC111547-A, IC111499, IC043743, IC1170895, IC043744, IC103913, IC048281, IC117212, Phule Utkarsh (C), VRO-5 (c), Hissar Unnat (c), and Pusa A-4 (c) had deep depth of lobbing. The rest of the genotypes exhibited medium leaf blade depth of lobbing. The findings are in agreement with the findings of degree of leaf lobbing by Simple inheritance (Kalia and Padda 1962a) and Mahajan *et al.* (1996).

Genotypes were categorized as green, red, green to red and purple for vein colour. Purple vein colour was exhibited in genotypes IC 015027 and IC 048281 and rest of the genotypes recorded green vein colour. None of the genotypes recorded red and green to red group of vein colour. These observations are in agreement with the result of Mahajan *et al.* (1996), Saifullah and Rabbani (2009) and Nwangburuka *et al.* (2011).

Significant variability was observed for fruit colour viz dark green, green, light green, red, light red and purple. Dark green fruits are attractive and have good consumer preference. Light green fruit colour was visible in genotypes IC112501, IC007452, IC003753, IC043732, EC169356, IC033345, IC018544, IC0 045727 and VRO-6(c). Genotypes IC018537, IC022283 and IC 111547-A expressed light red colour of fruits, while genotypes IC 015027 and IC 048281 revealed purple fruit. The remaining genotypes showed green fruit. Fruit colour is govern by simple inheritance multiple alleles (Kalia and Padda 1962a). The results were in close proximate to that of Mahajan *et al.* (1996), Saifullah and Rabbani (2009), Nwangburuka *et al.* (2011) and Oppong-Sekyere *et al.* (2011).

Considerable variability was observed among the genotypes for fruit surface between ridges and genotypes were categorized as flat, concave and convex. Genotypes IC043736, IC117024, IC305644, IC093734, IC111500, IC112494, IC093914, IC022283, IC103913, IC043748 and IC 117214 expressed concave fruit surface between ridges. Remaining genotypes showed flat fruit surface between ridges. These observations are in agreement with the result of Anonymous, 2008.

The genotypes have been classified in four groups based on fruit constriction at basal part i.e. strong, medium, weak and absent. These groups identified by the visual observation. Strong basal part was visible in genotype IC 048281. Absence of constriction on the basal part was observed on large number of genotypes viz., IC 117024, IC 105643, IC 111499, IC 039133, IC 022283 and IC 044190-C. Remaining genotypes expressed weak basal part. These observations are in agreement with the result of Anonymous, 2008.

Considerable variability was observed among the genotypes for fruit pubescence and was categorized as strong, medium, weak and absent. Weak fruit pubescence are good because easy picking and cutting. Genotypes IC117024, IC033340, IC111499, IC018537, IC103913 and IC044190-C expressed strong pubescence while genotype IC043736, IC045796, IC111515 and IC111547-A had medium hair. None of genotypes gave glabrous fruit surface. The remaining genotypes showed presence of weak hair. This character is governed by complex genes (Miller and Wilson 1938), while simple inheritance was reported by (Kalia and Padda 1962a) and incomplete dominance by (Nath and Dutta 1970). These observations are in agreement with the result of Saifullah and Rabbani (2009), Oppong-Sekyere *et al.* (2011) and Nwangburuka *et al.* (2011).

Variability was observed for fruit shape on apex i.e. acute, narrow acute and blunt. Acute and narrow acute fruit shape on apex are desirable. Genotypes IC117231, IC007452, IC033340, EC169356, IC111499, IC103913, IC090284 and IC043748 showed acute fruit shape, whereas genotypes IC043736, IC117024, IC305644 and IC093914 expressed blunt fruit shape on apex. Narrow acute fruit shape on apex was observed in rest of the genotypes. The fruit shape is governed by two genes (Kalia and Padda 1962a) several genes by (Miller and Wilson 1938).

