PERFORMANCE OF OKRA GERMPLASM WITH SPECIAL REFERENCE TO YELLOW VEIN MOSAIC VIRUS

A THESIS

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"Performance of Okra germplasm with special reference to Yellow Vein Mosaic Virus".** Submitted to Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE embodies the result of a piece of bonafide research work carried out by Md. Humayun Kabir-E-Rasul, Roll No- 00777 under my supervision and guidance. No part of the thesis has been submitted for any other degree in any other institutes.

I further certify that any help or sources of information, received during the course of this investigation have been duly acknowledged.

Date:

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Dedicated To

My Beloved Parents

LIST OF ABBREVIATIONS

BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BBS	Bangladesh Bureau of Statistics
CM	Centimeter
DAS	Days after sowing
LSD	Least Significant Difference
MP	Muriate of Potash
TSP	Triple Super Phosphate
t/ha	Tonnes per hectare

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The Author

PERFORMANCE OF OKRA GERMPLASM WITH SPECIAL REFERENCE TO YELLOW VEIN MOSAIC VIRUS

ABSTRACT

The experiment was undertaken to study the performance of okra germplasm with special reference to yellow vein mosaic virus among 36 accessions at the Horticulture Farm Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the period from April 2007 to August 2007. There was a wide range of different parameters. The maximum (169.37 cm) plant height was observed from accession number 14 and the maximum spread of plant was found from accession number 138 (14.62) was recorded from accession number 219 and 114 respectively. At 80 DAS the plant performed the maximum (94.2) number of leaves was obtained from accession number 138. The maximum leaf breath (35.1 cm) was recorded from accession number 148. The minimum (36.39) and the maximum (68.08) days was required for days to first flowering were from accession number 144 and 114 respectively. The minimum (14.27%) plant was infested by virus at 75 DAS in accession number 139 compare to other accessions number. So, accession number 139 was identified as agronomically acceptable resistant line against okra yellow vein mosaic virus.

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Chapter 1

Introduction

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), a popular and nutritious vegetable crop belongs to Malvaceae family. The tender fleshy fruits are used as vegetable. The crop was originated in tropical Africa and then gradually distributed to the Mediterranean Sea area, East Asia and Indian Subcontinent (Purseglove, 1968). Chassiar (1984) also reported that South and South East Asian countries might be the origin of okra and now it is widely cultivated throughout the tropical and subtropical areas of the world.

The okra fruits are very rich in calcium, vitamin-E and starch. It contains appreciable amount of dry matter, protein, carbohydrate, fiber, carotene, thiamin, riboflavin, niacin, iron, etc. The okra fruits also contain iodine as one of the important compositions, which makes the crop more valuable in a country like Bangladesh where iodine deficiency exists as a problem. Other than fruits, okra leaves are also used as vegetable in many countries. In Turkey, fried seeds of okra are used as substitute of coffee. In India, the stem and roots of okra are used in the sugarcane juice to get clean molasses or sugar. Ripen dry fruits and the stems of plant are used as raw materials for making paper. The okra has also got versatile medicinal values (Rashid, 1999).

The cultivation of okra in terms of area has gradually been increasing in Bangladesh, although per hectare production is either remains static or gradually declining (BBS, 1999).The total production of okra was about 18600 tonnes in 6072 hectares of land with an average yield 3.06 t/ha in the year 1999-2000.The yield is very low (BBS, 2000) compared to that of other developing countries, where the yield is as high as 7-12 t/ha (Yamaguchi, 1998). Even in Bangladesh, Ali (1999) reported the yield potential of okra is 20 to 30 tons/hectare from IPSA-1 variety.

The yield and quality of okra depend on several factors like diseases, insects, soil and climatic conditions. The crop is affected by fungal, bacteria, viral and nemic diseases. Among them, the okra yellow vein mosaic virus (YVMV) is the most destructive viral disease (Sastry and Singh, 1974; Mukhopadhyay *et al.*, 1986) which may cause more than 90% yield loss (Akanda, 1991).

Okra yellow vein mosaic virus has been considered as the most important factor of yield reduction in okra in India and some other okra growing countries (Harendar *et al.* 1993, Nath and Saikia 1993, Sastry and Singh 1975 and Sinha and Chakrabarti 1978). The virus seems to attack okra plants in any stages of growth, spreads quickly in the field and adversely affects the growth and yield contributing characters due to remarkable alteration in cellular components of the infected plants (Hossain *et al.* 1998, Sarma *et al.* 1993). Okra yellow vein mosaic virus proved to be a severe problem in Bangladesh which alone makes the okra cultivation non-profitable as reported by Akanda (1991) and Ali (1999). The systematic work on Okra yellow vein mosaic virus has little been done in Bangladesh. Some sporadic work has been reported to find resistant variety or control measures (Ali 1999, Ali *et al.* 2000 and Rashid *et al.* 1999). Most of the research so far conducted in Bangladesh was disease survey which listed the name of the disease observing the field symptoms, screening the varieties against the disease under natural conditions (Akanda, 1991 and Akanda *et al.*, 1991).

Considering the above facts the research programme was designed with the following objectives

- To assess the performance of okra accession for yield and yield contributing characters;
- To identify agronomically acceptable resistant lines against okra YVMV for varietal release.

Chapter 2

Review of Literature

REVIEW OF LITERATURE

Okra is an important vegetable grown round the year in Bangladesh. Though it is a most common crop, limited attempt has been made for genetic improvement. An understanding of the nature and magnitude of the variability among the genetic stocks is of prime importance to the researchers. A good knowledge of genetic wealth might also help identifying desirable cultivars for commercial cultivation. A good number of work relating to its variability aspects has been done in different parts of the world. Unfortunately, enough published work with respect to variability of okra in Bangladesh is not available. Some of the available research work in relevant to the present study has been reviewed in this chapter.

2.1 Variability of yield contributing characters

A logical way to start any crop breeding programme is to survey the genetic variation of plant characters in available germplasm materials. Different workers studied plant characters in a wide range of environmental condition.

Dash and Mishra (1995) studied variability of 27 okra genotypes. Genotypic, phenotypic, and environmental coefficient were determined. Pod length, pod diameter, number of primary branches, number of pod per plant and earliness were considered as useful indices for selection for higher yield.

Mishra *et al.* (1990) reported a wide range of variation in plant height, pod length, pod diameter, individual pod weight, number of pod per plant, weight of pod per plant, number of ridges per pod, dry matter content of pod and yield in okra varieties which they studied.

Hussein *et al.* (1994) evaluated six local ecotypes and six exotic cultivars of okra *(Abelmoschus esculentus)* for four yield components. Significant difference was observed among the accessions for the measured traits. The highest yielding ecotype was Balady Green and the highest yielding cultivar was Clemon Spineless.

Singh *et al.* (1998) conducted an experiment with three genotypes of okra viz. Parbhani Kranti, Hisar Unnat and Satdhar. Variability, heritability, genetic advance, correlation and coheritabiiity were studied for eleven characters in a field experiment in Varanasi, Uttar Pradesh, India. The highest genotypic coefficient of variation and phenotypic coefficient of variation were observed for number of fruits per plant, yield per plant, spread of plant and plant height. The variability and genetic advances were observed for yield per plant, plant height, number of seeds per fruit, number of fruits per plant, fruit length and girth and plant height.

In India, twenty two okra cultivars from West Bengal were evaluated during summer season to study the genetic variability of different character. There were wide ranges of variation in plant height, leaves per plant, nodes per plant, days to first flowering, fruit weight, fruits per plant, seed per fruit, fruit yield per plant; moderate variations in primary branches per plant and fruit length and lesser variations of node at first flower, ridges per fruit and dry weight of fruit (Hazra and Basu, 2000)

An experiment was conducted by Sonia (1999) in the mid hills of Himachal Pradesh. India, during kharif season. Forty eight diverse okra genotypes were sown in rows at 20 cm apart. Marketable fruit yield per plant varied from 154-467g 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 followed by Perfect Long Green, LC-26, LC-11, and LC-16. Days to 50% 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 pods.

Panda and Singh (1997) carried out an experiment using 40 F1 progenies of Okra *(Abelmoschus esculentus)* at Varanasi under *2* sowing dates (25 February, 1994 and 10 July, 1994). They stated that number of branches, number of pods and total pod yield per plant had higher genotypic and phenotypic coefficients of variation in both environments. All the characters under study except days to first flower appearance and girth of pod were highly heritable.

Patil *et al.* (1996) studied 11 characters in 171 okra genotypes grown at Dharawad, India during rabi season of 1990 and kharif season 1991. They observed considerable seasonal differences for number of pods per plant, weight of good pods per plant, number of borer infested pods per plant. They also reported that plant height, number of pod and weight of pod per plant were effective in selection of okra for higher yield.

