EFFECT OF POLLINATORS ON YIELD CHARACTERISTICS OF DIFFERENT VARIETIES OF OKRA

By

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CERTIFICATE

This is to certify that thesis entitled, "EFFECT OF POLLINATORS ON YIELD CHARACTERISTICS OF DIFFERENT VARIETIES OF OKRA" submitted to the Faculty of Agriculture, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRICULTURAL BOTANY, embodies the result of a piece of bonafide research work carried out by Md. Abu Hasnat, Registration No. 05-01651 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2011
Place: Dhaka, Bangladesh

Prof. Dr. Shahnaz Sarkar
Supervisor

DEDICATED
TO
MY BELOVED PARENTS

ABSTRACT

A field experiment was conducted at the field of Sher-e-Bangla Agricultural University (SAU) during May to September, 2011 in kharif season with a view to find out the contribution of pollinators on yield contributing characteristics and yield of different varieties of okra. The experimental treatments included four okra varieties (V_1: Metal; V_2: BARI dherosh 2; V_3: Munmun 45 and V_4: Sarosh). Four different treatments were used to find out the effect of pollinators on okra yield [T_1: Flowers bagged with net with medium mesh; T_2: Flowers bagged with net with very small mesh; T_3: Flowers bagged with net and Vaseline rubbed at the bottom of peduncle and T_4: Flower without net (control)]. The experiment was laid out in randomized complete block design with three replications. The plant height, plant girth, branches per plant, leaf per plant, leaf length and leaf breadth was measured at 30, 45 and 60 DAS. Days to first flowering and days to edible maturity were recorded by calculating the number of days required from sowing to the flowering and edible stage of fruit. Pod length, pod diameter, pods per plant and pod yield was calculated after harvesting of fruit. Significant differences were observed for pods per plant and pod yield. The variety Munmun 45 produced highest pods per plant (41) and pod yield per hectare (11.23 t). Invertebrate pollinators were observed to find out the effective pollinations for okra. Insects of different order such as Lepidoptera, Coleoptera and Diptera were found during the flowering period. Insects of Hymenoptera order were the major pollinators, visiting okra flowers and peak of foraging activity was found during 9-11 am which increased the highest number of fruit setting (26), number of seeds per plant (47) and germination percentage (92%) in Munmun 45 variety. These results suggest that growth and yield of okra are variable in different varieties and pollinator Hymenoptera increase the okra fruit yield under this climatic and edaphic condition of SAU.

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The author

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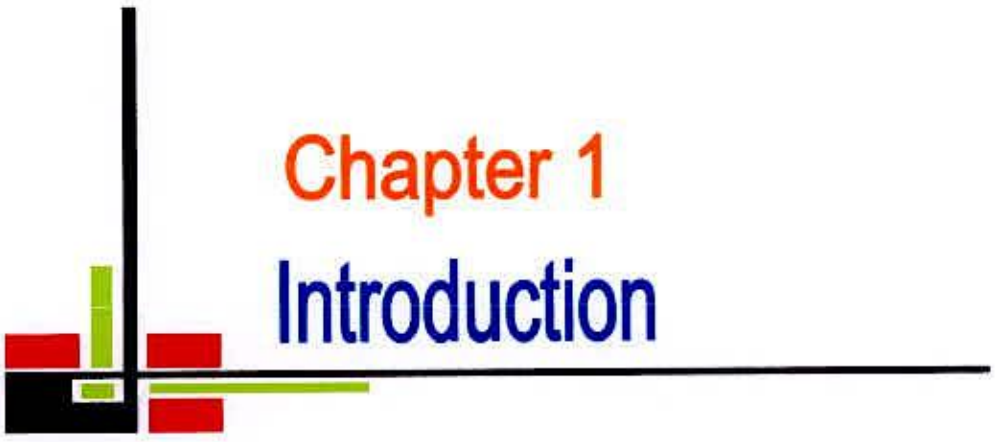
LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
cv.	=	Cultivar
DAS	=	Days after sowing
^{0}C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
t ha^{-1}	=	Ton per hectare
g	=	Gram
hr	=	Hour
Kg	=	Kilogram
LSD	=	Least significant difference
m	=	Meter
m^2	=	Meter squares
mm	=	Millimeter
viz.	=	Namely
N	=	Nitrogen
ns	=	Non significant
%	=	Per cent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
ppm	=	Parts per million
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
Zn	=	Zinc



Chapter 1

Introduction

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) belongs to the family Malvaceae, is a popular warm seasoned vegetable and is grown commercially in many parts of the world. It is also known as Lady's finger and produced in different districts such as Rangpur, Rajshahi, Pabna, Kushtia, Khulna, Faridpur, Dhaka and Chittagong of Bangladesh. It is consumed as fresh as well as canned product. Okra contains carbohydrates, proteins, and vitamin C in large quantities and also essential and non essential amino acids which are comparable to that of soybean (Adeboye and Oputa, 1996). It is grown mainly for its leaves and young pods which are frequently eaten as green vegetable. Therefore, the consumption of okra plays an important role in human nutrition.

Worldwide production of okra vegetable was estimated at 6000000 tons per year. In Bangladesh, it was estimated at 420000 tons per year (BBS, 2010). The production of okra is increasing day by day in Bangladesh. Okra is sensitive to low temperature and develops poorly below 15°C (Marsh, 1992). Reports of MacGillvary (1953) also indicate that okra requires high temperature and long day length for optimum growth and development. Studies on the optimum weather requirement for high yield okra in the tropics show that okra does best when the minimum and maximum temperatures are 18°C and 35°C, respectively (Ezeakunne, 1984). Grubben (1997) observed temperatures of between 35°C to 40°C for optimum growth and yield of okra, while Oyolu (1997) recorded a critical day length of 12.5 hr for flower initiation and fruit yield. Wellby and MacGillvary (1953) observed that an improvement in the performance of okra when rainfall was about 750 mm, evenly distributed and relative humidity was between 90-95%. However, low temperatures of 28°-29°C (maximum) and 17.9-19.8°C (minimum) and short day lengths of 5.2-5.7 hrs resulted in a higher number of flowers (Thamburaj, 1972). The sowing and harvesting time of okra are mid April to mid June and June to mid September, respectively. The production and economic importance of okra as a vegetable

in Bangladesh has rapidly increased in recent years. Different varieties were used by farmers in order to meet the demand of okra by consumers. Different okra genotypes differ significantly for most of the traits like number of green pods, pod length, pod weight and number of seeds per pod etc., ultimately determine overall green pod and seed yields of the cultivar and also respond differently to the varying environments with respect to their physiological characteristics and ultimately yield components (Shanmugavela, 1989; Dash and Misra, 1995; Gondane and Bhattia, 1995; Shri-Dhar and Dhar, 1995). Besides the improved cultural practices, there is also need to grow high yielding varieties to increase green pod yield per unit area.

Yield instability is generally considered a major problem in okra. As in many other crops, the number of both flowers and ovules that are formed almost always greatly exceeds the resulting number of pods and seeds that are produced. The reproductive system of okra is a mixture of cross and self-pollination. Insect play a significant role in the fertilization of flowers but the indiscriminate and treadmill use of pesticides reduced the number of various pollinators tremendously. Pollination is an important link in fertilization, a complex process resulting in the production of vegetables, seeds and seeds of flowering crops. Pollination by insects is called entomophily. Entomophily is a form of plant pollination whereby pollen is distributed by insects, particularly Hymenoptera (bees), Lepidoptera (e.g. butterflies and moths), Diptera (flies) and Coleoptera (beetles).

Abdul *et al.* (2003) reported that the number of seeds per plant, number of seeds per pod, seed weight per plant and pod weight of okra was greater in insect's pollinated plants than self pollinated plants. Insect pollinated plants showed a greater number of young pods and mature pods due to greater transformation of flowers into young pods. Moses *et al.* (2005) mentioned that hand and insect pollination of okra flowers gave seed sets varying between 73-84% per pod which differ significantly from that of the bagged flowers (spontaneous self pollination) which just rendered 57% seed sets per pod. An

increase of 10.3% in seed sets from cross pollination over forced-self pollination and 16% increase in seed sets was recorded from forced-self pollination over spontaneous-self pollinated flowers.

From the above point of view the present study was undertaken to fulfill the following objectives-

- To compare the performance and suitability of different okra varieties.
- To study the different pollinators on okra varieties.
- To observe the pollination performance on okra varieties.

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 varietal improvement. Pollination is an important stage in the reproduction of flowering plants. It is the transfer of pollen from male to female part of the flower that helps to fruit setting. Different types of insects are involved in pollination process. A good number of works related to varietal aspects and pollinators has been done in different parts of the world. Some of the available research work in relevant to the present study has been reviewed in this chapter

2.1 Effect on growth and yield contributing characters

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

Mirsha *et al.* (1995) 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 ridge 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 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 five genotypes of okra viz. Parbhani, Kranti, Hisar, Unnat and Satdhar. Variability, heritability, genetic advance, correlation and coheritability were studied for eleven characters in a

field experiment in Varanasi, Uttar Pradesh of 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 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, seeds per plant, fruit yield per plant, moderate variations in primary branches per plant and fruit length and lesser variations of node at first flower, rides 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 of India, during kharif season. Forty eight diverse okra genotypes were sown in rows at 20 cm apart. Marketable fruit yield per plant varied from 154-467 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 followed by Perfect Long Green, LC-11and 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 at Varanasi under 2 sowing dates. They stated that number of branches, number of pods and total pod yield per plant had higher genotypes and phenotypic coefficient 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 Dharaward, India during rabi season of 1990 and kharif season in 1991. They observed considerable seasonal differences for number of 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 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 occurred. 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 coefficient of variations was observed for pod yield, number of pod, plant height and number of branches per plant. 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 Marsh (1992). They reported that variability was highest for plant height by fruit girth and yield per plant.

A experiment on okra 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.

Sannigrani and Choudhury (1998) conducted an experiment at Tezpur, Assam, India during the kharif season of 1991 and 1992 on 8 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 Arka 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 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^{-1}).

Gondane and Bhatta (1995) studied variability of 50 0kra genotypes. They found all the genotypes responded differently to the environment. 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 introduction days to first at University of Viscosa, Brasilia. Days from sowing to the end of the juvenile 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 -130. The weight of 1000 number of seeds varied from 5.53 to 7.43g.

Martin and Rhodes (1983) studied variability of 95 accessions of okra. 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 coefficient 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 Assuit during the summer seasons of 1991 and 1992 to study the performance of 13 cultivars of okra. 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 tallest Balady. 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 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^{th} day after fruit set. Under Pona condition, the variety Pusa Sawani yielded 13.14t ha^{-1}. The number of fruits was reduced to one third when pods were allowed to mature after the first 3 weeks of picking. Plant height was also proportionately reduced.

Chen *et al.* (1999) conducted an experiment on flowering habit and hybridization technique of okra (*Hibiscus esculentus* L.). They stated that the flowers of okra [*Abelmoschus esculentus*] are borne singly and are hermaphrodite. They are pentamerous and 80-120 stamens. Flowering lasts 18-20 hr, generally commencing at 18.00-19.00 hr, with flowers fully opened at 08.00-09.00 hr the following day and closed by 14.00-15.00 hr. The female parent should be emasculated one day prior to flowering by paring apart the sepals with tweezers and carefully excising the stamens. This is preferably done on a clear day between 10.00 and 15.00 hr. The emasculated flower is then labelled and covered with a paper bag. The paternal parent should be bagged one day before flowering. Between 08.00-10.00 hr on the morning after flowering has commenced, the stamens are excised with tweezers or a knife and pollination effected artificially. After 2 days the bag is removed. If pollination was not successful the ovary will fall off when touched. Each plant can produce 40-50 flowers. For the female parent, removal of the first 10 flowers is recommended to promote vegetative growth. Two out of three of the subsequent flowers are also removed to promote development of fruits and seeds.

Saifullah and Rabbani (2009) conducted an experiment at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jamalpur in summer season, 2004. Significant variations among the genotypes were observed for different characters studied. The GCV and the PCV were very close in most of the characters which indicated less environmental influence on the expression of those characters. The high heritability estimates along with considerable genetic advance were noticed in days to first flowering, plant height, number of primary branches per plant, number of internodes per plant, number of fruits per plant, fruit weight, number of seeds per fruits and fruit yield per plant provided the basis for selection for development of new variety of okra based on phenotypic performance. Genotypes AE009, AE024, AE036, AE061, AE080 and AE087 possessed desirable characters and were selected for further evaluation.

Jindal and Deepak (2010) investigated on the evaluation of okra genotypes for earliness and yield attributes under North Indian conditions at Vegetable Research Farm of the Department of Vegetable Crops, Punjab Agricultural University, Ludhiana, Punjab during the rainy season. Five parents for trait node at which first flower appears and four parents for days to first picking showed better performance than grand mean values revealed that these parents can be used for improving earliness in okra. The parent IIVR-11 for fruit diameter; IIVR-11 and Varsha Uphar for average fruit length; HRB-107-4, VRO-4, PA-4 and S-2 for average fruit weight had higher values than their respective parental means, whereas no parent was reported to have more number of fruits per plant and high total yield per plant than their overall mean. The results suggests that combinations *viz.* IIVR-11 x HRB-108-2, HRB-107-4 x HU, HRB-107-4 x VRO-3, VRO-3 x NDO-10, PA-4 x S-2 and HRB-108-2 x S-2 showed better performance than the parental mean for earliness and yield traits can be commercially exploited as F1 hybrids or can be used for deriving improved lines of okra for earliness and yield traits.

Nageswari (2010) conducted an experiment on okra and stated that general combining ability variances (GCA) and the specific combining ability variances (SCA) were significant for the traits, plant height at first fruiting node, days to first flowering, inter nodal length, individual fruit weight, yellow vein mosaic virus incidence, node to first appearance of yellow vein mosaic virus, fruits per plant and yield per plant. The parent P2 was the best general combiner for yield. The parent P5 recorded significant and positive GCA for node number at which the symptoms of yellow vein mosaic virus appears in the plant. The hybrid P1 X P5 registered positive and significant SCA and both the parents (P1 and P5) possessed positive significant GCA for node number at which the symptoms of yellow vein mosaic virus appear in the plant.