5.5 Incidence of yellow vein mosaic virus

The incidence of yellow vein mosaic virus recorded as susceptible, highly susceptible, tolerant, moderately tolerant and resistance. Genotypes EC169511, IC117216, IC043732, IC117132, IC093734, IC1170895, IC058704, IC117078, VRO-5 (c) and Hissar Unnat (c) were found to be resistant under field conditions and genotypes IC117032, IC090185, IC093914, IC117214 and Phule Utkarsh (c) exhibited tolerance to this disease. However, genotypes IC117224, IC117231, EC305628, EC169356, IC112494, IC018537, IC117212, IC089876 and VRO-6 (c) revealed moderately tolerantly to yellow vein mosaic virus. The findings of Prabhu *et al*. (2007) and Saifullah and Rabbani (2009) for majority of the genotypes were susceptible to yellow vein mosaic virus. Some genotypes were also found to be high yielding and also tolerant to yellow vein mosaic virus are in close harmony to the present findings.

5.6 Identification of putative lines

It is revealed from the data obtained the most putative lines are as follows.

IC 058704

This is an early maturing, dwarf,having 1-2 branches with short internodal length The fruits are long , green, flat fruit surface, weak pubescence and narrow acute fruit shape. The average fruit weight is 42.0gm and 65.40 seed per fruit. This genotype exhibited highest fruit yield of 650.20gm/plant. It is resistant to yellow vein mosaic virus.

IC 117231

It is moderately tolerant to yellow vein mosaic virus. Its first picking may be taken in 47-48 days. The average fruit yield of 630.50gm/plant. Plants are medium tall with short internodes (7.2cm), producing 2-3 branches. Foliage and stem is green. Fruits are long green, flat fruit surface, weak pubescence and acute fruit shape. Fruits are 5 ridged, about 17.10cm long having well filled 51.2 seeds per fruit, weighing are around 40g each.

EC 169356

The plants are tall (120.6cm), 1-2 branches having short internodes (5.4cm) bearing 18-19 fruit each. Foliage and stem is green. Bearing starts in 50-51days after sowing from 5-6 nodes. Fruits are light green about 16.5cm long having 50.2 seeds per fruit, flat fruit surface, weak pubescence and acute fruit shape. Fruit weighing are around 39g each. It is moderately tolerant to yellow vein mosaic virus, the yield potential being 620.20gm/plant.

The genotypes viz., IC 058704, IC 117231 and EC 169356 were identified as elite lines due to their higher productivity fruit quality including green fruit colour, acute fruit apex, flat fruit surface with five ridges, long fruit length and width. These lines also expressed moderately tolerance - resistance to Yellow vain mosaic virus disease.

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

6.1 Summary

The present investigation “Characterization of okra genotypes based on morphological and phenological traits.” was carried out during kharif season of 2010-2011 at the Vegetable Research Farm, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.). The experimental material for the present investigation was comprised of 65 genotypes of okra. These genotypes were sown in Augmented Randomized Block Design with three blocks, to estimate the genetic variability, association analysis (Correlation and Path coefficient) and study morphological characterization. Observations were recorded on five random competitive plants selected from each genotypes separately for morphological, phonological, yield and other parameters were evaluated as per standard procedure .On the basis of results, the present investigation is summarized as follows:

The estimates of mean sum of square due to genotypes were highly significant for all the characters except for days to 50 per cent flowering and days to maturity, indicating the presence of substantial genetic diversity in the existing material however it is limiting for phenological traits.

The present study revealed that the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits which might be due to interaction of the genotypes with the environment to some degree or other explaining environmental factors influencing the expression of these characters. High phenotypic and genotypic coefficient of variation was observed for seeds per fruit followed by branches per plant, fruit weight, fruit diameter, fruits per plant, fruit yield per plant, fruit length, plant height and internodal length, which suggests greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. However, days to 50 per cent flowering, days to maturity and leaf blade width showed low estimates of genotypic and phenotypic coefficient of variation revealed limited variability for these traits indicating limited scope for their improvement.

High heritability coupled with high genetic advance as percentage of mean for traits like plant height, seeds per fruit, fruit yield per plant, fruit weight, fruit per plant, fruit length, fruit diameter and branches per plant, suggested preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions.

High heritability supplemented with moderate genetic advances as percentage of mean were manifested by internodal length, petiole length, locules per fruit, stem diameter and leaf blade length which might be attributed to additive gene action conditioning their expression hence phenotypic selection for their amenability can be brought about.