Sood *et al. (*1995) estimated phenotypic and genotypic coefficients of variability and genetic advances along with correlations between all combinations of 12 characters of okra. Ridges per pod had high genotypic and phenotypic coefficient of variation for the node at which the first fruit set, plant height and number of leaves per plant had occured. Nodes per plant, duration of availability of edible pods, plant height and pod length had positive and strong correlations with yield.

Chandra *et al.* (1996) estimated variability, heritability, in 10 genotypes of okra for ten characters. The highest genotypic and phenotypic coefficients of variations were observed for pod yield, number of pod, plant height, and number of branches per plant. High heritability and genetic advances were observed for pod yield, plant height, and number of seeds per pod. Plant height and length of pod showed maximum positive correlation among themselves. Pod number, plant height and length of pod showed maximum positive direct effect on pod yield.

Twenty eight okra genotypes were grown during the rainy season of 1991-1992 and data were recorded on plant height, days to maturity, fruit length, fruit girth and yield per plant by Mishra *et al.* (1990). They reported that variability was highest for plant height by fruit girth and yield per plant.

A survey of aubergine and okra *(Abelmoschus esculentus) was* undertaken by NBPGR under an IBPGR supported project by Verma (1993). Accessions collected included 183 of aubergine, 17 okra and several local landraces. Okra accessions also showed much variability for morphological characters (plant height 60-250 cm and fruit length 5-25 cm).

Rath *et al.* (1991) carried out an experiment on 12 cultivars of okra during 1986 for 10 yield components .They found highly significant differences between cultivars for all characters. Heritability estimates ranged from 99.7% for number of seeds per pod to 69.7% for number of branches per plant.

Kuwada (1964) grouped 29 varieties of okra into 3 or 4 groups according to plant height, number of nodes, onset of flowering, stem diameter, colour, and number of ribs of the pod and the number of seeds per pod. Variation was visible for which it was found possible to group the varieties into 3 or 4 classes.

Kuwada (1964) studied twenty one okra and one variety of *Abelmoschus moschata.* He observed considerable differences in plant height and number of nodes among the varieties and grouped them into 5 and 4 classes, respectively. The onset of flowering, stem colour and diameter, petal colour and leaf shape showed some variation. The pods were similar in all varieties, the late flowering varieties, however, bore very few.

Sannigrani and Choudhury (1998) conducted an experiment at Tezpur, Assam, India during the kharif season of 1991 and 1992 on 7 okra cultivars (Arka Abhay, Arka Anamika, BD-1, BD-2, Prabhani, Kranti, Punjab 7 and Pusa Swani). These cultivars were evaluated for growth and yield characteristics. All cultivars differed significantly for all characters. Arka Anamika and Aarka Abhay were the most suitable okra cultivars for commercial cultivation in Assam, compared with Pusa Sawani.

Shridhar (1995) observed significant difference among seven varieties for most of the traits studies and Pusa Swani were found to produce the greatest number of fruits per plant (10.5) and had the highest pooled yield(17.8 t/ha).

Gondane and Bhatia (1995) studied variability of 50 okra genotypes. They found all the genotypes responded differently to the

environments. Significant and marked variation was noted in the yield components, particularly the plant height, plant spread, number of nodes per plant, number of leaf per plant, leaf length and breadth, petiole length, pod per plant, nodes to first pod and yield.

Gill *et al.* (1997) conducted an experiment to develop a key for varietal identification on the basis of morphological characters of 10 okra varieties. Considerable variation with respect to vegetative, floral and fruit characters was observed and few distinguishing characters were identified in each variety.

Perdosa *et al.* (1983) observed wide variation among 100 okra introductions at University of Viscosa, Brasilia. Days from sowing to the end of the juvenile period varied from 43 to 63 days to first anthesis from 52 to 85 and for the cultural cycle from 131 to 227. Plant height at the end of the cultural cycle varied from 73 to 240 cm. Percentage of fruit set varied from 57% to 92.9%. Fruit length varied from 12 to 28 cm, fruit diameter from 1.9 to 2.6 cm and mean number of seeds per fruit from 54 to 130. The weight of 1000 number of seeds varied from 5.53 to 7.43 g,

Martin and Rhodes (1983) studied variability of 95 accessions of and *Abelmoschus esculentus* and *Abelmoschus tetraphylous*. They found significant differences among the accession for all the characters studied viz. plant height, plant spread, number of primary branches per plant, days to flowering, nodes where the first flower appear, number of leaf per plant, leaf length, leaf breadth, petiole length, number of pod per plant, pod weight and total yield. Variability was greatest for pod **weight** .

Lotilo (1989) studied variability in okra and reported that the phenotypic co-efficient of variation (PCV) was higher than the

genotypic coefficient of variation (GCV). The differences between the GCV and PCV suggested the presence of a dominating environmental influence on genetic expression for pod length and yield per plant.

Damarany and Farag (1994) conducted an experiment at Assiut during the summer seasons of 1991 and 1992 to study the performance of 13 cultivars of okra *(Abelmoschus esculentus).*They found Blondy as the earliest flowering cultivar (46.9 and 44.2 days respectively) and produced the most pods per plant and the highest total yield of pods. The shortest cultivar was Dwarf Long Pod Green and the tallest Balady, Aswan. They also observed that the coefficient of variation for parameters studied was generally low.

Farghali *et al.* (1994) investigated the fruit development of the twelve genotypes of okra over 2 successive seasons. The cultivars with the longest fruits was Clemson Spineless, while Balady Cairo and Balady Green had the shortest fruit, Balady Red had the longest fruit diameter and Green Spineless the smallest.

Kolhe and Chavan (1967) reported that fruit length, thickness, weight, specific gravity and dry matter were varietal characters in okra. For a maximum yield of edible pods it was recommended that Pusa Sawani be picked on the 7^{th} or 8^{lh} day after fruit set. Under Poona condition, the variety Pusa Sawani yielded 13.14 t/ha. The number of fruits was reduced to one-third when pods were allowed to mature from beginning to one-half when they were allowed to mature after the first 3 weeks of picking. Plant height was also proportionately reduced.

2.2 Characteristics of Okra YVMV

Symptoms

The common symptoms of Okra yellow mosaic virus (OYVMV) are vein clearing ,vein chlorosis and yellowing having mosaic noted by the researchers who worked on the virus at the beginning (Handa, 1991).They also included dwarfing of the infected plants which produced distorted small sized fruits .

Fernando and Udurwana (1942) observed the development of vein banding along with vein clearing , chlorosis and stunting due to a virus disease of okra in Srilanka and they named the virus as Okra yellow vein banding virus . The severe stunting of OYVMV infected plant was reported by Sastry and Singh (1975). The infected plants produced few leaves and fruits as they described.

Capoor and Verma 1950 also studied symptomatology and host range and noted that the first visible symptom is small vein clearing due to *Yellow vein mosaic virus* infection which gradually extends to other veins and finally turns to vein chlorosis ,vein banding and profuse vein-swellings on the other sides of the leaves. The veins of the leaves of infected plants are thick, brittle, dark green and curled downward. The infected plants produced pale colored hard and fibrous fruits.

Impact of YVMV on growth and yield of okra

Nariani and Seth (1958) provided the information from their experiments that the disease caused by *Yellow vein mosaic virus* of Okra inflicts significant reduction in the fruit yield and also impairs the fruit quality.

Investigation was carried out by Sastry and Singh (1975) to find out the effect of *Yellow vein mosaic virus* on the growth and yield of okra at different stages of plant growth. The results revealed that the infected plants became very much stunted and produced very few leaves and fruits when the infection occurred within 35 days following germination. As high as 93.80% yield reduction on an average was observed when the plants were infected within 35 days following germination. The yield reduction estimated as 83.63% and 49.63% in the plants infected within 50 and 60 days following germination respectively. They concluded that the yield loss of okra depends upon the time of infection.

Chelliah and Murugesan (1976a) evaluated the seasonal incidence by conducting year round experiment. The results suggested that there was a significant increase of *Yellow vein mosaic virus* in *Abelmoschus esculentus* in March to May comparing to the rest of the years.

In another experiment, Chelliah and Murugesan (1976b) observed that the number of fruits harvested per plant which developed symptoms at 30, 45 or 60 days after sowing were 4, 7 and 8, respectively, with 16 for healthy plants. The corresponding yields were 27.62, 94 and 222 g/per plant, respectively.