2.2 Effect of pollinators

Al-Ghzawi *et al.* (2003) conducted a field study during 2002 in northern Jordan, to determine the performance of eight okra genotypes (Local, Mousel, pakistanim Perkins Dwarf, Spinless, Clemson, Clemson Spinless and Perkins Spinless) and their response to two sets of pollination conditions, control (plants in a cage with no insect pollinators) and open pollination (plants accessible to naturally occurring insect pollinators). Significant differences ($P<=0.05$) in number of seeds per plant, number of flower per plant, number of seeds per pod, seed weight per plant, and pod length were recorded between the genotypes studied. Clemson gave the highest seed weight per plant. The number of seeds per plant, number of seeds per pod, seed weight per plant, and pod length was greater in insect-pollinated plants than self-pollinated plants. Insect-pollinated plants showed a greater number of young pods and mature pods due to greater transformation of flowers into young pods.

Malerbo-Souza *et al.* (2001) conducted an experiment in Sao Paulo, Brazil, to evaluate the frequency of nectar or pollen hoarding by insects, and the opening and closing time in flowers of okra cv. Chifre-de-veado. The effect of insect

visits on fruit production was also investigated. Flowers were visited by insects between 7.00 and 18.00 hr. Ten flowers were protected by bags and compared to unprotected flowers. Okra flowers began opening by 9.40-10.00 hr, and closed by 14.45 and 15.20 hr of the same day, when they started to shrivel. The nectar hoarding insects were Thysanoptera, Formicidae, Coleoptera and Hymenoptera (*Melipona* sp. and *Apis mellifera*). The crop showed 100% self-fertilization and did not require pollinators to produce fruits. However, flowers visited by insect fruits were heavier, longer and wider.

Abdul *et al.* (2003) conducted an experiment on the impact of wild bees on the pollination of eight okra genotypes under semi-arid Mediterranean condition during 2002 in northern Jordan to determine the performance of eight okra genotypes and their response to two sets of pollination conditions [control (plants in a cage with no insect pollinators) and open pollination (plants accessible to naturally occurring insect pollinators)]. Significant difference in number of seeds per plant, number of flower per plant, number of seeds per pod, seed weight per plant and pod length were recorded between the genotypes studied. Clemson gave the highest seed weight per plant. The number of seeds per plant, number of seeds per pod, seed weight per plant, and pod weight was greater in insect's pollinated plants than self pollinated plants. Insect pollinated plants showed a greater number of young pods and mature pods due to greater transformation of flowers into young pods.

Thand (2011) conducted an experiment on floral biology, pollen dispersal, and foraging behiviour of honeybees in okra cv. Pusa Sawani at Ludhiana, Punjab, India. He stated that the most important insect pollinator were the honebees *Apis mellifera* and *Apis cerana indica*. Of a sample of 100 *Apis mellifera* foragers in a field of okra, 88 collected nectar, eight pollen and four both nectar and pollen. In a 6 hour period, pollen was dispersed by insects over an area of 8-m radius. The floral biology of okra and foraging behavior on okra of the two honeybee species are described.

Moses *et al.* (2005) conducted an experiment from June 2004 to August 2004 at the out sketch of Yaounde (Cameroon). Okra (*Abelmoschus esculentus*), Malvaceae, is a native of West Africa. It has a considerable economic importance because the seeds and pods are used for food. Hand and insect pollination of okra flowers gave seed sets varying between 73-84% per pod which differ significantly ($P<0.05$) from that of the bagged flowers (spontaneous self pollination) which just rendered 57% seed sets per pod. An increase of 10.3% in seed sets from cross pollination over forced-self pollination and a 16% increase in seed sets was recorded from forced-self pollination over spontaneous-self pollinated flowers. Noteworthy, that a fecundated seed contains 91.5µg nitrogen whereas an unfecundated seed has only 2.6µg nitrogen; this means that a fecundated seeds contains 35 times much more nitrogen. As a consequence, cross-pollinated flowers rendered more fecundated seeds; with 311.1µg more nitrogen per carpel than seeds from spontaneous-self pollinated flowers with more unfecundated seeds. An increase of 754.1µg carbons and 192.2µg of nitrogen per carpel were noted comparing seeds from forced self-pollinated flowers with those from spontaneous self-pollinated flowers. This demonstrates the need for cross-pollination in the okra garden to achieve optimum yields both in both seed quality and seed sets. Observation of 829 individual bees of at least 4 different species visiting okra flowers indicates that *Megachile* sp had more contacts with the stigma upon landing (56.1%), thus, it possibly does cross pollination. *Halictus* spp are considered potential pollinators for self-pollination, as they frequently roll on the anthers and consequently on the stigma of the same flower (86.3%) before taking off. *Xylocopa* sp is a pollen thief, as it visits okra flower just to collect pollen but does not aid in pollination. *Apis mellifera* is mainly a nectar collector in okra flowers.

From the reviews cited and discussed above, it can be concluded that varieties and different pollinators play a remarkable role for growth, yield contributing characters and yield of okra.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

3.1 Experimental period

The experiment was conducted during the period from May to September 2011 in kharif season.

3.2 Site description

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28. For better understanding the experimental site is shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Climate

The experimental area under the sub-tropical climate is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season (October-March). The weather data during the study period at the experimental site are shown in Appendix II.

3.4 Soil

The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period.

3.5 Experimental treatments

Treatment was considered as following

1) V_1 = Metal
2) V_2 = BARI Dherosh 2
3) V_3 = Munmun 45
4) V_4 = Sarosh

3.6 Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were 12 treatments combinations. The total numbers of unit plots were 12. The size of unit plot was 3m x 3m = $9m^2$. The distances between plot to plot and plant to plant were 50 and 40 cm, respectively.

3.7 Crop / planting material

Four okra varieties such as Metal, BARI Dherosh 2, Munmun 45 and Sarosh were used as the test crop.

3.8 Seed collection and sowing of seeds

The seeds of okra cv. Metal, BARI dherosh 2, Munmun 45 and Sarosh were collected from Kushtia Seed Store, Dhaka. The seeds were soaked in water for 24 hours and then wrapped with a piece of thin cloth. The soaked seeds were then spreaded over polythene sheet for 2 hours to dry out the surface water. This treatment was given to help quick germination of seeds. The seeds were sown in the rows of the raised bed on 15 April, 2011. Row to row and plant to plant distance were maintained. Two to three seeds were sown in each pit. Then the seeds were covered with fine soil by hand.

3.9 Preparation of experimental land

The experimental field was first opened on 15 April, 2011 with the help of a power tiller and then it was kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a good tilth. All kinds of weeds and residues of previous crop were removed from the field. Simultaneously the clods were broken and the soil was made into good tilth. The basal dose of fertilizer and well decomposed cowdung 10 t ha^{-1} were mixed into the soil during final land preparation. The field layout was made on 15 April, 2011 according to design immediately after final land preparation. The plots were raised 10 cm from the soil surface to keeping the drain around the plot. Individual plots were cleaned and finally leveled.

3.10 Fertilizer management

The experimental plots were fertilized with 220, 65, 220, 20, 10, 5 kg ha^{-1} urea, triple super phosphate (TSP), Murate of potash (MoP), gypsum, zinc sulphate and boron, respectively. TSP, gypsum, zinc sulphate and boron were given as basal during final land preparation. Split application of urea and MoP were done at 20, 40 and 60 days after sowing.

3.11 Observation of pollinators

Experimental observation starting weekly from initial flowering to the final session during four period of the day 9.00-11.00am, 11.00-1.00 pm, 1.00-3.00 pm and 3.00-5.00 pm. Observation time was ten minutes in each period. Fifty sweeps per plot were taken to collect the pollinators. The collected insects were killed in a killing bottle and transferred to the laboratory. The large insects were pinned, labeled and preserved in the collection box. The smaller insects were mounted, labeled and preserved too. Insects were identified to species where possible through the use of published systematic keys and direct

comparisons with museum specimens at the Department of Entomology, Sher-e-Bangla Agricultural University. Data were recorded for pollinators belonging to different insect orders.

3.12 Pollinators effect

T_1 = Flowers bagged with net with medium mesh.

T_2 = Flowers bagged with net with very small mesh.

T_3 = Flowers bagged with net and Vaseline rubbed at the bottom of peduncle.

T_4 = Flower without net (control).

Four different treatments were to find out the effect of pollinators on okra yield. Medium meshed netted flowers can stop the entry of medium sized flower visiting insects but not small sized insects. Small meshed netted flowers are used to stop all sized insects except minute in size like ants. Vaseline with netted flowers are used to stop the entry of all different sized insects including the minute crawling insects which have the ability to enter inside the net and to visit flowers. Flowers without net is in controlled condition where all kinds and sized of insects can visit.

Plate 1. Vaseline treated plant to make barrier for crawling insect

Plate 2. Research field

3.13 Intercultural operations

3.13.1 Gap filling

After one week of sowing, a minor gap filling was done where it was necessary using the seed from the same source.

3.13.2 Weeding

During plant growth period two hand weeding were done, first weeding was done at 20 DAS (Days after sowing) followed by second weeding at 40 DAS.

3.13.3 Application of irrigation water

Irrigation water was added to each plot according to the critical stage.

3.13.4 Method of water application

The experimental plots were irrigated through watering cans.

3.13.5 Drainage

Stagnant water was effectively drained out at the time of heavy rains.

3.13.6 Plant protection measures

For controlling shoot and pod borer before pod setting sprayed Diazinone 60 EC @ 3.5 ml/L water in thrice in an interval of 10 days started soon after the appearance of infestation. After fruit setting Nogos @ 0.02% was sprayed 4 times in an interval of 7 days for controlling Jassid.

3.14 General observation of the experimental field

The field was investigated time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that

considerable losses by pest should be minimized. The field looked nice with normal green color plants. Incidence of shoot borer, pod borer, jassid was observed time to time. Viral affected plant also observed in the field.

3.15 Recording of data

A. Growth characters

Plant height (cm) at 15 days interval started from 30 DAS to harvest

Plant girth (cm) at 15 days interval started from 30 DAS to harvest

Branches per plant (No.) at 15 days interval started from 30 DAS to harvest

Leaves per plant (No.) at 30 days interval started from 30 DAT to harvest

Leaf length and breadth (cm) at 15 days interval started from 30 DAS to harvest.

B. Yield contributing characters

Days to first flowering

Days to edible maturity

Pod length (cm)

Pod diameter (cm)

Numbers of pods per plant

C. Yield

Edible pod yield (t ha^{-1})

D. Pollinators

Number of pollinators visited per flower in three different times.

E. Pollinators effect

Number of setted fruit

Number of seeds $fruit^{-1}$

3.16 Experimental measurements

The necessary data were collected from sample plants during the course of experiment. Randomly ten selected plants from each plot were selected for recording data. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The data were collected at 30, 45 and 60 DAS. The following growth, yield contributing characters and yield were considered in this study.

A. Plant characteristics

Plant height (cm)

The height of the plant was determined by measuring the distance from the soil surface to the tip of the longest leaf. Average height of 10 plants was taken very carefully from the randomly selected plants.

Plant girth (cm)

The plant girth (diameter) measured by a slide calipers. The girth of the plants was measured in centimeter (cm) at thickened portion of the plant.

Number of branches per plant

Number of leaves per plant of randomly selected plants was counted. All the branches of each plant were counted separately. Only the smallest young branches at the growing point of the plant were excluded from counting. Calculation the average number of branches, then average number was recorded.

B. Leaf characteristics

Leaf length

Length of leaves were measured in centimeter (cm) with the help of a meter scale from the base of leaf which attached with petiole up to tip point of leaves and average leaf length of 10 leaves per plant were recorded from randomly selected from sample plants.

Leaf breadth

Breadth of leaves was measured in centimeter (cm) with the help of a meter scale from of the middle of the leaves. Average leaf breadth of 10 leaves per plant was recorded from randomly selected sample plants.

Numbers of leaves per plant

Numbers of leaves per plant of 10 randomly selected plants. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. Calculating the average number of leaves, then average number was recorded.

C. Flower characteristics

Days to first flowering

Different dates of first flowering were recorded. The observation was considered when the first flower opens.

D. Pod characteristics

Pod length (cm)

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).

Pod breadth (cm)

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

Number of pods per plant

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

Yield of green pod (t ha^{-1})

The pod yield per plant per hectare as calculated in ton by converting the total yield of pod per plot.

Pollinators

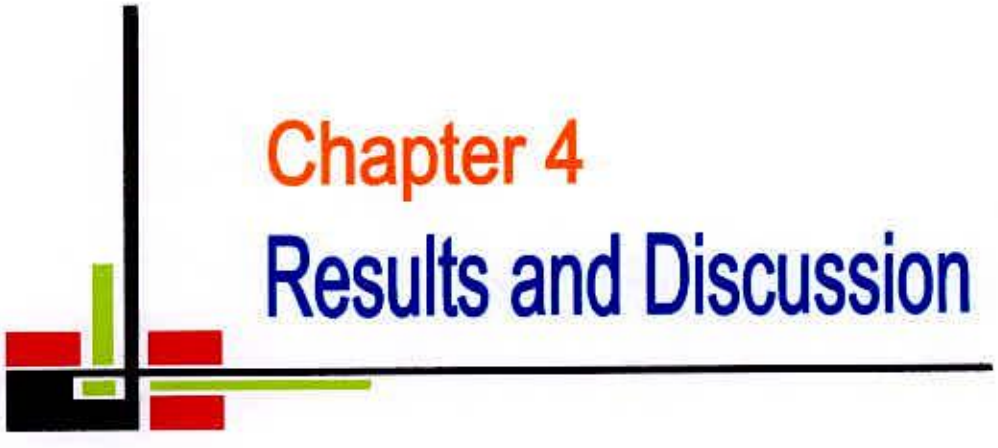
Pollinators are clarified on the basis of their morphology. All the visited insects were counted and different insects of different orders were counted.