High heritability coupled with low genetic advance as percentage of mean was observed for nodes to first flowering and leaf blade width. This revealed the predominance of non-additive gene action in expression of these characters.

Low estimates of heritability coupled with low genetic advances as percentage of mean were displayed by days to maturity that indicated that this character was highly influenced by environmental effects and consequently its selection would be ineffective.

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

The highest positive correlation coefficient of fruit yield per plant was noted with fruits per plant, and seeds per fruit, which indicated that effective improvement in okra yield through these components could be achieved .The yield attributing characters exhibited varying trend amongst themselves. Plant height showed strong positive and significant association with petiole length and leaf blade width. However, association was negative with fruit length. Stem diameter revealed positive relationship with internodal length. Nodes to first flowering expressed negative association with fruits per plant. Highly significant and positive association of branches per plant was recorded with seeds per fruit. The correlation of internodal length was significant and negative with days to maturity. Correlation coefficient of leaf blade length was positive with petiole length. Leaf blade width showed strong positive association with petiole length and locules per fruit while it was negative with fruit length. Petiole length exhibited negative association with fruit weight. Fruit length expressed a strong positive correlation with seeds per fruit and fruit weight. Correlation coefficient for fruits per plant was positive with fruit yield per plant and seeds per fruit. Positive correlation of fruit weight with seeds per fruit was significant.

Path coefficient analysis of the different characters revealed that fruits per plant had highest positive direct effect on fruit yield per plant followed by fruit weight, stem diameter, seed per fruit, nodes to first flowering, petiole length and plant height. The characters fruit per plant revealed correlation coefficient values at par with their direct effect on fruit yield per plant. This indicates true relationships with fruit yield per plant and direct selection for these traits would result in higher breeding efficiency for improving yield. Thus, these traits might be reckoned as the most important component trait of fruit yield per plant.

Characters like internodal length expressed highest negative direct effects on fruits yield per plant followed by leaf blade length, branches per plant, days to 50 per cent flowering, days to maturity, fruit length and fruit diameter. But leaf blade length, branches per plant, fruit length and fruit diameter were positively correlated to it. This indicated that the indirect effect was the cause of correlation and the indirect causal factors are to be considered simultaneously for selection.

The traits viz., internodal length, days to 50 per cent flowering and days to maturity imparted negative direct effect on fruit yield per plant, as well as they were negatively correlated to it. Under such circumstance direct selection for these traits should be avoided, instead indirect selection should be followed.

Visually expressions of eleven distinguishing morphological traits revealed that at plant and fruit level.

The expression of six morphological characters at different stages of plant growth was observed to categorize the genotypes. Stem colour, intensity of green colour on stem, leaf blade serration of margin, leaf blade depth of lobing, leaf blade colour between veins and vein colour are the most stable and uniform distinguishing characters for verification of okra genotypes at field level.

Fruit colour, fruit pubescence, fruit surface between ridges, fruit shape on apex and fruit constriction at basal part were observed at fruit level are the most stable and uniform distinguishing characters. Dark fruit colour, weak fruit pubescence, flat fruit surface between ridges and acute and narrow acute fruit shape on apex determines the fruit quality.

Genotypes EC169511, IC117216, IC043732, IC117132, IC093734, IC1170895, IC058704, IC117078, VRO-5 (c) and Hissar Unnat (c) were found to be resistant under field condition and genotypes IC117032, IC090185, IC093914, IC117214 and Phule Utkarsh (c) were exhibited to tolerant to this disease. However, genotypes IC117224, IC117231, EC305628, EC169356, IC112494, IC018537, IC117212, IC089876 and VRO-6 (c) were observed moderately tolerantly to yellow vein mosaic virus.

The genotypes viz., IC 058704, IC 117231 and EC 169356 were identified as putative lines due to their higher productivity fruit quality including green fruit colour, acute fruit apex, flat fruit surface with five ridges, long fruit length and width. These lines also expressed moderately tolerance - resistance to Yellow vain mosaic virus disease.