Sinha and Chakrabarti (1978) evaluated the adverse effects of *Yellow vein mosaic virus* infection on okra seed production and reported that the highest seed yield loss was 86.13% in the plants, in which symptoms appeared at 33 days after sowing and which was decreased to 32,85% in plants, in which symptoms appeared 75 days after sowing. They also suggested that *Yellow vein mosaic virus* infection could not affect the germinability of okra seeds obtained from infected plants.

Atiri (1990) observed the relationships between growth stages, leaf curl symptom development and fruit yield in okra and found the effect of growth stage at which leaf-curl virus disease symptoms developed on fruit yield of some okra *(Abelmoschus esculentus)* lines. Symptoms developed before flowering and symptoms appeared during flowering, the number, size and weight of fruits were significantly lower in diseased than in healthy plants. The lines in which symptoms appeared only after the commencement of fruiting, the disease did not significantly reduce fruit yield. It is concluded that expensive control measures against the disease or its vector (*Bemisia tabaci*) may be unnecessary for the last group and that this trait may be bred as commercial cultivars.

Sharma *et al.* (1993) evaluated eight varieties of okra for their comparative resistance to okra (bhendi) *Yellow vein mosaic bigeminivinis* and marketable yield over a period of 4 year from 1986 to 1989, Punjab Padmini and Punjab-7 were high yielding cultivars that were resistant to the virus. A mutant EMS-8 and the high yielding variety Parbhani Kranti were also resistant to the virus. Pusa Sawani and Pusa Makhmali were highly susceptible to the virus and were low yielding cultivars.

A field experiment was conducted by Mazumder *et al.* (1999) for consecutive two years (1992 and 1993) on the incidence of Pusa Sawani, Parbhani Kranti and M-31 Lower disease incidence and whitefly populations were released in crop sown between February 25 and March 20 compared with sowing dates of April 15 to July 25. The number of whiteflies was lower on Parbhani Kranti and M-31 than on Pusa Sawani. The total yield and marketable yield were maximum in early sown crop rather than crop sown after 15 April and number of unmarketable okras increased with delayed sowing. Simple correlation studies revealed a positive significant association between disease incidence and whitefly

population, temperature, relative humidity (evening), rainfall and number of rainy days. Marketable fruit yield of okra was negatively correlated with disease incidence and a positive correlation between disease incidence and unmarketable fruit yield was obtained

Bhagat (2000) worked on the effect of *Bhindi yellow vein mosaic virus* (BYVMV) on growth and yield of bhindi. He cultivated 3 okra cultivars, Parbhani Kranti, Vaishali Vadhu and Pusa Sawani in field plots to find out the BYVMV infection on the growth and yield of okra. A quantitative assessment of plant height, number of leaves, fruit/plant, fruit length, fruit girth, fruit weight and fruit weight/plant revealed that the yield and other growth parameters were less affected in the resistant cultivar Parbhani Kranti in comparison to Vaishali Vadhu (susceptible) and Pusa Sawani (highly susceptible) cultivars.

Singh and Singh (1986) studied the varietal resistance in okra to yellow vein mosaic virus under field condition sowing 27 *Abelmoschus esculentus* varieties in the field over two seasons. Kbs 312 were more resistant to yellow vein mosaic virus with 3.3% infection in Kharif 1983 and none in summer 1994 . KS 322, KS 323 and AS 12 also have shown low infection percentages.

Chapter 3
Materials and Methods

MATERIALS AND METHODS

In this chapter, a short description of location of the experimental plot, climatic conditions of the area where the plot was situated, materials used for the experiment, treatments, design of the experiment and method of cultivation, data collection and statistical analysis have been presented.

3.1 Location of the experimental plot

The field experiment was carried out at the Horticultural farm of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh during the month of April 2007 to August 2007. The location of the site is at 24.00^{0}N Latitude and 90.25^{0}E Longitude at an elevation of 8.4 meters from the sea level (Anon., 1995).

3.2 Climate and Soil

The experimental site was situated on the sub-tropical climatic zone and characterized by heavy rainfall during the months of May to August and scanty rainfall during rest of the year. The average minimum and maximum temperature during the crop period was 24.35^{0}C and 34.03^{0}C respectively. The mean minimum and maximum relative humidity was 77.58% and 91.65% respectively. The weather data (air temperature and humidity) during the study period are presented in Appendix 1. The soil of the experimental field was sandy clay loam in texture having a pH around 6.0. The soil belongs to the Chita soil series of red brown terrace (Anon., 1988; Brammer, 1971 and Shaheed, 1984). The soil for vegetable research was later developed purposely by riverbed silt.

3.3 Planting materials used for the experiment

Thirty six okra accessions were included in this study. Those were collected from Gene bank of BARI and different parts of Bangladesh. Accessions were chosen primarily to represent the commercial types of okra grown in the country.

3.4 Experimental treatments

The experiment was conducted to evaluate the performance of 36 accessions of okra. The okra accessions were considered as the treatments of the experiment. The sources of the 36 okra accessions are summarized in Table 1.

Table 1. Accession number and sources of 36 okra accessions

Treatment	Accession No.	Source	Treatment	Accession No.	Source
T_1	Accession=1	Gene Bank	T_{19}	Accession=139	United Seed
T_2	Accession=2	Gene Bank	T_{20}	Accession=140	United Seed
T_3	Accession=3	Gene Bank	T_{21}	Accession=143	Sungro Seed
T_4	Accession=5	Gene Bank	T_{22}	Accession=148	Mollik Seed
T_5	Accession=13	Gene Bank	T_{23}	Accession=151	Shawon Seed
T_6	Accession=14	Gene Bank	T_{24}	Accession=153	Mollik Seed
T_7	Accession=17	Gene Bank	T_{25}	Accession=194	Jamalpur
T_8	Accession=23	Gene Bank	T_{26}	Accession=199	Jamalpur
T_9	Accession=24	Gene Bank	T_{27}	Accession=212	Jamalpur
T_{10}	Accession=36	Gene Bank	T_{28}	Accession=215	Jamalpur
T_{11}	Accession=38	Gene Bank	T_{29}	Accession=219	Jamalpur
T_{12}	Accession=43	Gene Bank	T_{30}	Accession=292	Jamalpur
T_{13}	Accession=49	Gene Bank	T_{31}	Accession=157	Jamalpur
T_{14}	Accession=61	Gene Bank	T_{32}	Accession=155	Jamalpur
T_{15}	Accession=83	Gene Bank	T_{33}	Accession=144	Jamalpur
T_{16}	Accession=90	Gene Bank	T_{34}	Accession=136	Jamalpur
T_{17}	Accession=114	Gene Bank	T_{35}	Accession=247	Jamalpur
T_{18}	Accession=138	East West Seed	T_{36}	Accession=253	Jamalpur

3.5 Design and layout of the experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. One accession represented one treatment and five plants in an accession represented one replication. The distance

between replication to replication was 1m.

3.6 Land preparation

The selected land for the experiment was first opened on 5 April 2007 by disc plough. After opening the land with a tractor it was ploughed and cross-ploughed six times with a power tiller and each ploughing was followed by laddering to break the clods to obtain good tilth and to level the land. All weeds and stubbles and dead roots were removed. After final land preparation, the experimental plot was laid out.

3.7 Manure and fertilizer application

The following doses of manure and fertilizers were applied to the plots for okra cultivation (Anon., 1998).

Table 2. Doses of manure and fertilizers used in the present study

Manures/Fertilizer	Doses
Cow dung	14 ton/ha
TSP	150 kg/ha
MP	150kg/ha
Urea	150 kg/ha

The entire amount of cow dung, TSP and MP @ 100 kg/ha were applied at the time of final land preparation. The remaining TSP and MP were applied after 30 days of seed sowing. Urea was applied in three equal installments at 30, 45 and 60 days after sowing.

3.8 Sowing of seeds

The okra seeds of different accessions were sown on 23 April 2007 in rows of raised beds. Row to row and plant to plant spacing were maintained at 60 cm

and 50cm, respectively and 2-3 seeds were placed in each hill. Then the seeds were covered with fine soil.

3.9 Intercultural operation

The seedlings were always kept under careful observation. Necessary intercultural operations were done through the cropping season for proper growth and development of the plant from five to six days after germination, only one healthy seedling was kept to grow in each hill and other seedlings were removed.

3.9.1 Thinning and gap filling

The seedlings were thinned out from the hill at 10 DAS keeping only one healthy seedling per hill. On the contrary, gap filling was done where needed with healthy seedling.

3.9.2 Irrigation

The plot was irrigated as and when needed.

3.9.3 Weeding and mulching

Weeding and mulching were necessary to keep the plots free from weeds for ease aeration and to conserve soil moisture. Total five weedings were done lo keep the plots free from weeds.