Pollinators effect

Fruit set percentage were calculated and numbers of seeds per fruit were calculated. Ten flowers were selected from each plot.

3.17 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments were calculated and the analysis of variance for most of the characters was accomplished by "F" variance test. The significance of difference between pair of means was tested at 5% and 1% level of probability (Gomez and Gomez, 1984).



Chapter 4
Results and Discussion

RESULTS AND DISCUSSION

The experiment was conducted to compare the performance of different cultivable modern okra varieties.

4.1 Plant height

Plant height of the okra varieties was measured at 30, 45 and 60 DAS. It is evident from Fig.1 that plant height was significantly differed by the varieties at all the sampling stages. Regardless of varietal differences, plant height increased progressively up to harvesting. At 30 DAS, maximum plant height (19 cm) was observed in BARI dherosh 2 (V_2). The second highest plant height (15.33 cm) was found in Metal (V_1) which was statistically similar with Munmun 45 (V_3) (14.3 cm). The lowest plant height (11.33 cm) was measured from Sarosh (V_4).

At 45 DAS, maximum plant height (110.66 cm) was obtained from BARI dherosh 2 (V_2). The minimum plant height (101.33 cm) was measured from Metal (V_1) which was statistically similar with Munmun 45 (V_3) and Sarosh (V_4).

At 60 DAS, the highest plant height (143.67 cm) was measured from BARI dherosh 2 (V_2). The second highest plant height (133.33 cm) was measured from Metal (V_1) which was statistically similar with Munmun 45 (V_3). The lowest plant height (126.67 cm) was measured from Sarosh (V_4) which was statistically similar with Munmun 45 (V_3).

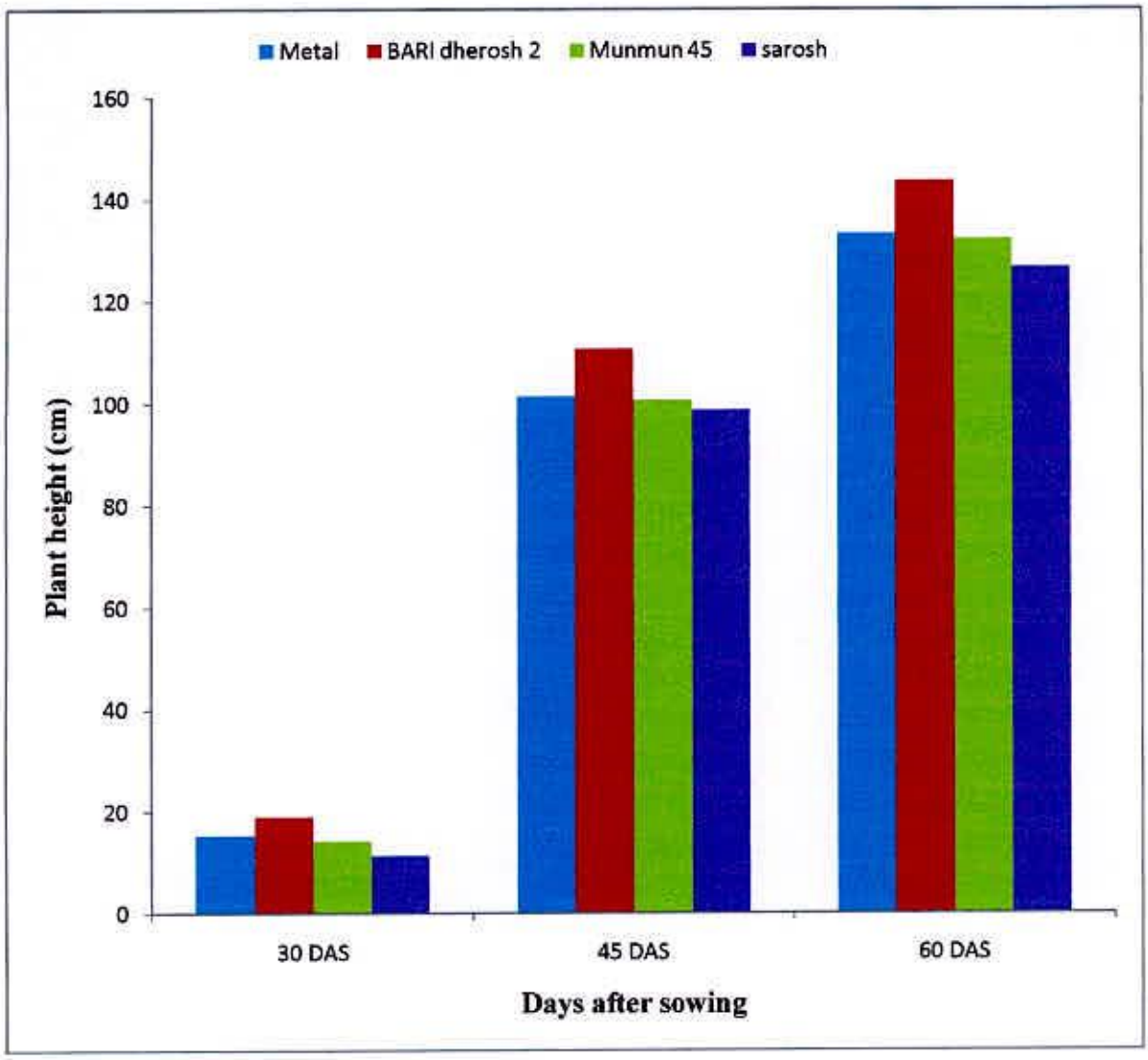


Figure 1. Effect of varieties on plant height at different days after sowing (lsd=2.514, 7.272, 5.947 and CV % =8.39, 3.44 and 2.22 at 30, 45 and 60 DAS, respectively)

4.2 Plant girth

No significant variation was observed among the cultivars in respect of plant girth at 30, 45 and 60 DAS (Fig. 2).

At 30 DAS, numerically highest plant girth (0.70 cm) was found from Sarosh (V_4) and lowest plant girth (0.60 cm) was found from Metal (V_1).

At 45 DAS, numerically higher plant girth (1.73 cm) was measured from Sarosh (V_4) and lowest plant girth (1.56 cm) was found from Metal (V_1).

At 60 DAS, numerically higher plant girth (3.4 cm) was measured from BARI dherosh 2 (V_2) and lowest plant girth (209 cm) was found from Metal (V_1).

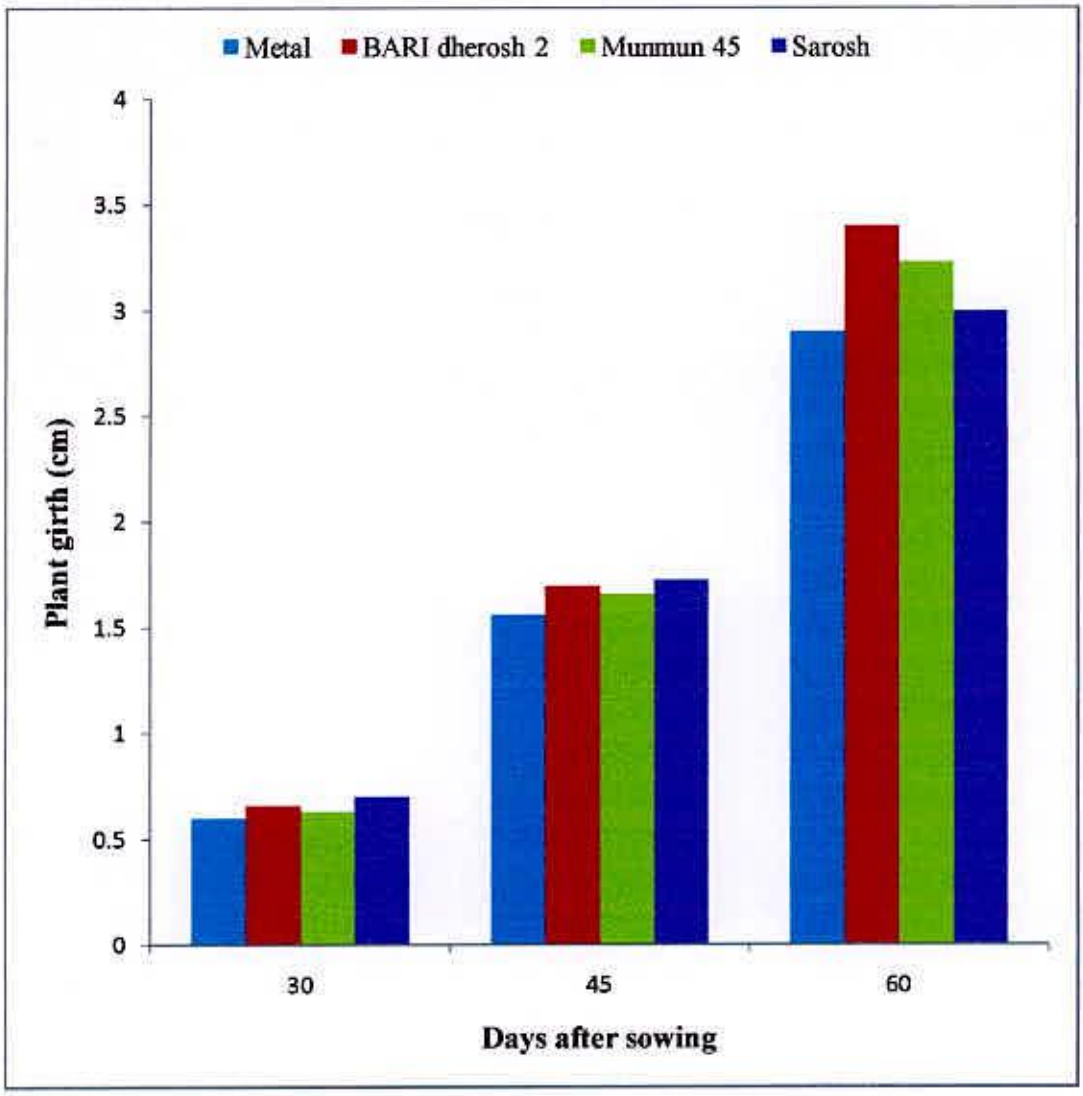


Figure 2. Effect of cultivars on plant girth (cm) at different days after sowing (CV% =18.67, 10.34 and 9.21 at 30, 45 and 60 DAS, respectively)

4.3 Number of branches per plant

Significant variation was observed among the cultivars in respect of number of branches per plant at 60 DAS but insignificant at 30 and 45 DAS (Fig. 3).

At 30 DAS, numerically higher number of branches per plant (0.53) was obtained from Munmun 45 (V_3) and lower number of branches per plant (0.26) from Metal (V_1) and Sarosh (V_4).

At 45 DAS, numerically higher number of branches per plant (3.93) was obtained from BARI dherosh 2 (V_2) and lower number of branches per plant (3.13) from Sarosh (V_4).

At 60 DAS, maximum number of branches per plant (4.06) was obtained from BARI dherosh 2 (V_2) which was statistically at par with Metal (V_1) and Munmun 45 (V_3). The minimum number of branches per plant was found from (3.2) from Sarosh (V_4).

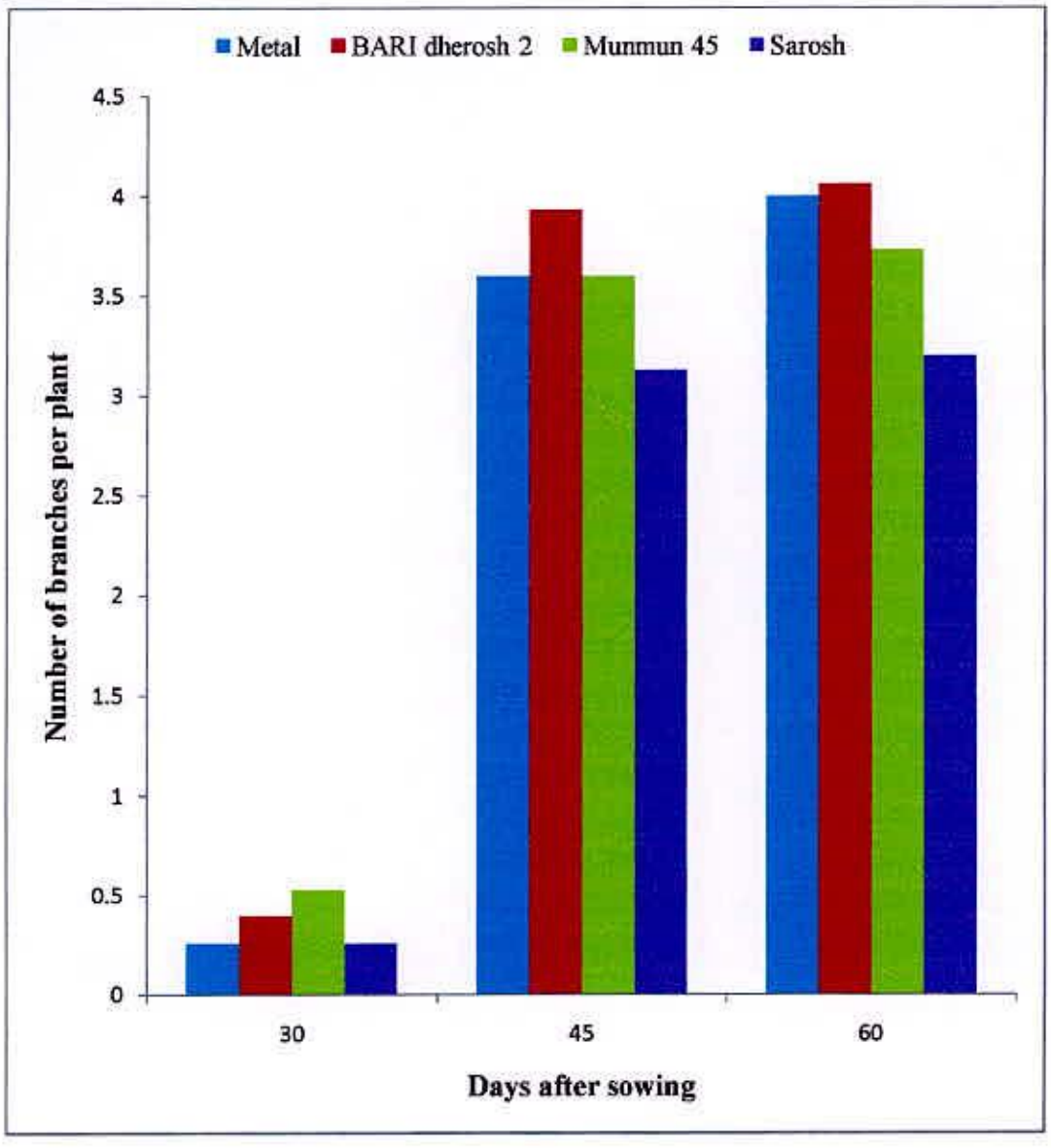


Figure 3. Effect of varieties on number of branches per plant at different days after sowing (lsd= 0.585 at 60 DAS and CV%= 43.6, 8.15 and 7.80 at 30, 45 and 60 DAS, respectively)

4.4 Number of leaves per plant

Significant variation was observed among the cultivars in respect of number of leaves per plant at 60 DAS but insignificant at 30 and 45 DAS (Fig. 4).