6.2 Conclusion

Analysis of variance revealed highly significant variance for all the traits except for days to 50 percent flowering and days to maturity depicting greater variability in the existing material.

High heritability supplemented with high genetic advance as percentage of mean was manifested by plant height, seeds per fruit, fruit yield per plant, fruit weight, fruit per plant, fruit length, fruit diameter and branches per plant and these traits also expressed high PCV and GCV. suggested that they can be improved through direct selection.

The correlation and path coefficient analysis revealed that fruits per plant, fruit weight, seeds per fruit, were the most important characters contributing towards fruit yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of okra.

The genotypes viz., IC 058704, IC 117231 and EC 169356 were identified as elite lines due to their higher productivity fruit quality including green fruit colour, acute fruit apex, flat fruit surface with five ridges, long fruit length and width. These lines also expressed moderately tolerance - resistance to Yellow vain mosaic virus disease.

6.3 Suggestions for further work

1. Stability of distinct traits of okra should be established over the years.
2. An umbrageous characteristics pattern of elite okra genotypes should be obtained through DNA finger printing.
3. Characters having desirable association and direct effects with fruit yield should be given due consideration for genetic improvement in okra.

4. Traits viz., seeds per fruit, fruit weight, fruit per plant, fruit length and fruit diameter fruit yield per plant, while dark fruit colour, weak fruit pubescence, flat fruit surface between ridges and acute and narrow acute fruit apex determines the fruit quality. Genotypes IC 058704, IC 117231 and EC 169356 revealed above traits. These lines also expressed moderately tolerance - resistance to Yellow vain mosaic virus disease. Hence, these putative lines may be subjected to selection/ recombination breeding or for expression of heterosis for improvement of okra genotypes.

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Fig. 1. Variation for stem colour in Okra

IC111515 | IC112501 | IC015027

Fig. 2. Variation for Leaf Shape, Size, Lobes, Serration and vein color in okra

IC039132

ICO18975

IC018544

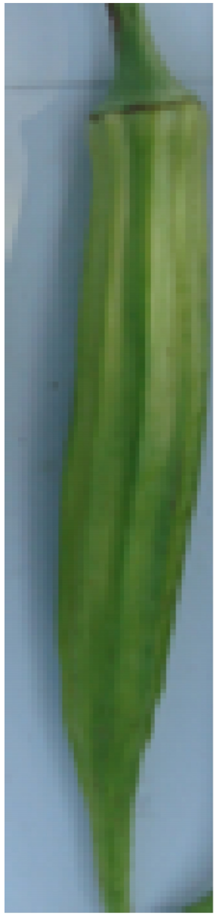
IC048281

ICO27874

Variation for Fruit characters viz. 1. Fruit colour **2.** Fruit length **3.** Fruit diameter **4.** Fruit surface between ridges **5.** Fruit shape on apex **6.** Number of locules.

IC093734

IC022283



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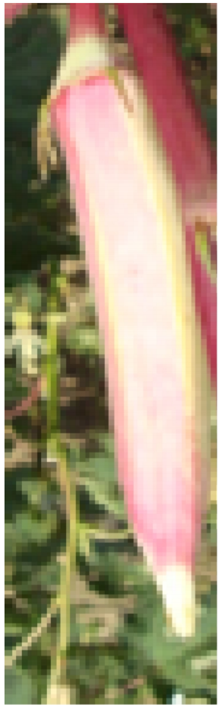

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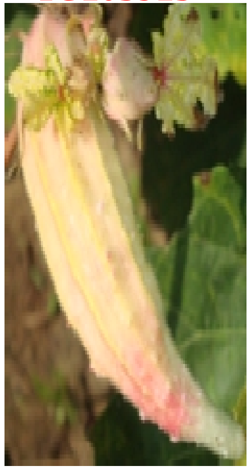

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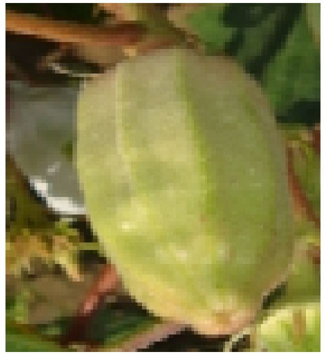