3.10 Harvesting

Green pods were harvested regularly when they attained edible stage. Harvesting was started from 2 June 2007 (after 42 days of seed sowing) and was continued up to 23 July 2007(after 52 days of first harvest).

3.11 Data collection

Data on the following parameters were recorded from 5 randomly selected plants as representative of an accession.

A. Plant characteristics

i) Height of Plant

The height of a plant was measured in centimeter (cm) from the ground level to the tip of the growing point with a meter scale at first and last harvest.

ii) Number of primary branches per plant

During the last green pod harvest, number of branches per plant of selected plants from each accession was recorded.

iii) Spread of plant

The spread of the plant was measured by placing scale in the largest direction upon the plant and it was expressed in centimeter (cm).

B. Leaf characteristics

i) Number of leaves per plant

The number of leaves was counted at 80 DAS from randomly selected 5 plants .

ii) Length of leaf

The length of leaves was measured by a measuring scale from leaf base to the tip and was expressed in centimeter (cm).

iii) Breadth of leaf

The breadth of leaves was measured by a measuring tape and expressed in centimeter (cm).

iv) Length of petiole

The length of petioles was measured with the help of a scale in centimeter (cm) at 80 DAS from the selected plants.

v) **Shape of leaf**

Five leaves were selected randomly from each of the five plants of each accession. The shape of the leaves was recorded by visual observation. The shapes of the leaves were classified into palmatifid, palmatipartite and palmatisect.

vi) Color of leaf

The color of the leaves was determined by comparing with a color chart and recorded either as light green, green, or deep green.

C. Flower characteristics

i) Days to first flowering

Different dates of first flowering were recorded. The observation was made from the date of seed sowing. It was considered when the first flower opens.

ii) Number of node at which first flower appeared

The number of nodes at which first flower appeared was recorded by counting the 5 individual plants.

D. Pod characteristics

i) Length of green pod

Five randomly selected green pods from selected plants of each accession were taken and length was measured at harvest from the selected pod with the help of a measuring tape in centimeter (cm).

ii) Diameter of green pod

Diameter of 5 randomly selected green pods from selected plants of each accession was measured with the help of slide calipers in centimeter (cm).

iii) Weight of individual green pod

Weight of 5 randomly selected green pods at edible stage from each accession was measured in gram (g) and means were calculated.

iv) Number of green pods per plant

The number of green pods was recorded from 5 selected plants and their mean was taken.

v) **Weight of green pods per plant**

Mean weight of edible green pods of selected plants from each accession was weighed in gram (g).

vi) Yield of green pod (t/ha)

Yield of green pod (t/ha) was calculated by converting the mean green pod weight per row into yield per plot.

3.12 Statistical analysis

Collected data on yield and yield contributing characters under study were statistically analyzed to find out the significance of difference among treatment means. The means for all the treatments were calculated and analyses of variance for most of the characters under consideration were performed by F variance test. The significance of difference between pairs of means were evaluated by least significant difference test (LSD) (Gomez and Gomez, 1984)

3.12.1 Analysis of variance

The analyses of variances for most of the characters under consideration were performed by F variance test. The significance of the difference between treatments means was evaluated by least significance difference (LSD) test for the interpretation of the results (Gomez and Gomez, 1984)

Chapter 4
Results and Discussion

RESULTS & DISCUSSION

The present study was conducted during the period from 5April 2007 to 23 July 2007 to investigate the performance of 36 accession of okra. The variability among the accession and direct and indirect effect of pod producing traits were estimated. A summary of the analyses of variances of characters studied with their sources of variation and corresponding degrees of freedom have been shown in Appendix II. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Plant Characteristics

The plant characteristics like height of plant, number of branches/plant, spread of plant and stem color were recorded and shown in fig 1 to 3 and Table 1to 8.

4.1.1 Height of Plant

The height of plant in this experiment varied significantly among the accessions (Appendix II). The tallest plant at 90 DAS was found in accession number 14 (169.37cm) which was closely followed by accession number 144 (168.23cm) while the shortest plant was recorded in accession number 24 (Table 3). The results obtained were related with the findings of Gondane and Bhatia (1995), Perdosa *et al.* (1983) and Martin and Rhodes (1983).

4.1.2 Number of branches per plant

Significant variation was found in respect of number of branches per plant among the accessions (Appendix II). The number of branches per plant ranged from 2.2-14.62 with the mean value of 4.93. The accession

114 had the highest number of branches per plant (14.62) followed by accession number 212 and 36 (7.31 and 7.11, respectively) while accession number 155 had the least number of branches per plant (2.2), which was statistically similar with the accession 157,144 and 83 (Table 3). This is in conformity with the findings of Dash and Mishra (1995) who observed significant differences in number of branches per plant among 27 okra cultivars.

4.1.3 Spread of plant

Spread of plants varied significantly (Appendix II) and ranged from 34-68 cm with the mean value of 5 cm as shown in Table 4. The highest spread of plant was found in accession number 138 (68 cm) followed by accession number 194 and 292 (63 cm and 63 cm respectively) whereas, the lowest spread of plant was observed in accession number 144 (34 cm) which was statistically similar with the accession 83 and 13 (Table 3). The result agreed with the findings of Gondane and Bhatia (1995) and Martin and Rhodes (1983) who observed considerable variation in case of spread of plant in Okra.

4.1.4 Color of stem

Accessions were separated into 3 groups on the basis of their difference of colour of stem. There were green, green with red patches and purple. The green stems colour were found in accessions 1, 2, 3, 5, 13, 14, 17, 23, 24, 36, 38, 49, 61, 83, 138, 139, 140, 143, 148, 151, 153, 194, 212, 215, 219, 292, 157, 144, 247 and 253. Green with red patches stem colour were found in accession 43, 90, 114 and 199. Purple stem colour was observed in accession 155 and 136 (Table 8). This result was supported by Kuwada (1964) who observed variation in colour of stem in 29 okra varieties.

Table 3. Plant characteristics in respect of plant height and number of branches per plant of 36 accession of okra

Treatment	Plant height at		Plant spread (cm)	No. of branches/ Plant
	1st harvest (cm)	Last harvest (cm)		
T_1(A1)	87.1	148.5	49	3.2
T_2(A2)	79.5	108.5	46	4.3
T_3(A3)	83.5	139.17	56	6.81
T_4(A5)	68.4	89.43	47	6.51
T_5(A13)	69.1	107.43	37	6.81
T_6(A14)	96.17	**169.37**	44	3.3
T_7(A17)	91.5	140.13	38	4.61
T_8(A23)	67.1	100.1	49	5.61
T_9(A24)	45.5	**69.43**	56	4.81
T_{10}(A36)	52.13	78.6	4	7.11
T_{11}(A38)	58.24	92.67	55	5.31
T_{12}(A43)	61.72	80.2	42	5.11
T_{13}(A49)	70.1	120.2	55	5.41
T_{14}(A61)	58.2	78.1	49	6.21
T_{15}(A83)	50.3	87.5	35	2.66
T_{16}(A90)	90.3	139.7	54	4.1
T_{17}(A114)	50.2	76.1	51	**14.62**
T_{18}(A138)	120.1	149.2	**68**	4.51
T_{19}(A139)	102.7	140.3	57	4.2
T_{20}(A140)	100.1	111.1	43	5.21
T_{21}(A143)	99.17	160.17	56	4.41
T_{22}(A148)	116.1	158.7	53	3.71
T_{23}(A151)	100.6	130.1	58	5.31
T_{24}(A153)	81.1	125.17	39	6.11
T_{25}(A194)	96.17	118.6	63	3.6
T_{26}(A199)	105.17	156.7	42	3.91
T_{27}(A212)	99.33	147.17	54	7.31
T_{28}(A215)	49.6	167.17	52	4.51
T_{29}(A219)	94.27	78.1	53	5.61
T_{30}(A292)	97.22	121.2	63	4.41
T_{31}(A157)	88.5	139.2	56	2.6
T_{32}(A155)	94.65	155.2	48	**2.2**
T_{33}(A144)	106.2	168.23	**34**	2.8
T_{34}(A136)	83.6	155.2	55	3.81
T_{35}(A247)	86.22	165.17	42	3.2
T_{36}(A253)	81.3	140.2	39	3.5
MEAN	82.81	125.33	5	4.93
Max	120.1	169.37	68	14.62
Min	45.5	69.43	34	2.2
LSD	0.21	0.19	0	0.05
CV%	0.16	0.09	59	0.56

4.2 Leaf characteristics

The leaf characteristics like number of leaf per plant at 80 DAS, length of leaf, breadth of leaf, length of petiole, shape of leaf and color of leaf were recorded and shown in Table 4 and Table 7 respectively.