At 30 DAS, numerically higher number of leaves per plant (11.8) was obtained from Munmun 45 (V_3) and lower number of leaves per plant (8.87) from Sarosh (V_4).

At 45 DAS, numerically higher number of leaves per plant (22.2) was obtained from BARI dherosh 2 (V_2) and lower number of leaves per plant (19.73) from Sarosh (V_4).

At 60 DAS, maximum number of leaves per plant (43.2) was obtained from BARI dherosh 2 (V_2) which was statistically at par with Munmun 45 (V_3). The minimum number of leaves per plant was found from (35.66) from Sarosh (V_4) which was statistically similar with Metal (V_1).

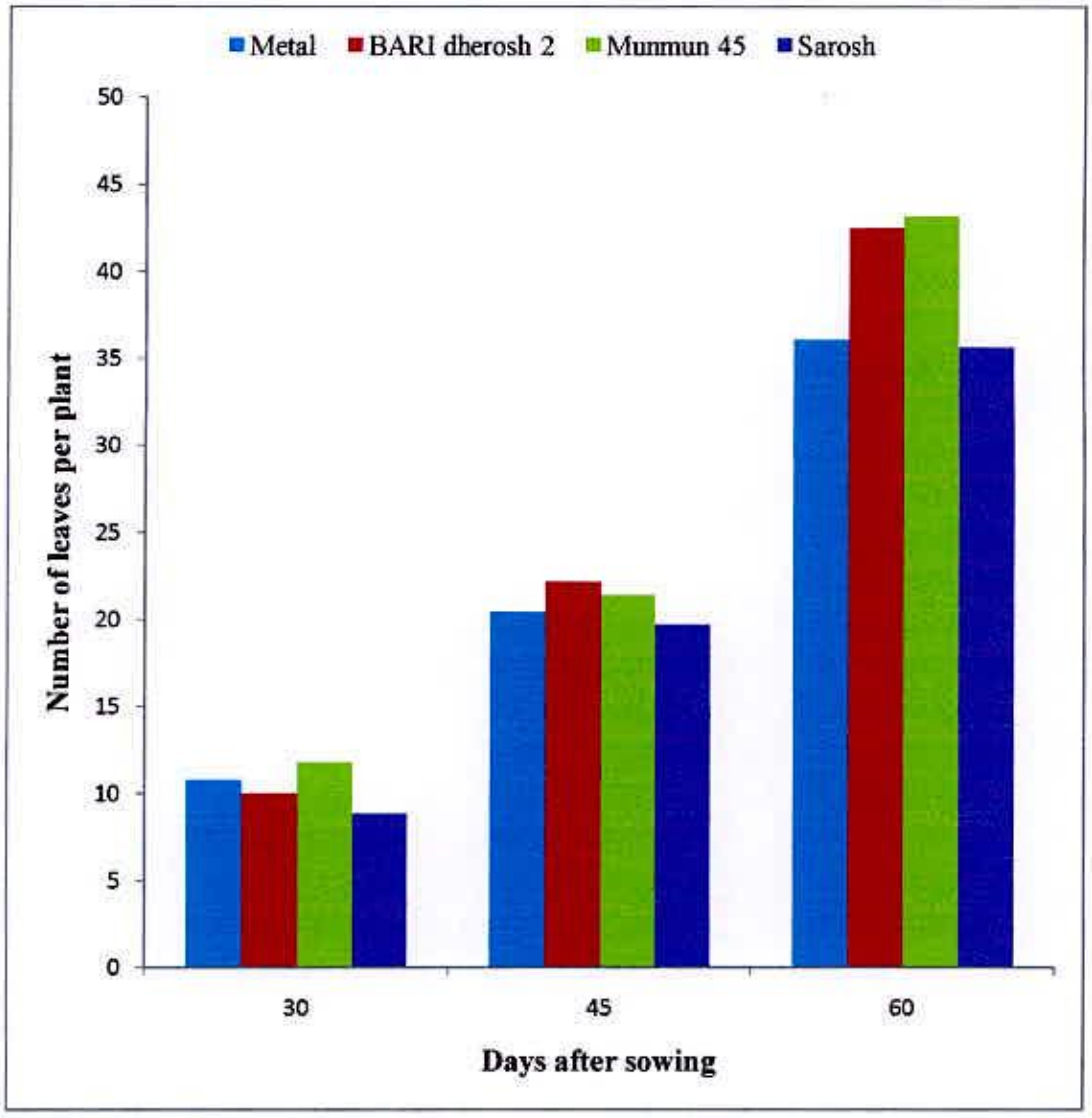


Figure 4. Effect of varieties on number of leaves per plant at different days after sowing (lsd= 5.456 and CV%= 19.49, 11.08 and 6.94 at 30, 45 and 60 DAS, respectively)

4.5 Leaf length

No significant variation was observed among the cultivars in respect of leaf length at 30, 45 and 60 DAS (Fig. 5).

At 30 DAS, numerically highest leaf length (10.13 cm) was found from Munmun 45 (V_3) and lowest leaf length (9.10 cm) was found from Metal (V_1).

At 45 DAS, numerically higher leaf length (15.8 cm) was measured from Sarosh (V_4) and lowest leaf length (14.10 cm) was found from Metal (V_1).

At 60 DAS, numerically higher leaf length (16.16 cm) was measured from Sarosh (V_4) and lowest leaf length (14.33 cm) was found from Metal (V_1).

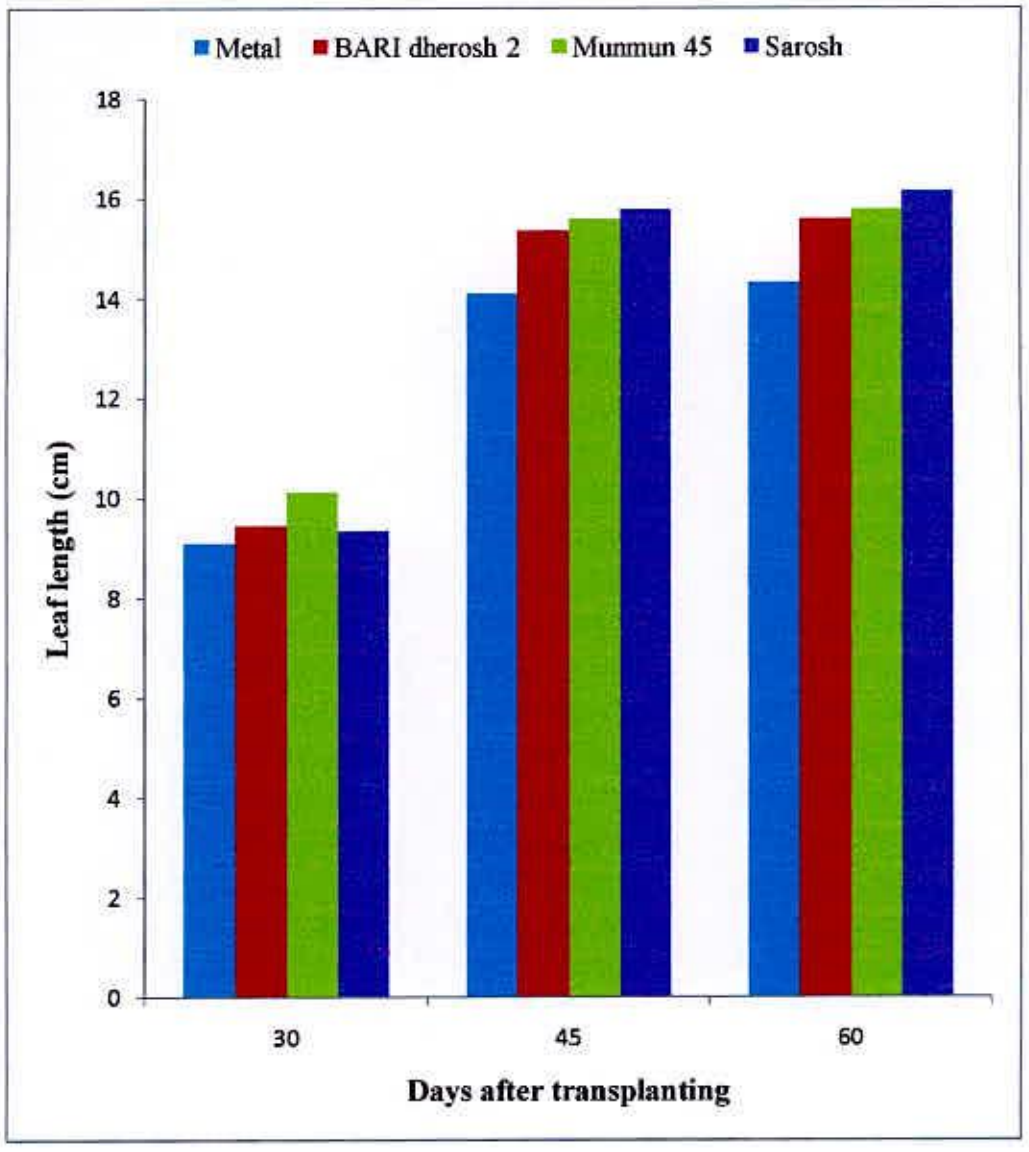


Figure 5. Effect of varieties on leaf length at different days after sowing (CV%=15.35, 10.04 and 10.39 at 30, 45 and 60 DAS respectively)

4.6 Leaf breadth

No significant variation was observed among the cultivars in respect of leaf breadth at 30, 45 and 60 DAS (Fig. 6).

At 30 DAS, numerically highest leaf breadth (12.43 cm) was found from Munmun 45 (V_3) and lowest leaf breadth (10.96 cm) was found from Sarosh (V_4).

At 45 DAS, numerically higher leaf breadth (25 cm) was measured from Munmun 45 (V_3) and lowest leaf breadth (21.6 cm) was found from Metal (V_1).

At 60 DAS, numerically higher leaf breadth (25.03 cm) was measured from Munmun 45 (V_3) and lowest leaf breadth (21.66 cm) was found from Metal (V_1).

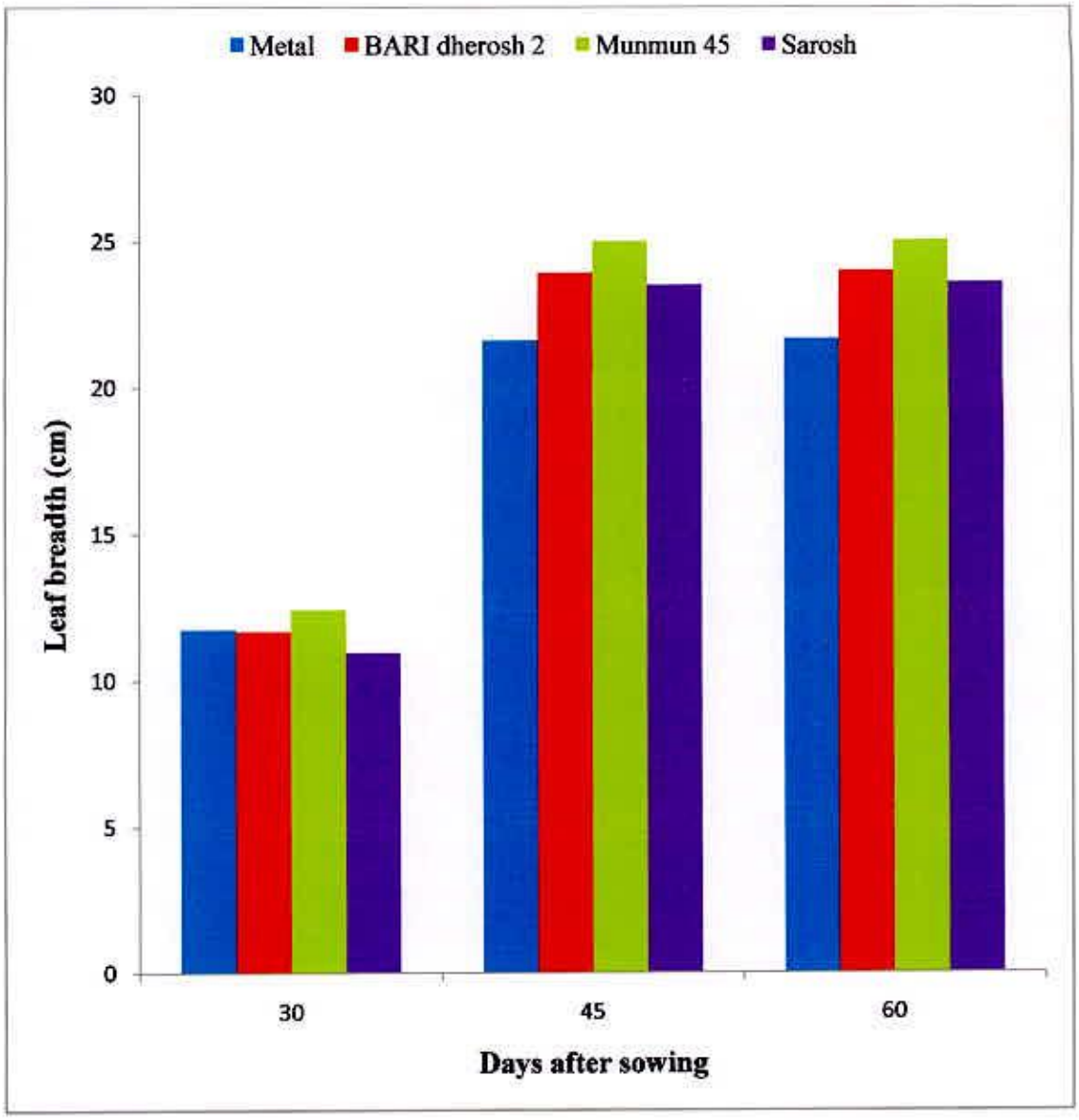


Figure 6. Effect of varieties on leaf breadth at different days after sowing (CV%=18.75, 6.85 and 6.70 at 30, 45 and 60 DAS, respectively)

4.7 Days to first flowering

No significant variation was observed among the cultivars in respect of days to flowering (Table 1). The variety Munmun 45 (V_3) required 41 days to first flowering. But other varieties required 40 days to first flowering.