ABSTRACT

Title of the thesis	:	“Characterization of okra (*Abelmoschus esuleutus* (L) Moench) genotypes based on morphological and phenological traits”
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ABSTRACT

The present investigation "Characterization of okra genotypes based on morphological and phenological traits." was carried out during kharif season of 2010-2011 at the Vegetable Research Farm, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.). The experimental material for the present investigation was comprised of 65 genotypes of okra. These genotypes were sown in Augmented Randomized Block Design with three blocks, to observed morphological characterization and to estimate the genetic variability and association analysis (Correlation and Path coefficient). Observations were recorded on the basis of five random competitive plants selected from each genotypes separately for morphological, phenological, yield and other parameters were evaluated as per standard procedure. The variance components and coefficient of variation were determined according to Burton (1952). The heritability (broad sense) and genetic advance was worked out by Hanson et *et al*. (1956) and Johnson *et al*. (1955). correlation coefficient and path coefficient was computed by the formula suggested by Miller *et al*. (1958) and Dewey and Lu (1959).

Analysis of variance revealed highly significant variance for all the traits except for days to 50 percent flowering and days to maturity depicting greater variability in the existing material.

High heritability supplemented with high genetic advance as percentage of mean was manifested by plant height, seeds per fruit, fruit yield per plant, fruit weight, fruit per plant, fruit length, fruit diameter and branches per plant and these traits also expressed high PCV and GCV. suggested that they can be improved through direct selection.

The correlation and path coefficient analysis revealed that fruits per plant, fruit weight, seeds per fruit, were the most important characters contributing towards fruit yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of okra.

It is revealed from the data obtained, the most putative lines are as follows.

IC 058704

It is an early (48.5 days). The plant are dwarf (56.2cm) having 1-2 branches with short internodal length (8.5cm). The fruits are long (22.50cm), green, flat fruit surface, weak pubescence and narrow acute fruit shape. The average fruit weight is 42.0gm and 65.40 seed per fruit. This genotype exhibited higher fruit yield of 650.20gm/plant. It is resistant to yellow vein mosaic virus.

IC 117231

It is moderately tolerant to yellow vein mosaic virus. Its first picking may be taken in 47-48 days. The average fruit yield of 630.50gm/plant. Plants are medium tall with short internodes (7.2cm), producing 2-3 branches. Foliage and stem is green. Fruits are long green, flat fruit surface, weak pubescence and acute fruit shape. Fruits are 5 ridged, about 17.10cm long having well filled 51.2 seeds per fruit, weighing are around 40g each.

EC 169356

The plants are tall (120.6cm), 1-2 branches having short internodes (5.4cm) bearing 18-19 fruit each. Foliage and stem is green. Bearing starts in 50-51days after sowing from 5-6 nodes. Fruits are light green about 16.5cm long having 50.2 seeds per fruit, flat fruit surface, weak pubescence and acute fruit shape. Fruit weighing are around 39g each. It is moderately tolerant to yellow vein mosaic virus, the yield potential being 620.20gm/plant.

VITA

The author of this thesis **Pappu Singh Waskel** S/o Shri Galsingh Waskel and Smt. Kusum Bai Waskel was born on 8th August 1985 at Dhar (MP). He passed his higher secondary school certificate examination from Govt. Boys Higher Secondary School, Dharampuri, Dhar with 67.7% first division he joined the R.A.K., College of Agriculture, Sehore sub campus of Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) in the year 2005-06 and successfully completed the degree of B.Sc. (Ag.) during the year 2008-09 with 6.73 OGPA at 10 point scale.

For further study he got admission in M.Sc.(Horti.) specialization in Vegetable Science at College of Agriculture, JNKVV, Jabalpur where he successfully completed the entire course requirement for master's degree with 6.92 OGPA at 10 point scale.

For the partial fulfillment of the master's degree programme he was allotted a research problem on **"Characterization of okra (*Abelmoschus esculentus* (L.) Moench) genotypes based on morphological and phenological traits"** which was successfully conducted by him and being submitted in the form of this thesis.

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