4.2.1 Number of leaf per plant

Significant variation in respect of number of leaf per plant among the accessions was found (Appendix II). The maximum number of leaves per plant was produced by the accession number 138 (94.2) at 80 DAS. It was followed by the accession number 3 (87.2) and 212 (86.2) at 80 DAS. The minimum number of leaves per plant was recorded in accession number 83 (29.75) at 80 DAS, which was followed by the accession number 114 and 194 (Table 4). These results were in full conformity with Gondane and Bhatia (1995) and Martin and Rhodes (1983) who found significant differences for the number of leaves per plant in okra.

4.2.2 Length of leaf

As regards length of leaf, it was observed that it varied significantly (Appendix II) and ranged from 18.7 cm to 26.7 cm with the mean value of 22.18 cm. The longest length of leaf 26.7 cm was found from accession 138 and 139 which was followed by accession numbers 140, 144 and 153 (25.6, 25.7 and 26.4 cm, respectively). The shortest length of leaf was found in accession 157 (18.7 cm) (Table 4). These results agreed with the findings of Gondane and Bhatia (1995).

Table 4. Leaf characteristics in respect of length of leaf, breadth of leaf, length of petiole, shape of leaf and color of leaf of 36 accessions of okra

Treatment	Length of leaf (cm)	Breadth of leaf (cm)	Length of petiole (cm)	No. of Leaf per plant at 80 DAS
T_1(A1)	23.77	27.2	29.8	60
T_2(A2)	24.5	28.8	32.4	67.6
T_3(A3)	22.7	27.4	29.8	87.2
T_4(A5)	21.1	23.6	27.4	60.2
T_5(A13)	21.1	27.7	30.67	78.6
T_6(A14)	18.8	26.7	30.4	69.6
T_7(A17)	18.8	28.2	33	73.2
T_8(A23)	20.8	24.5	29.8	64.3
T_9(A24)	19.6	24.6	29.2	80.25
T_{10}(A36)	23.7	27.1	29.4	74.25
T_{11}(A38)	19.7	25.77	30.2	61
T_{12}(A43)	21.7	25.3	28.6	66.4
T_{13}(A49)	21.7	29.7	31.6	70
T_{14}(A61)	23.3	26.57	30.5	76.8
T_{15}(A83)	20.3	26.1	28.8	**29.75**
T_{16}(A90)	18.8	24.8	34.8	70.1
T_{17}(A114)	23.7	31.7	30.2	44
T_{18}(A138)	**26.7**	30.03	34.7	**94.2**
T_{19}(A139)	**26.7**	32.2	36.7	81.6
T_{20}(A140)	25.6	28.23	31.6	80.4
T_{21}(A143)	22.3	26.1	38	79
T_{22}(A148)	25.1	**35.1**	36.1	83
T_{23}(A151)	20.1	**23.2**	28.6	77.8
T_{24}(A153)	26.4	30.2	36.1	94
T_{25}(A194)	21.6	26.2	30.2	56.4
T_{26}(A199)	22.8	24.6	29.1	66
T_{27}(A212)	20.6	27.5	30.8	86.2
T_{28}(A215)	21.8	28.1	33.8	72.8
T_{29}(A219)	22.8	28.27	**48**	64
T_{30}(A292)	23.6	30.7	33	64
T_{31}(A157)	**18.7**	30.7	30.5	77.8
T_{32}(A155)	22.2	26.6	39.2	66.2
T_{33}(A144)	25.7	26.8	31.5	81.8
T_{34}(A136)	21.7	29.53	31.6	73.75
T_{35}(A247)	18.8	24.6	34	61
T_{36}(A253)	21.1	23.6	**27.3**	71
MEAN	22.18	27.44	32.15	71.23
Max	26.7	35.1	48	94.2
Min	18.7	23.2	27.3	29.75
LSD	0.14	0.38	0.25	0.18
CV%	0.4	0.84	0.47	0.15

4.2.3 Breadth of leaf

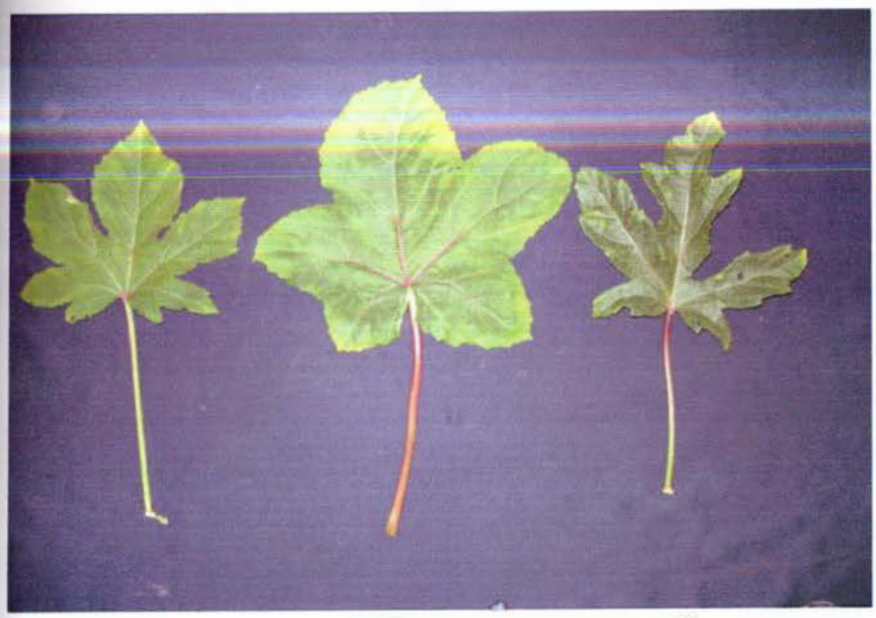
It was revealed that breadth of leaf ranged from 23.2 to 35.1 cm (Appendix II) with the mean value of 27.44 cm among the accessions. The plants of accession number 148 showed the highest breadth of leaf (35.1 cm), which was followed by accession number 157, 292 and 114 (30.7, 30.7 and 31.7 cm respectively). The lowest breadth of leaf (23.2 cm) was observed in accession number 151 which was statistically similar to the accession number 5 and 253 (Table 4). There results agreed with the findings of Martin and Rhodes (1983).

4.2.4 Length of petiole

The results on length of petiole of leaves varied significantly (Appendix II) and ranged from 27.3 cm to 48 cm with the mean value of 32.15 cm. The longest length of petiole was found from accession number 219 (48 cm) which was followed by accession number 139 and 155 (36.7 and 39.2 cm, respectively). The lowest length of petiole (27.3cm) was observed in accession number 253 (Table 4). Gondane and Bhatia (1995) and Hazra and Basu (2000) reported similar trends of result in respect of length of petiole.

4.2.5 Shape of leaf

From Table 7, it was found that the leaves of accession number 1, 5, 61, 90, 138, 215, 136 and 247 were palmatisect and the accession no. 2, 3, 13, 14, 17, 23, 24, 36, 43, 83, 114, 140, 151, 153, 219, 155, 144 and 253 were palmatifid shaped. Rest of the accessions had palmatipartite leaves. The shapes of the leaves have been shown in plate 1. Kuwada (1964) observed similar shape of leaf in okra.



A=Palmatisect
B=Palmatifid
C=Palmatipartite

A B C

Plate 1. **Photograph showing different shape of leaves among the studied accessions of okra**

4.2.6 Colour of leaf

Accessions were separated into 3 groups on the basis of their color of leaf. There were light green, green and deep green. The deep green leaves were found in accession 13, 24, 138, 140, 143, 199, 212 and 155. Light green leaves were observed in accession 2, 3, 5, 23, 36, 38, 49, 83, 90, 114, 151, 219, 292, 136 and 247. Green leaves were observed in accession 1, 14, 17, 43, 61, 139, 148, 153, 194, 215, 157, 144 and 253 (Table 8) This result was supported by Kuwada (1964) who observed color of leaf in 29 okra varieties.

4.3 Flower characteristics

The flower characteristics like days to first flowering and number of node at which first flower appeared were recorded (Table 5).

4.3.1 Days to first flowering

It was revealed from the results that the days to first flower varied significantly among the accessions (Appendix II) and ranged from 36.39 to 68.80 with the mean value 43.91 days. The plant of accession number 144 showed the minimum days to reach first flowering (36.39) which was statistically similar with the accession 1,14,139,157 and 155 (Table 5). The plant of accession number 114 took the maximum days to first flowering (68.08) followed by accession number 5, 24, 61 and 151 (54.88, 49.98, 49.59 and 49.28, respectively). The days to first flowering as obtained in this study agreed with the findings of Singh *et al.* (1998) and Damarany and Farag (1994).