4.8 Days to edible maturity

No significant variation was observed among the cultivars in respect of days to maturity (Table 1). The variety Sarosh required 6.7 days to maturity. BARI dherosh 2 (V_2), Metal (V_1) and Munmun 45 (V_3) were ready to harvest at 6.2, 6.26 and 6.46 days, respectively.

Table 1. Effect of varieties of okra on days to first anthesis and edible maturity

Treatments	Days to first flowering	Days to edible matutity
V_1	40.00	6.26
V_2	40.50	6.20
V_3	41.66	6.46
V_4	40.00	6.70
Lsd $_{0.05\%}$	**ns**	**ns**
CV (%)	**2.05**	**4.42**

4.9 Pod length

No significant variation was observed among the cultivars in respect of pod length (Fig. 7). Numerically highest pod length (12.80 cm) was found from Munmun 45 (V_3) and lowest pod length (12.06 cm) was found from Metal (V_1).

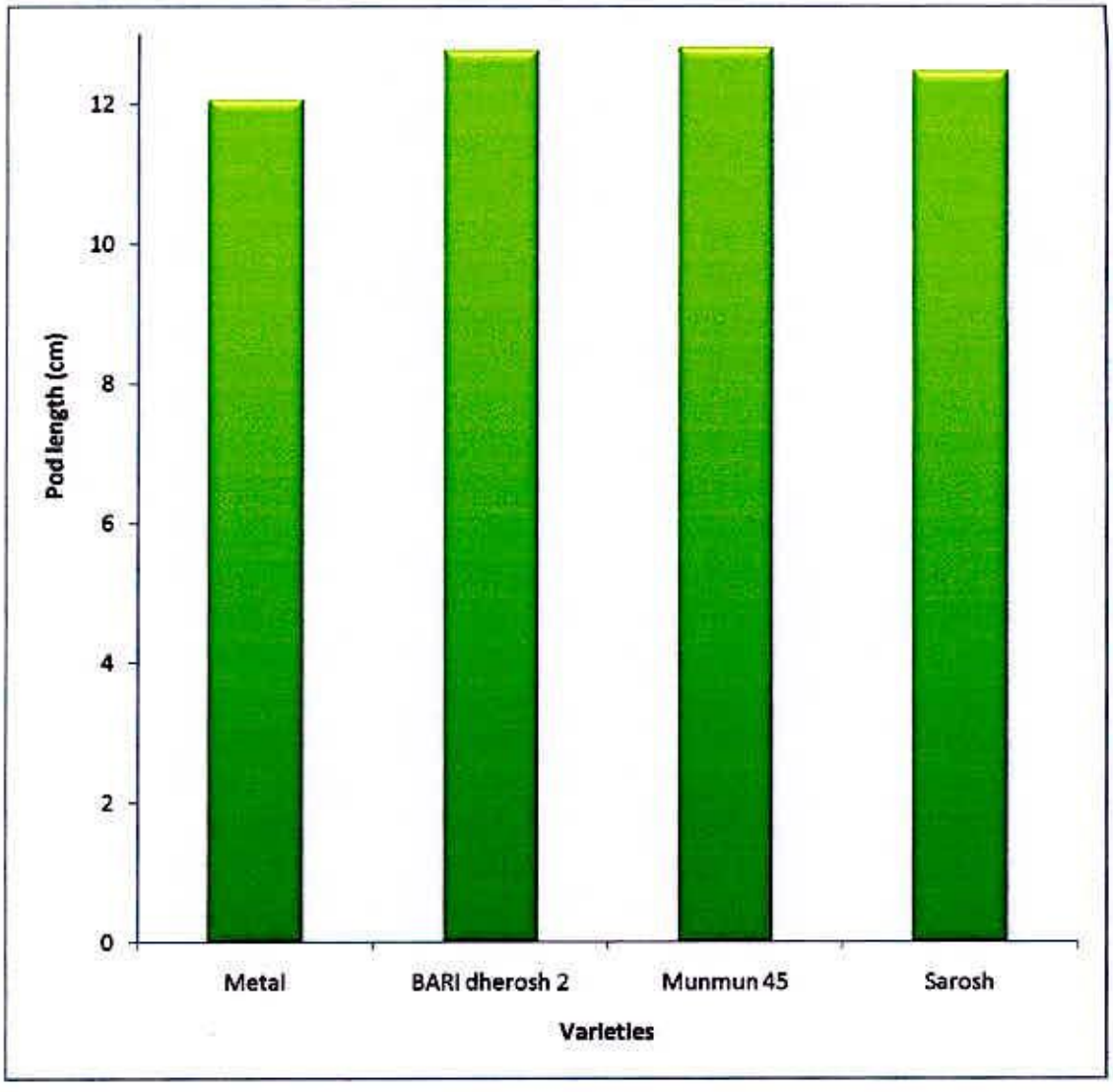


Figure 7. Effect of varieties on pod length of okra (CV%=7.2)

4.10 Pod diameter

No significant variation was observed among the cultivars in respect of pod diameter (Fig. 8). Numerically highest pod diameter (1.76 cm) was found from Metal (V_1) and lowest pod diameter (1.7 cm) was found from Munmun 45 (V_3).

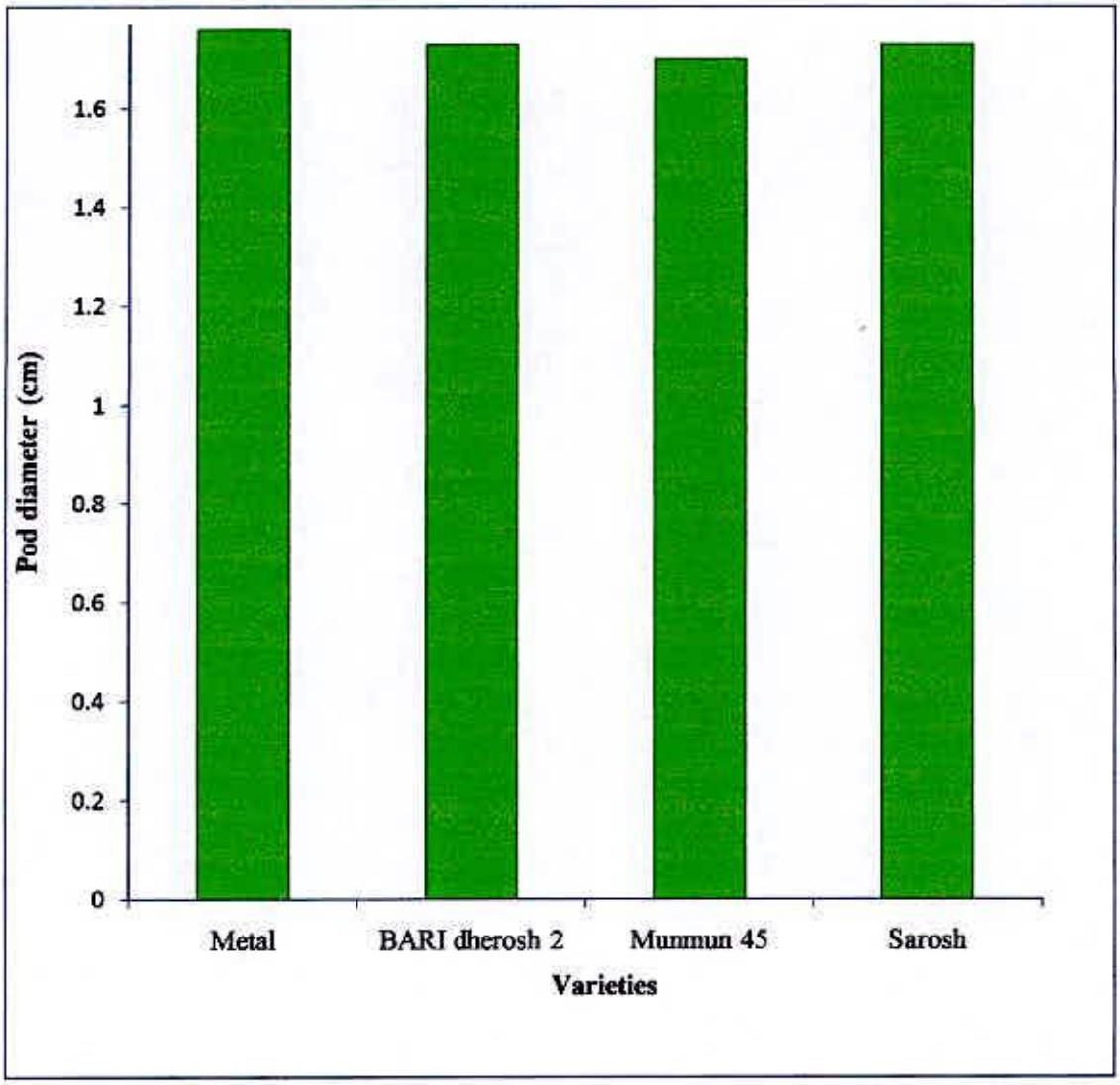


Figure 8. Effect of varieties on pod diameter of okra (CV%=6.59)

4.11 Number of pods per plant

Number of pods per plant differed significantly among the tested varieties (Fig. 9). The maximum number of pods per plant (41) was obtained from Munmun 45 (V_3) which was statistically at par with BARI dherosh 2 (V_2) due to the higher number of leaves and branches which help to increase the dry matter accumulation through photosynthesis. The minimum number of pods per plant (29.33) was found from Metal (V_1) which was similar to Sarosh (V_4). The results of present study are in good conformity with Jordan-Molero (1986), Gondane and Bhattia (1995) and Shri-Dhar and Dhar (1995), who in separate experiments have already reported variation in number of pods per plant among several okra cultivars.

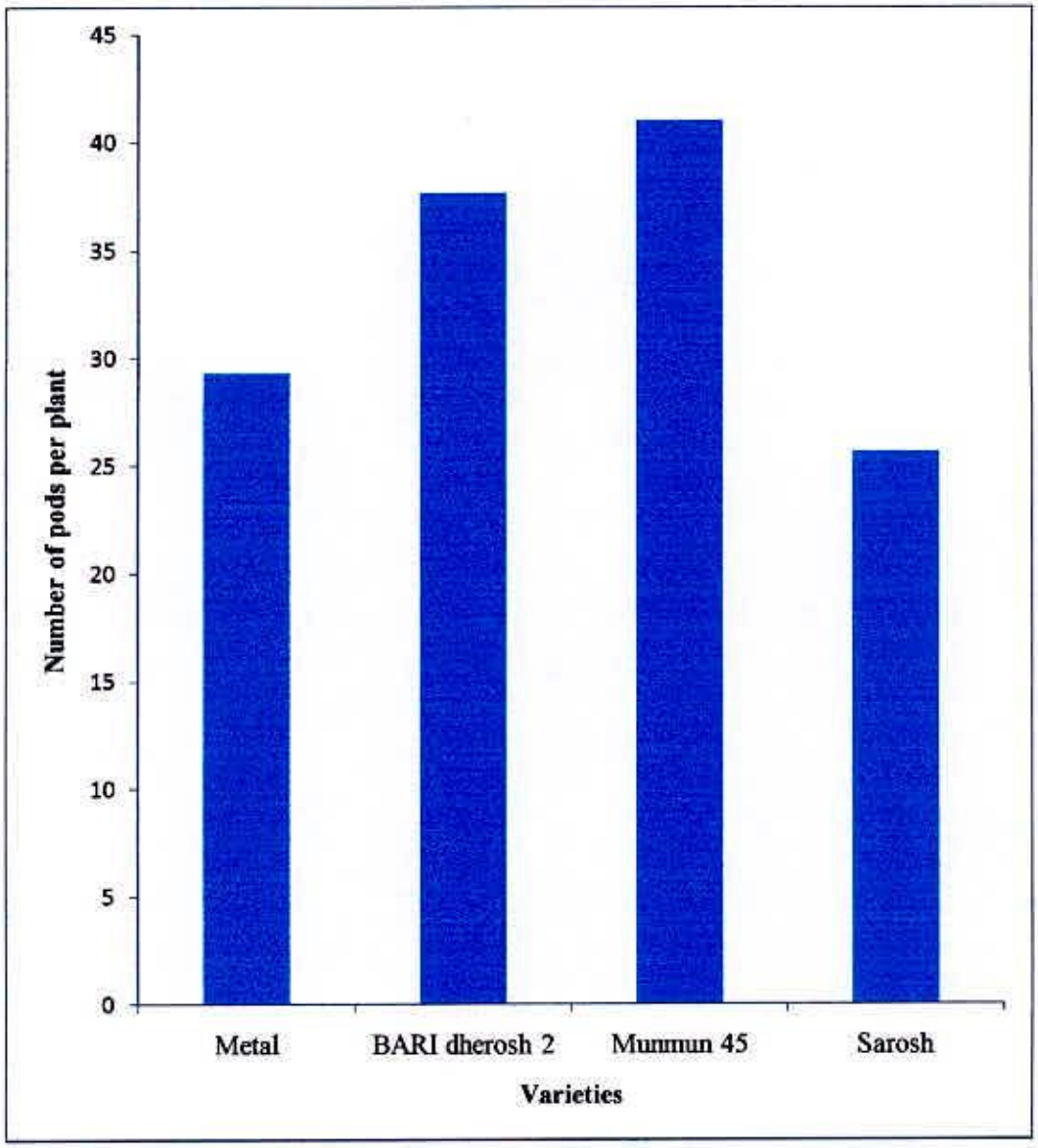


Figure 9. Effect of varieties on number of pods per plant (Lsd=8.19 and CV%= 12.27)

4.12 Pod yield per hectare

Pod yield differed significantly among the tested varieties (Fig. 10). The maximum pod yield (11.23 kg) was obtained from Munmun 45 (V_3) which was statistically at par with BARI dherosh 2 (V_2). The minimum number of pods per plant (6.8) was found from Sarosh (V_4) which was similar to Metal (V_1). Variation in yield among different okra cultivars has also been reported by other researchers (Shaikh *et al.*, 1987; Baloch *et al.*, 1990; Arora *et al.*, 1991; Somkuwar *et al.*, 1997).