4.3.2 Number of node at which first flower appeared

Number of node at which the first flower appeared varied significantly among the accessions (Appendix II) and ranged from 5.09 to 11.59 with the mean value of 7.59. The accession number 114 and 157 had the minimum number of nodes (5.09) at which first flower appeared which was statistically similar to the accession 151 and 199. The number of node at which the first flower appeared (11.59) was the highest in the accession number 153 followed by accession number 143, 212, 3 and 5 (11.09, 11.09, 10.49 and 10.09, respectively) (Table 5). Gondane and Bhatia (1995) observed similar result in respect of number of node at which first flower appeared.

Table 5. Flower characteristics in respect of days to first flowering and number of node at which 1st flower appeared of 36 accessions of okra

Treatment	Days to 1st flowering	No. of node at which 1st flower appeared
T_1(A1)	37.99	7.19
T_2(A2)	46.49	7.59
T_3(A3)	45.38	10.49
T_4(A5)	54.88	10.09
T_5(A13)	48.18	9.59
T_6(A14)	37.79	7.59
T_7(A17)	41.79	7.39
T_8(A23)	47.09	8.99
T_9(A24)	49.98	7.09
T_{10}(A36)	43.19	8.09
T_{11}(A38)	40.19	6.69
T_{12}(A43)	41.69	6.99
T_{13}(A49)	47.48	7.79
T_{14}(A61)	49.59	10.49
T_{15}(A83)	42.09	7.99
T_{16}(A90)	38.99	6.99
T_{17}(A114)	**68.08**	**5.09**
T_{18}(A138)	41.29	6.69
T_{19}(A139)	36.59	7.19
T_{20}(A140)	44.59	6.59
T_{21}(A143)	47.48	11.09
T_{22}(A148)	43.09	6.09
T_{23}(A151)	49.28	5.19
T_{24}(A153)	42.09	**11.59**
T_{25}(A194)	40.25	5.75
T_{26}(A199)	40.89	5.39
T_{27}(A212)	47.09	11.09
T_{28}(A215)	42.59	8.19
T_{29}(A219)	45.18	8.59
T_{30}(A292)	44.19	8.09
T_{31}(A157)	36.59	**5.09**
T_{32}(A155)	37.19	5.6
T_{33}(A144)	**36.39**	6.19
T_{34}(A136)	38.09	5.39
T_{35}(A247)	43.19	7.09
T_{36}(A253)	43.99	6.25
MEAN	43.91	7.59
Max	68.08	11.59
Min	36.39	5.09
LSD	0.12	0.04
CV%	0.17	0.28

4.3.3 Petal color

Accessions were separated into three groups on the basis of their petal colour. There were yellow, cream and golden. The yellow petal colour was found in accessions 1, 2, 3, 5, 13, 14, 17, 24, 36, 38, 43, 49, 61, 83, 90, 138, 139, 140, 143, 148, 153, 199, 212, 215, 219, 292, 144, 136 and 247. Cream petal colour was observed in accession 23, 114, 151, 219 and 155. Golden petal colour was observed in 194 and 253 (Table 7). This results were supported by Kuwada (1964) who observed different colour of leaf in 29 okra varieties.

4.4 Pod Characteristics

Pod characteristics pertaining to length of green pod, diameter of green pod, weight of individual green pod, number of green pods per plant, weight of green pods per plant and yield of green pod were studied and shown in Table 6, Table 7 and Fig 1, 2, 3.

4.4.1 Length of green pod

As regards length of green pod, it ranged from 11.35 cm to 16.08 cm and significantly varied with the mean value of 13.18 cm among the studied accessions (Appendix II) . The maximum length of green pod was observed in the accession number 144 (16.08cm) while the minimum length of green pod was recorded in the accession number 83 (11.35 cm) which was statistically similar with the accession 13, 24, 50, 114 and 151 (Table 6). The result on length of green pod supports the findings of Mishra *et al.* (1990) and Sridhar (1995).

Table 6. Pod characteristics in respect of length and diameter of green pod of 36 accessions of okra

Treatment	Length of green pod (cm)	Diameter of green pod (cm)
T_1(A1)	14.22	1.38
T_2(A2)	13.28	1.4
T_3(A3)	12.84	1.42
T_4(A5)	13.76	1.58
T_5(A13)	12.12	1.73
T_6(A14)	13.36	1.43
T_7(A17)	13.08	1.66
T_8(A23)	13.00	1.74
T_9(A24)	12.20	1.61
T_{10}(A36)	12.65	1.56
T_{11}(A38)	12.44	1.48
T_{12}(A43)	12.47	1.44
T_{13}(A49)	12.76	1.7
T_{14}(A61)	13.32	1.67
T_{15}(A83)	**11.35**	1.74
T_{16}(A90)	12.00	1.59
T_{17}(A114)	11.52	1.71
T_{18}(A138)	12.84	1.77
T_{19}(A139)	14.24	**1.78**
T_{20}(A140)	13.00	1.52
T_{21}(A143)	12.60	1.64
T_{22}(A148)	13.64	1.75
T_{23}(A151)	11.96	1.6
T_{24}(A153)	13.22	1.62
T_{25}(A194)	14.25	1.42
T_{26}(A199)	14.12	1.59
T_{27}(A212)	13.15	1.44
T_{28}(A215)	13.48	1.72
T_{29}(A219)	13.47	1.59
T_{30}(A292)	14.4	1.71
T_{31}(A157)	12.8	1.57
T_{32}(A155)	13.17	1.43
T_{33}(A144)	**16.08**	1.74
T_{34}(A136)	15.00	1.5
T_{35}(A247)	13.52	1.54
T_{36}(A253)	13.00	1.58
MEAN	13.18	1.59
Max	16.08	1.78
Min	11.35	1.38
LSD	0.08	0.13
CV%	0.36	5.13

4.4.2 Diameter of green pod

In respect of diameter of green pod, significant variation was observed among the accessions (Appendix II). The highest diameter of green pod was obtained from the accession number 139 (1.78 cm) followed by accession number 148, 23, 83 and 155 (1.75, 1.74, 1.74 and 1.74 cm, respectively). The smallest diameter of green pod was recorded from the accession number 1 (1.38 cm) which was statistically similar with the accession 2, 3, 14, 43 and 212 (Table 6). This finding was supported by Dash and Mishra (1995).

4.4.3 Number of green pods per plant

The number of green pods per plant varied significantly among the accessions (Appendix II) and ranged from 21.93 to 32.89. The plants of accession number 38 had the minimum number of green pods (21.93) whereas the accession number 194 had the maximum number of green pods (32.89) followed by accession number 292 and 199 (32.69 and 32.49, respectively) Fig 1. It was supported by Sridhar (1995).

4.4.4 Weight of green pod/plant

Weight of green pod varied significantly among the accessions (Appendix II) and ranged from 378.46 g to 661.81g. The highest weight of green pod per plant was found from the accession 194 (661.81 g) followed by accession number 199 (638.71) and 292 (644.67g) whereas accession number 83 had the lowest weight of green pod per plant (378.46g). These results were supported by Mishra *et al.* (1996) and Gondone and Bhatia (1995).

4.4.5 Weight of individual green pod

Weight of individual green pod varied significantly among the accessions (Appendix II) and it ranged from 14.94 g to 21.76 g (Fig 2). The maximum weight of pod was recorded in accession 247 (21.76) followed by accession 3,138 and 151 (21.63, 21.21 g and 21.6 g respectively). On the contrary, accession 83 had the minimum weight (14.94 g) followed by accession 253 and 144 (16.01 g and 15.57. respectively). The result was in agreement with the findings of Mishra et al. (1990) who observed significant difference in the weight of individual green pod among 27 okra genotypes.

4.4.6 Yield of green pod

Among the observed accessions yield of green pod varied significantly (Appendix II) and it ranged from 7.13 to 12.49 t/ha with the average value of 9.88 t/ha (Fig 3). The maximum yield of green pod of 12.49 t/ha was obtained in the accession 194 followed by accession 199 and 219 (12.06 and 12.17 t/ha, respectively) whereas the minimum yield of green pod (7.13t/ha) was obtained from accession number 83. This result agreed with the findings of Hossein *et al.* (1994) and Martin and Rhodes (1983).

Table 7. Qualitative characteristics of 36 accessions of okra.