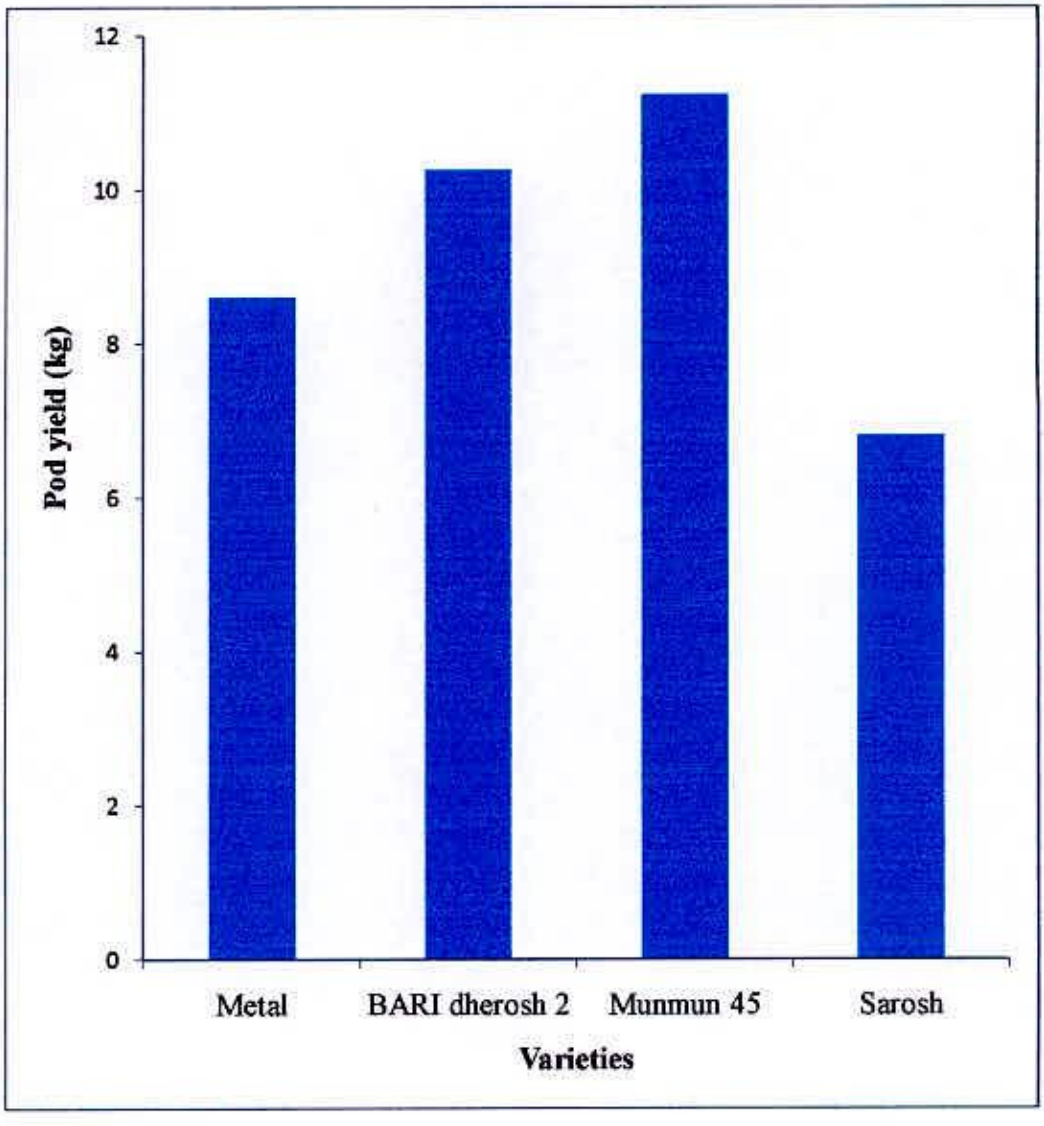


Figure 10. Effect of varieties on pod yield of okra (lsd= 2.129 and CV%= 11.55)

4.13 Pollinators

4.13.1 Types of pollinators

Investigations carried out on the major insect orders visiting okra during flowering period. Fig. 11 revealed that four groups of pollinators visited the okra belonging to order Hymenoptera, Diptera, Lepidoptera and Coleoptera during the flowering period. The number of Hymenoptera insects was higher than the others which are followed by Lepidoptera and then both of Coleoptera and Diptera. The results indicate that Hymenopterans are the major pollinators visiting okra flowers. These findings are in close agreement with Mahfouz *et al.* (2012) who studied the pollinators visiting sesame seed crop and stated that Hymenopterans were higher, followed by Lepidopterans and then both of Coleopterans and Dipterans. Viraktmath *et al.* (2001) who studied the relative abundance of pollinator fauna of sesame during two successive seasons and stated that Hymenopterans insects were higher, followed Dipterans and Lepidopterans.

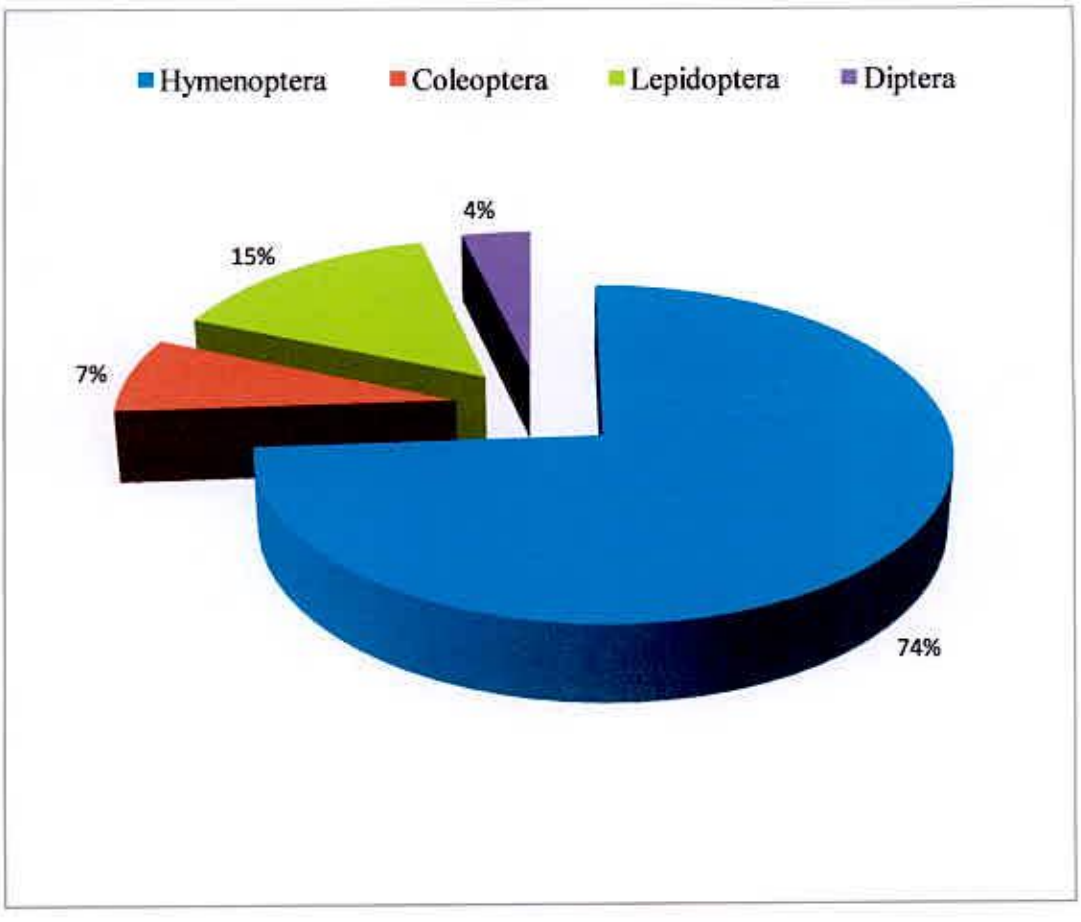


Figure 11. Percentage proportion of the major insect orders visiting okra during flowering period

4.13.2 Time span of visiting pollinators

The types as well as the number of insect visitors changed with time during the flowering span of the okra. Results in Fig. 12 revealed that insects belonging Hymenopteran order increased by increasing the number of flowers. Most bees were recorded when the number of flowers per plant was maximum (at the fourth week of flowering). Bee population decreased with diminishing of flowers per plant due to advancing age of the crop.

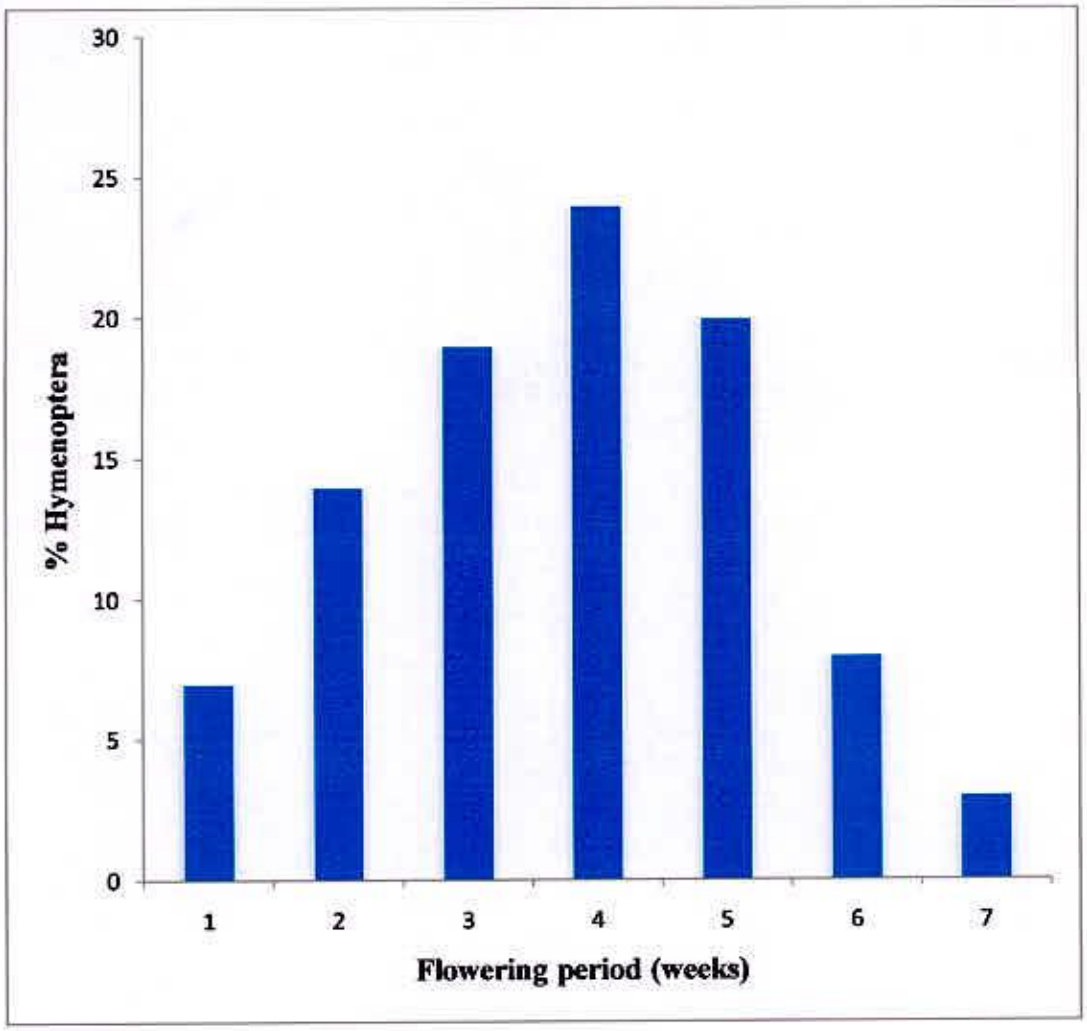


Figure 12. Fluctuation percent of Hymenopteran population during flowering period of okra

4.13.3 Time of foraging activity

Data in Fig. 13 showed that the foraging activity of the major insect orders visiting okra during flowering period. Peak of foraging activity was observed in Hymenoptera order during 9.00-11.00 am and lowest during 3.00-5.00 pm in this study. Bee pollination not only ensures the increase in yields of okra but also improve its quality. It ensures uniform maturity and early harvest of crop.