Treatment	Color of stem	Color of leaf	Shape of leaf	Petal color
T_1(A1)	Green	Green	Palmatisect	Yellow
T_2(A2)	Green	Light green	Palmatifid	Yellow
T_3(A3)	Green	Light green	Palmatifid	Yellow
T_4(A5)	Green	Light green	Palmatisect	Yellow
T_5(A13)	Green	Deep green	Palmatifid	Yellow
T_6(A14)	Green	Green	Palmatifid	Yellow
T_7(A17)	Green	Green	Palmatifid	Yellow
T_8(A23)	Green	Light green	Palmatifid	Cream
T_9(A24)	Green	Deep green	Palmatifid	Yellow
T_{10}(A36)	Green	Light green	Palmatifid	Yellow
T_{11}(A38)	Green	Light green	Palmatipartite	Yellow
T_{12}(A43)	Green with red patches	Green	Palmatifid	Yellow
T_{13}(A49)	Green	Light green	Palmatipartite	Yellow
T_{14}(A61)	Green	Green	Palmatisect	Yellow
T_{15}(A83)	Green	Light green	Palmatifid	Yellow
T_{16}(A90)	Green with red patches	Light green	Palmatisect	Yellow
T_{17}(A114)	Green with red patches	Light green	Palmatifid	Cream
T_{18}(A138)	Green	Deep green	Palmatisect	Yellow
T_{19}(A139)	Green	Green	Palmatisect	Yellow
T_{20}(A140)	Green	Deep green	Palmatifid	Yellow
T_{21}(A143)	Green	Deep green	Palmatipartite	Yellow
T_{22}(A148)	Green	Green	Palmatipartite	Yellow
T_{23}(A151)	Green	Light green	Palmatifid	Cream
T_{24}(A153)	Green	Green	Palmatifid	Yellow
T_{25}(A194)	Green	Green	Palmatipartite	Golden
T_{26}(A199)	Green with red patches	Deep green	Palmatipartite	Yellow
T_{27}(A212)	Green	Deep green	Palmatipartite	Yellow
T_{28}(A215)	Green	Green	Palmatisect	Yellow
T_{29}(A219)	Green	Light green	Palmatifid	Cream
T_{30}(A292)	Green	Light green	Palmatipartite	Yellow
T_{31}(A157)	Green	Green	Palmatipartite	Yellow
T_{32}(A155)	Purple	Deep green	Palmatifid	Cream
T_{33}(A144)	Green	Green	Palmatifid	Yellow
T_{34}(A136)	Purple	Light green	Palmatisect	Yellow
T_{35}(A247)	Green	Light green	Palmatisect	Yellow
T_{36}(A253)	Green	Green	Palmatifid	Golden

4.5 Percent of virus infested plant

Significant variation in respect of virus infested plant among the accessions were found (Appendix II) . The maximum percentage of virus infested plant was found in accession numbers 1, 13, 14, 17, 23, 36, 38, 43, 61, 83, 90, 138, 140, 148, 153, 194, 199, 212, 215, 292, 157, 155, 144, 136, 247 and 253 (99.9% at 75 DAS). The minimum percentage of virus infested plant was recorded in accession numbers 139 (14.27% at 75

DAS) (Table 8). It was followed by the accession number 219 (71.42%) and 24 (82.5%) at 75 DAS. This result was supported by Singh and Singh (1986) who observed similar percentage of virus infested plant in 27 okra varieties.

Plate 2. Photograph showing the yellow vein mosaic virus free accession no. 139 of okra

Plate 3. Photograph showing the infestation of yellow vein mosaic virus among the studied accessions of okra

Table 8. Percent of virus infested plant at different developmental stage of 36 accessions of okra

Treatment	% of Virus infested plant at	
	20 DAS	75 DAS
T_1(A1)	12.6	99.9
T_2(A2)	14.28	85.72
T_3(A3)	14.27	85.72
T_4(A5)	37.6	87.6
T_5(A13)	37.6	99.9
T_6(A14)	14.29	99.9
T_7(A17)	25.1	99.9
T_8(A23)	50.1	99.9
T_9(A24)	50.1	82.5
T_{10}(A36)	50.1	99.9
T_{11}(A38)	40.1	99.9
T_{12}(A43)	33.33	99.9
T_{13}(A49)	12.6	82.6
T_{14}(A61)	28.58	99.9
T_{15}(A83)	25.2	99.9
T_{16}(A90)	20.1	99.9
T_{17}(A114)	12.6	82.6
T_{18}(A138)	14.29	99.9
T_{19}(A139)	14.29	**14.27**
T_{20}(A140)	37.6	99.9
T_{21}(A143)	12.6	82.6
T_{22}(A148)	12.6	99.9
T_{23}(A151)	14.29	82.6
T_{24}(A153)	12.6	99.9
T_{25}(A194)	12.6	99.9
T_{26}(A199)	12.6	99.9
T_{27}(A212)	14.29	99.9
T_{28}(A215)	33.4	99.9
T_{29}(A219)	14.29	71.42
T_{30}(A292)	28.62	99.9
T_{31}(A157)	25.1	99.9
T_{32}(A155)	25.1	99.9
T_{33}(A144)	28.56	99.9
T_{34}(A136)	12.6	99.9
T_{35}(A247)	12.6	99.9
T_{36}(A253)	25.2	99.9
MEAN	23.38	93.2
Max	50.1	99.9
Min	12.6	14.27
LSD	0.11	0.16
CV%	0.29	0.11