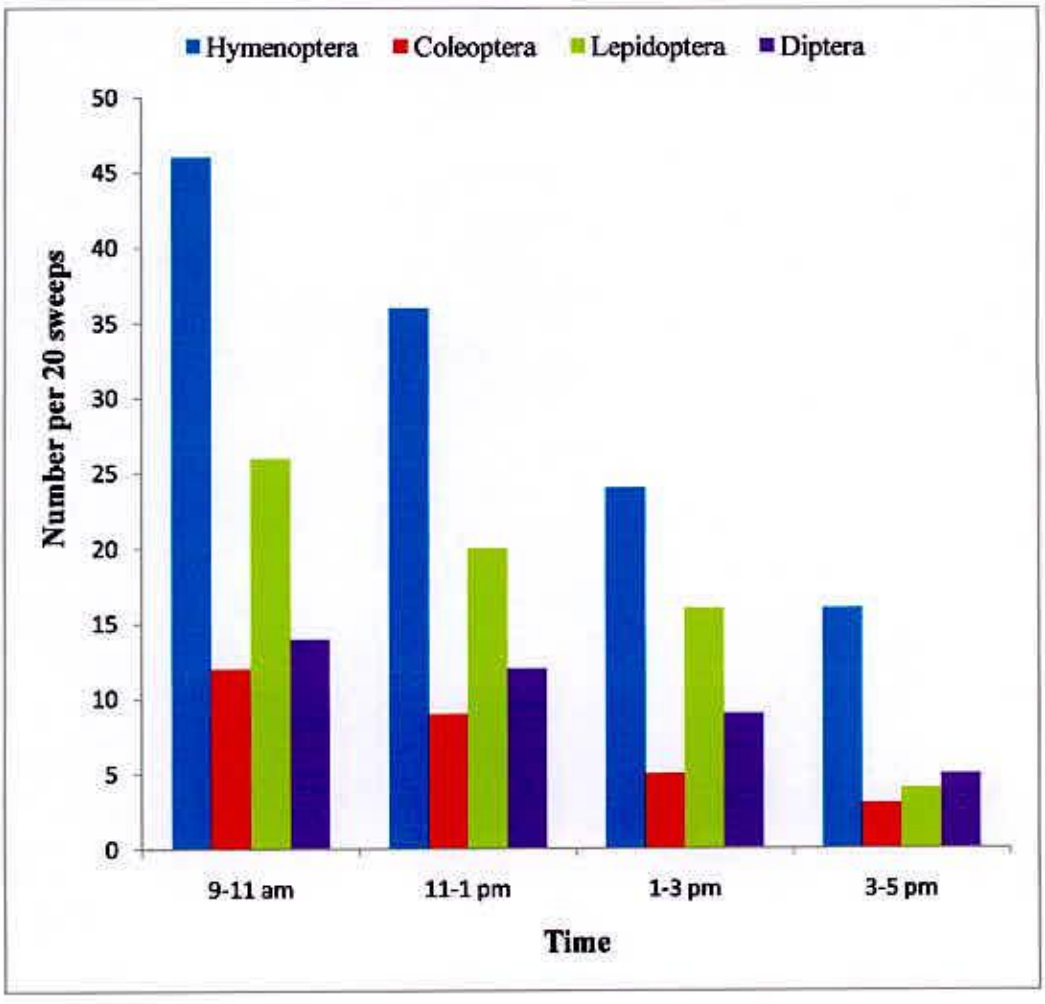


Figure 13. Foraging activity of the major insect orders visiting okra during flowering period

Major flower visiting insects.

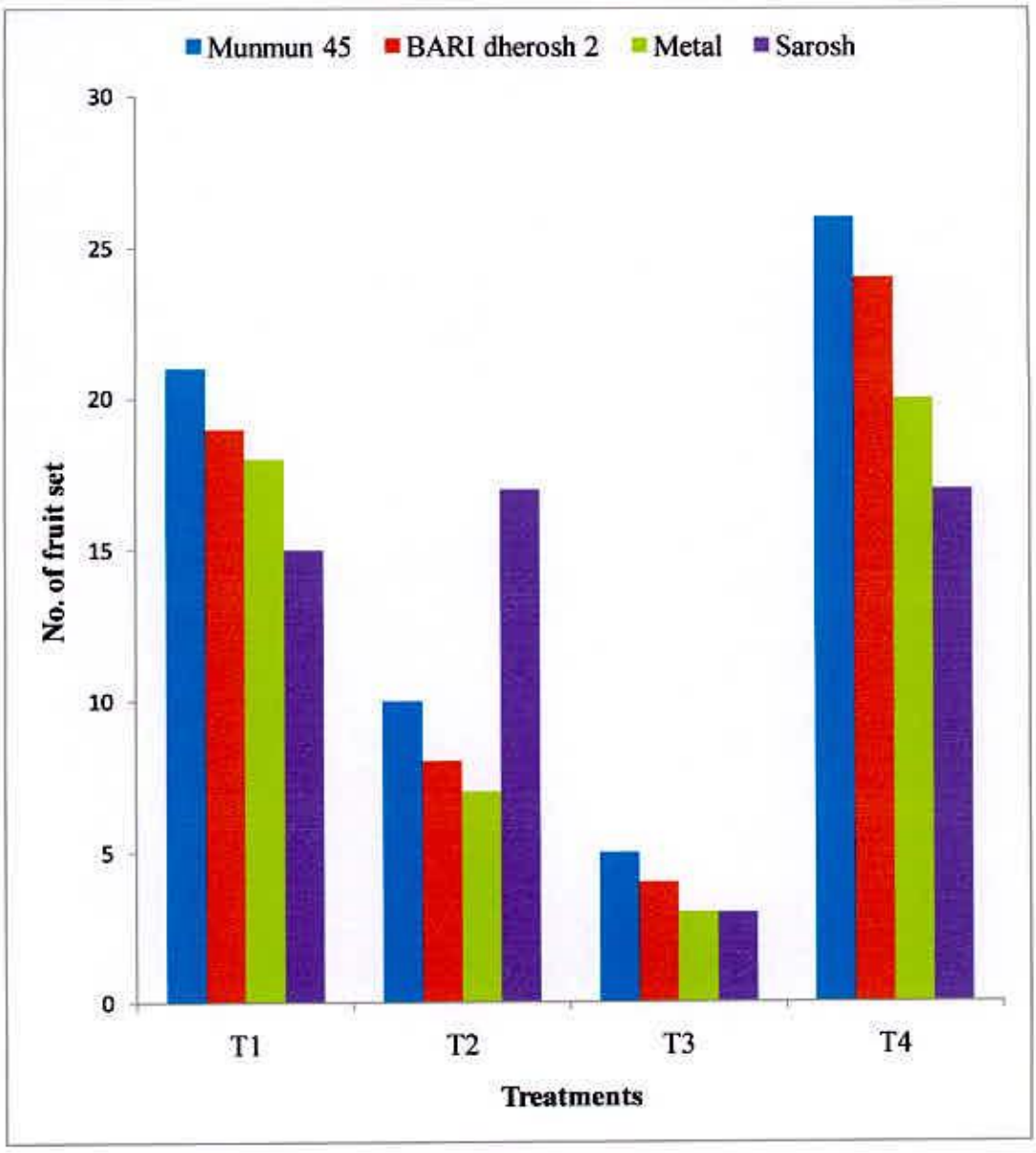
Plate 3. Ant foraging on okra flower

Plate 4. Beetle visiting on okra flower

4.14 Effect of pollinators

4.14.1 Number of fruit set

Significant variation was observed among the treatment like flowers bagged with net with medium mesh, very small mesh, net and Vaseline rubbed at the bottom of peduncle and flower without net in respect of number of fruit setting (Fig. 14). The highest number of fruit (26) in Munmun 45 was found with flower without net (T_4) due to the foraging activity of different insect orders without any kind of obstacle during the flowering period of okra which helps to pollination and ultimately increases the number of fruit setting. The second highest number of fruit (21) in BARI dherosh 2 was observed with flowers bagged with net with medium mesh (T_1). The lowest number of fruit set (5) in Sarosh was obtained from the flowers bagged with net and Vaseline rubbed at the bottom of peduncle (T_3) due to the obstacle of foraging activity of major insects during the flowering period of okra which reduces the pollination and ultimately decreases the number of fruit setting.

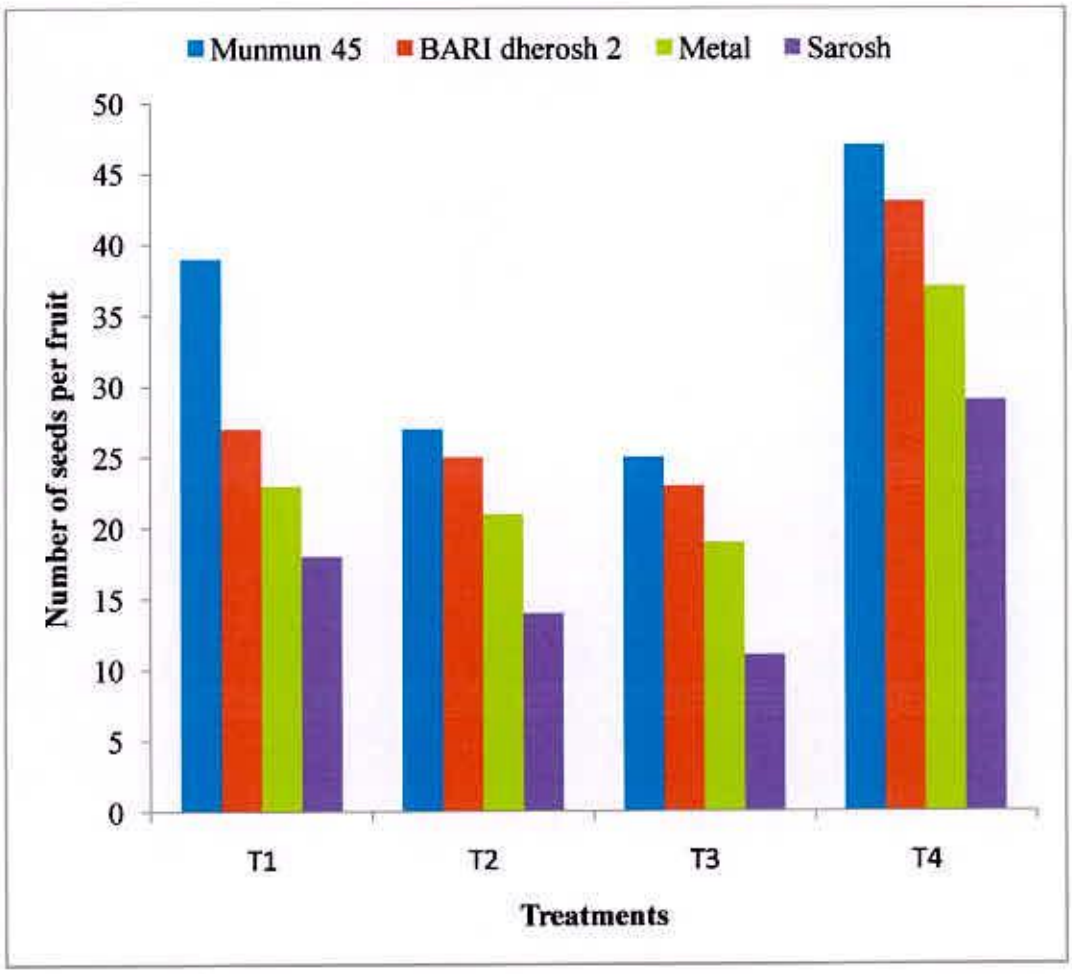


T_1=Flower bagged with net with medium mesh, T_2= Flower bagged with net with very small mesh, T_3= flower bagged with net and Vaseline rubbed at the bottom of peduncle and T_4= Flower without net (control)

Figure 14. Effect of pollinators on fruit setting of okra (Lsd=5.27 and CV%= 3.56)

4.14.2 Number of seeds per fruit

Significant variation was observed among the treatments like flowers bagged with net with medium mesh, very small mesh, net and Vaseline rubbed at the bottom of peduncle and flower without net in respect of number of seeds per fruit (Fig. 15). The highest number of seeds per fruit (47) in Munmun 45 variety was found with flower without net (T_4) due to the proper pollination effect and ultimately increases the number of seeds per fruit. The second highest number of seeds per fruit (39) in BARI dherosh 2 was observed with flowers bagged with net with medium mesh (T_1). The lowest number of seeds per fruit (25) in Sarosh was obtained from the flowers bagged with net and Vaseline rubbed at the bottom of peduncle (T_3) due to the obstacle of foraging activity of major insects during the flowering period of okra which reduces the pollination and ultimately decreases the number of seeds per fruit.