Fig 1: Number of Green Pods per Plant of 36 Okra Accessions

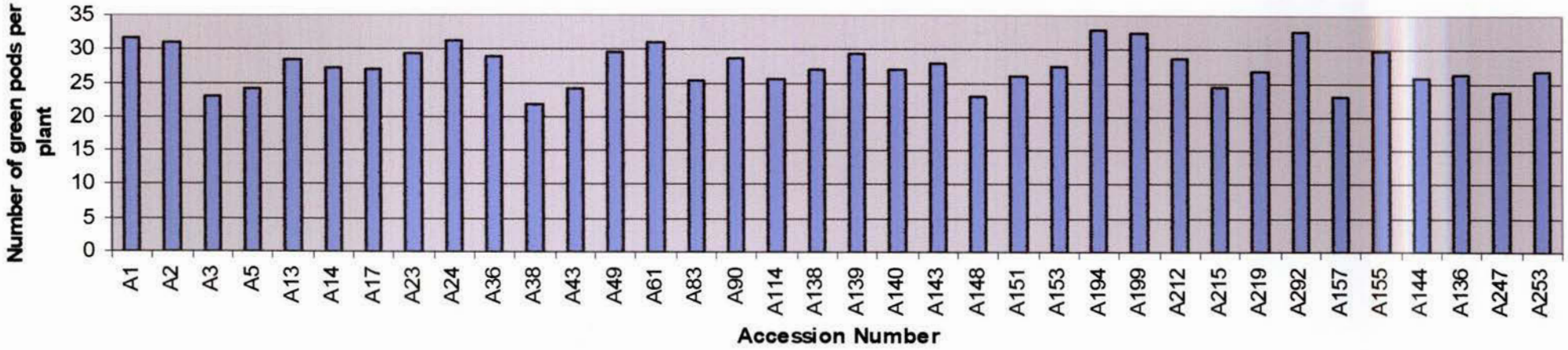


Fig 2: Weight of Green pod per plant of 36 accesssions of okra

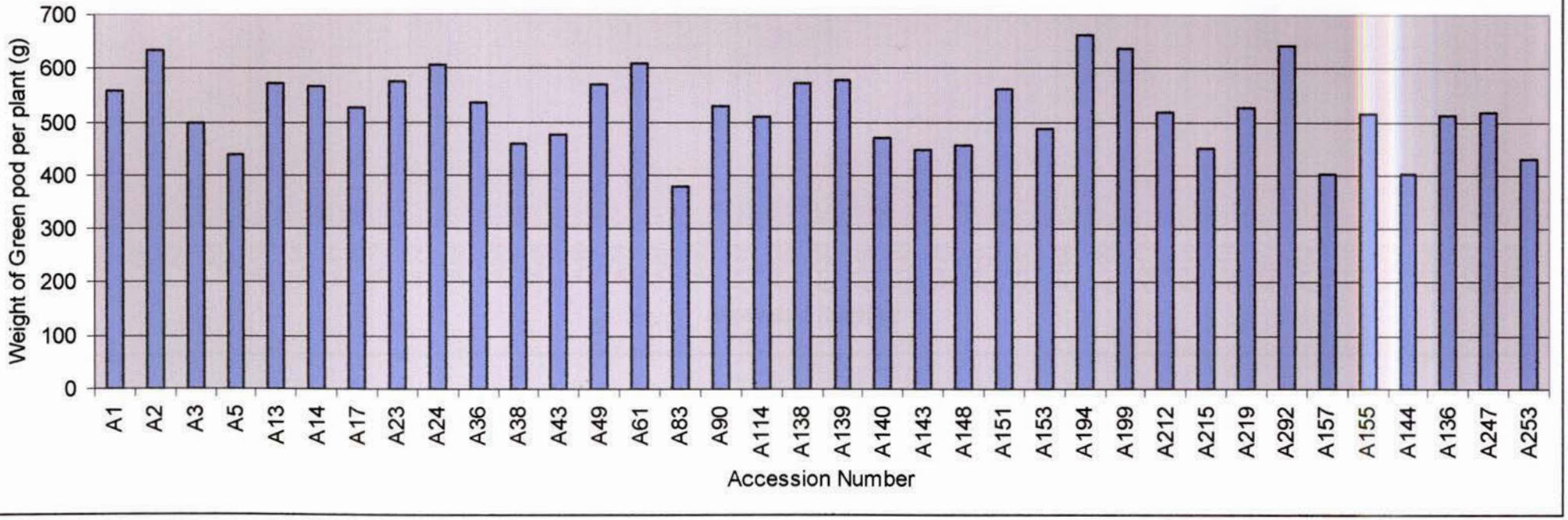
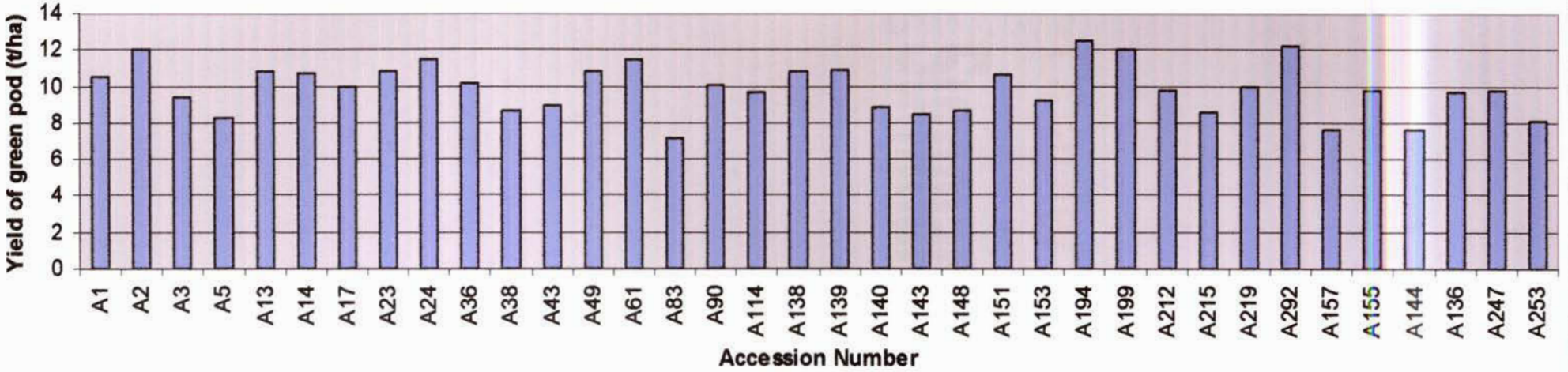


Fig 3: Yield of green pod of 36 okra accessions.



Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

The present experiment was undertaken to study the variability and character association in 36 okra accessions. The experiment was conducted at the Horticulture Farm of Bangladesh Agricultural Research Institute, Gazipur during the period from April to August 2007. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. One accession represented one treatment and 5 plants in an accession represented one replication. Data on yield contributing characters and yield of green pod were recorded. Statistical analyses of all characters studied were done using the appropriate formulae.

In respect of plant height, accession 14 was the tallest (169.37 cm at 80 DAS) and accession 24 was the smallest (69.43 cm at 80 DAS).

In respect of days to flowering, accession 144 took the minimum days to reach first flowering (36.39) which was statistically similar with the accession 1,14,139,157 and 155 and; the maximum days to first flowering was taken by accession 114 (68.08).

The number of node at which first flower appeared in accession 114 and 157 were 5.09 which was statistically similar with the accession 151 and 199. On the other hand, accession 153 bore first flower at the highest number of nodes (11.59).

The spread of plant in accession 138 was the maximum (68 cm) and the least in accession 144 (34 cm) which was statistically similar to the accessions 83 and 13.

The shortest leaf was observed in accession 157 (18.7 cm) while accessions 138 and 139 had the longest leaf (26.7 cm). For the breadth of leaf, accession 151 had the lowest (23.2 cm) which was statistically similar to accession 5 and 253. On the other hand, accession 148 had the highest breadth of leaf (35.1 cm).

In case of length of green pod, accession 83 had the lowest length (11.35 cm) which was statistically similar to the accession 13, 24, 90, 114 and 151. On the other hand, accession 144 had the highest length of green pod (16.08 cm). For diameter of green pod, it was noticed that accession 1 had the lowest diameter (1.38 cm) which was statistically similar to the accession 2, 3, 14, 43, and 212 but accession 139 had the highest diameter (1.78 cm).

In case of weight of individual green pod, it was found that accession 83 had the lowest weight (14.98 g) which was statistically similar to the accessions 253 and 144 but accession 247 had the highest weight 21.76 g.

The number of green pod per plant in accession 38 had the lowest number (21.93) and accession 194 had the highest (32.89). The lowest weight of green pod per plant (378.46 g) was found in accession 83. On the other hand, the highest weight of green pod was found in accession 194 (661.81 g)

The yield of green pod was the lowest in accession 83 (7.13 t/ha) which was statistically similar to accessions 292 and 155 but accession 194 had the highest yield (12.49 t/ha).

In respect of virus infestation 26 treatment was severely susceptible to virus (99.9% at 75 DAS), 9 treatment was moderately susceptible to virus (71.42% to 87.6% at 75 DAS) and one treatment was less susceptible to

virus (14.27% at 75 DAS).

The result of the present experiment revealed that a wide variability exists among the collected okra accessions. From the results of the experiment the foilowing conclusion can be drawn.

1. Wide variability exists among the okra grown in our country.
2. Selection pressure should be applied to the desired characters such as node to first flowering, number of green pod per plant, green pod weight etc. to develop a high yielding variety of okra.
3. Further collection of okra germplasm should be continued for getting more variability and desired traits in okra germplasm.
4. Accession number 139 was identified agronomically acceptable resistant lines against okra yellow vein mosaic virus.

Chapter 6

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APPENDICES

Appendix I. Monthly mean temperature and relative humidity during the crop period at BARI,Gazipur.

Year	Month	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
		Minimum	Maximum	Minimum	Maximum	
BARI 2007	April	29.90	21.69	76.90	84.45	259.8
	May	24.35	33.71	77.92	91.65	225.8
	June	25.62	34.03	77.58	90.54	305.38
	July	27.15	32.58	80.52	90.48	204.56
	August	26.80	32.90	82.44	91.62	128.26

Source: Meterological Department, BARI, Gazipur.

Appendix II. Analysis of variance of data on yield and yield contributing characters of okra

Sources of variation(SV)	Degree of freedom(df)	Mean sum of squares			
		Height of plant(cm) at		No. of branches/plant	Plant spread(m)
		1st harvest	Last harvest		
Replication	2	-0.0625	0.125	0.14978030	0.00209808
Treatment	35	1213.591**	2967.553**	13.69501**	0.02055043**
Error	70	0.0142	0.0089	0.00079171	0.00000850

**Significant at 1% level of probability.

Appendix II. Contd.

Number of leaf per plant at 80 DAS	Length of leaf (cm)	Breadth of Leaf(cm)	Length of petiole(cm)	Days to first flowering	Number of node at which first flower appeared	% virus infested plant	
						20 DAS	75 DAS
-0.12500000	0.09375000	0.07031250	-0.00781250	10.89063000	0.27807620	.10351	.15625
487.58930000**	16.77199000**	21.53036000**	47.84040000**	109.70940000**	10.02732000**	442.2**	735.3**
0.01071429	0.00820312	0.04933036	0.02332589	0.00491071	0.00043945	.00351	.00625

** Significant at 1% level of probability.

Appendix II. Contd.

Length of Green Pod (cm)	Diameter of Green Pod (cm)	Number of green pod	Weight of green pod/plant (g)	Weight of individual green pod (g)	Yield (t/ha)
0.01757813	0.35081480	6.41406300	4335.00000000	-0.00585938	0.72802730
2.72098200**	0.04436471**	26.72187000**	15832.11000000**	8.78683000**	5.6283480**
0.00220424	0.00586417	0.00178571	2.28571400	0.00139509	0.00066964

** Significant at 1% level of probability.