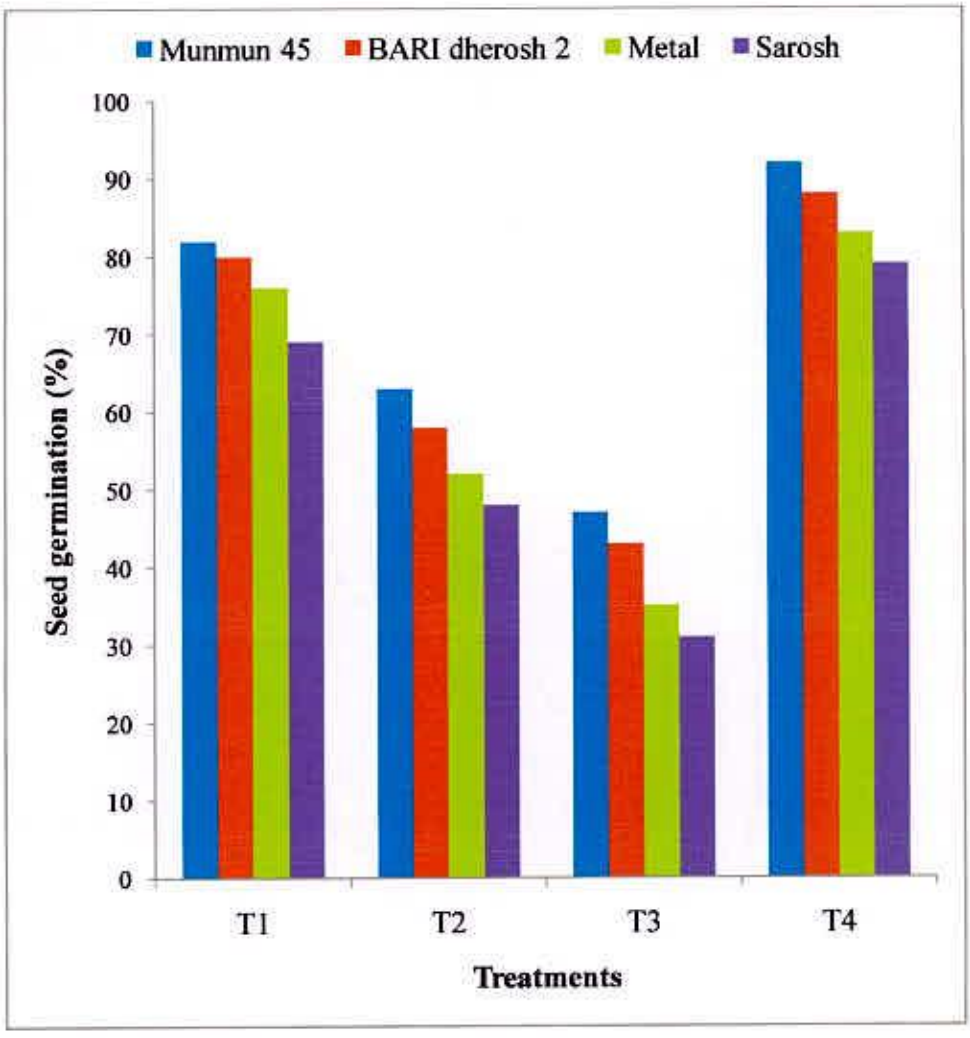


T_1=Flower bagged with net with medium mesh, T_2= Flower bagged with net with very small mesh, T_3= flower bagged with net and Vaseline rubbed at the bottom of peduncle and T_4= Flower without net (control)

Figure 15. Effect of pollinators on number of seeds per fruit (lsd= 4.05 and CV%= 6.97)

4.14.3 Germination test

Significant variation was observed among the treatment like flowers bagged with net with medium mesh, very small mesh, net and Vaseline rubbed at the bottom of peduncle and flower without net in respect of percent of germination of seeds (Fig. 16). The highest number of germination of seed (92%) in Munmun 45 was found with flower without net (T_4) due to the proper pollination effect. The second highest number of germination of seed (82%) in BARI dherosh 2 was observed with flowers bagged with net with medium mesh (T_1). The lowest number of germination of seed (47%) in Sarosh was obtained from the flowers bagged with net and Vaseline rubbed at the bottom of peduncle (T_3) due to the obstacle of foraging activity of major insects during the flowering period of okra which reduces the pollination and ultimately decreases the germination percentage.



T_1=Flower bagged with net with medium mesh, T_2= Flower bagged with net with very small mesh, T_3= flower bagged with net and Vaseline rubbed at the bottom of peduncle and T_4= Flower without net (control)

Figure 16. Effect of pollinators on seed germination percentage (lsd=6.34 and CV%= 5.45)

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted at the field, Sher-e-Bangla Agricultural University (SAU), during May to September, 2011 in kharif season with a view to finding out the effect of pollinators and yield characteristics of different varieties of okra. The experimental treatments included four okra varieties (V_1 = Metal, V_2 = BARI dherosh 2, V_3 = Munmun 45, V_4 = Sarosh) and four different treatments were to find out the effect of pollinators on okra yield (T_1 = Flowers bagged with net with medium mesh, T_2 = Flowers bagged with net with very small mesh, T_3 = Flowers bagged with net and Vaseline rubbed at the bottom of peduncle, T_4 = Flower without net (control). The experiment was laid out in randomized complete block design with three replications. The total numbers of unit plots were 12. The size of unit plot was 3m x 3m = $9m^2$.

The soaked 2-3 seeds were sown regarding to the treatment in the rows of the raised bed with maintaining the row to row and plant to plant distance. Intercultural operations such as fertilizer application, gap filling, weeding, water management and pest management were done as and when necessary.

The data on crop growth characters like plant height, plant girth, Branches per plant, leaves per plant and leaf length and breadth were recorded at 30, 45, 60 DAS. The yield contributing characters like pod length, pod diameter, pods per plant and days to edible maturity were recorded. The pollinators were observed during four periods in a day and identified in the laboratory. Finally the data were analyzed by using the MSTAT computer package program. The mean differences among the treatments were compared by Least Significant Difference Test (LSD).

A significant variation in plant height at different plant ages was observed due to varietal differences. Plant height increased progressively up to maturity. At 30, 45 and 60 DAS highest plant height (19 cm, 110.66 cm and 143.67 cm,

respectively) was observed from BARI dherosh 2 and the shortest plant height was obtained from Sarosh and Munmun 45.

No significant variation was observed among the cultivars in respect of plant girth at 30, 45 and 60 DAS. At 30 DAS and 45 DAS, numerically highest plant girth (0.70 cm and 1.73 cm) was found from Sarosh (V_4) and lowest plant girth (0.60 cm and 1.56 cm) was found from Metal (V_1). At 60 DAS, numerically higher plant girth (3.4 cm) was measured from BARI dherosh 2 (V_2) and lowest plant girth (209 cm) was found from Metal (V_1).

Significant variation was observed among the cultivars in respect of number of branches per plant and number of leaves per plant at 60 DAS but insignificant at 30 and 45 DAS. At 30 DAS, numerically higher number of branches per plant (0.53) was obtained from Munmun 45 (V_3) and lower number of branches per plant (0.26) from Metal (V_1) and Sarosh (V_4). At 45 DAS, numerically higher number of branches per plant (3.93) was obtained from BARI dherosh 2 (V_2) and lower number of branches per plant (3.13) from Sarosh (V_4). At 60 DAS, maximum number of branches per plant (4.06) was obtained from BARI dherosh 2 (V_2) and minimum number of branches per plant was found from (3.2) from Sarosh (T_4).

At 30 DAS, numerically higher number of leaves per plant (11.8) was obtained from Munmun 45 (V_3) and lower number of leaves per plant (8.87) from Sarosh (V_4). At 45 DAS, numerically higher number of leaves per plant (22.2) was obtained from BARI dherosh 2 (V_2) and lower number of leaves per plant (19.73) from Sarosh (V_4). At 60 DAS, maximum number of leaves per plant (43.2) was obtained from BARI dherosh 2 (V_2) and minimum number of leaves per plant was found from (35.66) from Sarosh (V_4).

No significant variation was observed among the cultivars in respect of leaf length and leaf breadth at 30, 45 and 60 DAS. At 30 DAS, numerically highest

leaf length (10.13 cm) was found from Munmun 45 (V_3) and lowest leaf length (9.10 cm) was found from Metal (V_1). At 45 DAS, numerically higher leaf length (15.8 cm) was measured from Sarosh (V_4) and lowest leaf length (14.10 cm) was found from Metal (V_1). At 60 DAS, numerically higher leaf length (16.16 cm) was measured from Sarosh (V_4) and lowest leaf length (14.33 cm) was found from Metal (V_1).

At 30 DAS, numerically highest leaf breadth (12.43 cm) was found from Munmun 45 (V_3) and lowest leaf breadth (10.96 cm) was found from Sarosh (V_4). At 45 DAS, numerically higher leaf breadth (25 cm) was measured from Munmun 45 (V_3) and lowest leaf breadth (21.6 cm) was found from Metal (V_1). At 60 DAS, numerically higher leaf breadth (25.03 cm) was measured from Munmun 45 (V_3) and lowest leaf breadth (21.66 cm) was found from Metal (V_1).

No significant variation was observed among the varieties in case of flowering period, edible maturity, pod length and pod diameter. Number of pods per plant and pod yield differed significantly among the tested varieties. The maximum number of pods per plant (41) was obtained from Munmun 45 (V_3) and minimum number of pods per plant (29.33) was found from Metal (V_1). The maximum pod yield (11.23 kg) was obtained from Munmun 45 (V_3) and minimum number of pods per plant (6.8) was found from Sarosh (V_4).

Four groups of pollinators visited the okra belongs to order Hymenoptera, Diptera, Lepidoptera and coleopteran of class insects during the flowering period. The number of Hymenoptera was higher, followed by Lepidoptera and then both of Coleoptera and Diptera. It was observed that Hymenopterans are the major pollinators visiting okra flowers. The insects belong to Hymenopteran order increased by increasing the percentage of flowers. Bee population decreased with diminishing of flowers per plant due to advancing

age of the crop. Peak of foraging activity was observed in Hymenoptera order during 9.00-11.00 am and lowest during 3.00-5.00 pm in this study.

Significant variation was observed among the treatments like flowers bagged with net with medium mesh, very small mesh, net and Vaseline rubbed at the bottom of peduncle and flower without net in respect of number of fruit setting, number of seeds per fruit and germination percentage. The highest number of fruit (26), seeds per fruit (47) and germination of seed (92%) was found with flower without net (T_4) due to the foraging activity of different insect orders without any kind of obstacle during the flowering period of okra which helps to pollination and ultimately increases the number of fruit setting. The lowest number of fruit set (5), seeds per fruit (25) and germination of seeds (45%) was obtained from the flowers bagged with net and Vaseline rubbed at the bottom of peduncle (T_3) due to the obstacle of foraging activity of major insects during the flowering period of okra which reduces the pollination and ultimately decreases the number of fruit setting.

It could be concluded that among the tested okra varieties the maximum number of pods per plant (41) and pod yield (11.23 kg) was obtained from Munmun 45 (T_3). The results indicate that Hymenopterans are the major pollinators visiting okra flowers and peak of foraging activity was observed in Hymenoptera order during 9.00-11.00 am and lowest during 3.00-5.00 pm which increased the highest number of fruit setting (26), number of seeds per plant (47) and germination percentage (92%).

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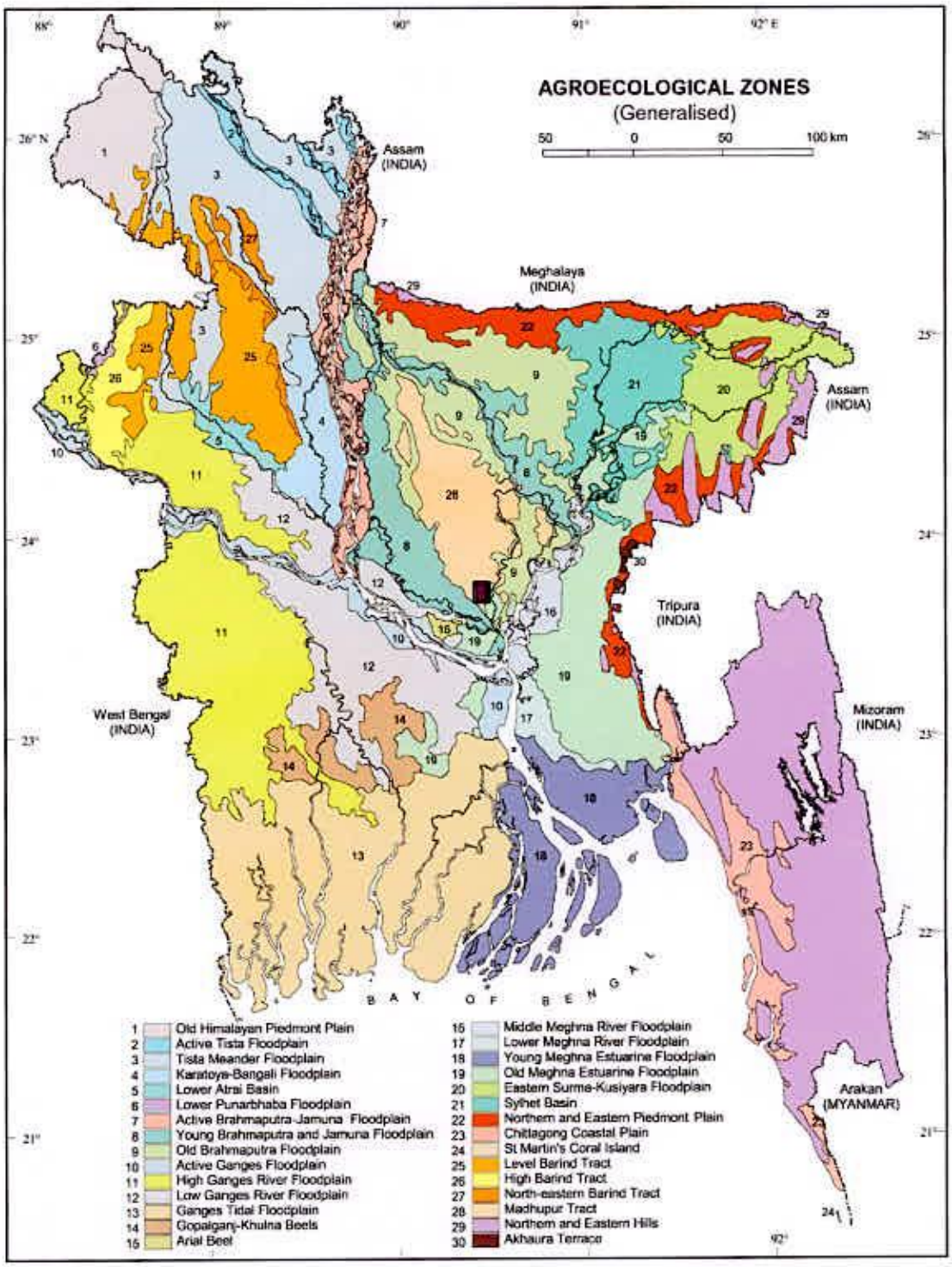
Appendices

APPENDICES

Appendix I. Map showing the experimental site under study



■ Position of experimental site

Appendix II. Weather data, 2011, Dhaka

Month	Average RH (%)	Average Temperature (°C)	Total Rainfall (mm)	Average Sunshine hours
May	81	32.9	340.4	4.7
June	84	31.9	1721	3.3
July	80	31.1	1295	4.9
August	80	31.4	1191	3.0
September	78	31.5	805	5.2
October	77	29.5	172.3	5.7

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.