SCREENING OF OKRA GERMPLASM BASED ON MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS

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CERTIFICATE

This is to certify that the thesis entitled **"***SCREENING OF OKRA GERMPLASM BASED ON MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS***"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agricultural Botany**, embodies the result of a piece of *bona fide* research work carried out by **MD. Kamrul Hasan** Registration number: **09-03502** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Dr. Md. Moinul Hoque
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SCREENING OF OKRA GERMPLASM BASED ON MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS

ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207, from March to July, 2014 to evaluate promising cultivars of okra. Sixteen okra cultivars viz. Shaymol Bangla, Sarosh-3, BARI Dherosh-1, Porosh Plus, OK-285, Deb-412, Parvani Kranti, Kalatia, Green soft, Arka Anamika, Malvika, Green valley, Toa DK-2, Shehzadi, Gunjon, Kochi were used as treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Screening was done based on morphological features, yield and yield contributing features and physiological features. Leaves per plant were the maximum for Parvani kranti at harvest. Anthesis occurred in OK-285 prior to any other varieties. Minimum incidence of YVMV was found from the variety Sharosh-3. In all other morphological attributes *viz.* plant height, days required for 80% germination, pods plant^{-1} and pod yield as well as physiological attributes like net assimilation rate, intercellular CO_2 concentration, respiration rate and stomatal conductance were the highest for variety Green valley. The highest pod yield (14.26 t/ha) was obtained from the variety Green valley which was closely followed by Porosh plus (10.22 t/ha) and the lowest yield was obtained from the variety Parvani kranti (5.23 t/ha). So, Green Valley was the best variety in respect of morphological and physiological characteristics among the studied varieties.

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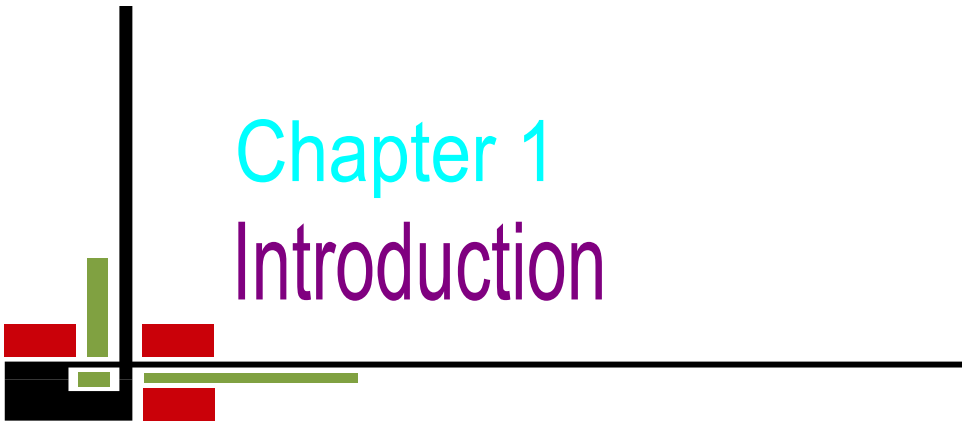
LIST OF ABBRIVIATION

ABBRIVIATION	FULL NAME
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Cont'd	Continued
Cm.	Centimeter
DAS	Days after Sowing
^{0}C	Degree Centigrade
et al.	and others
etc.	Etcetera
eg.	Example
g	Gram
HI	Harvest Index
Zn	Zink
Kg	Kilogram
Kg/ha	Kilogram per hectare
LSD	Least significant difference
LAI	Leaf Area Index
m	Meter
ns	Non-significant
%	Percent
CV%	Percentage of Coefficient of Variance
SRDI	Soil Resources and Development Institute
viz.	Namely
P	Phosphorus
B	Boron
S	Sulphur



Chapter 1
Introduction

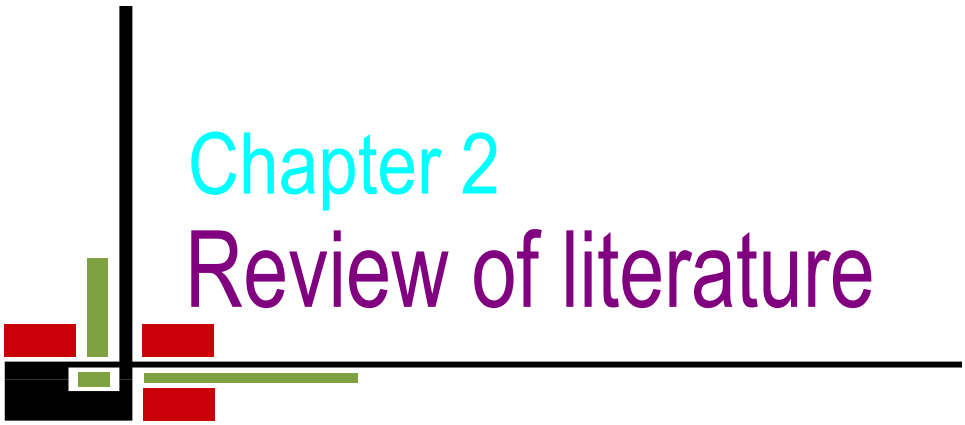
Chapter 1

INTRODUCTION

Vegetables are one of the essential items of daily requirement. Daily consumption of vegetables in Bangladesh is 96 gm whereas 200 gm is recommended (Haque, 2002). Okra (*Abelmoschus esculentus* L.) is a popular and important vegetable crop grown mainly for its tender green fruits in Bangladesh. The cultivation of okra in terms of area has gradually been increasing in Bangladesh, although per hectare production is either remain static or gradually declining (BBS, 2009). Total production of okra was 42,366 MT produced from 10,204 ha of land in the year 2009-2010 and the average yield was 3.92 t/ha (BBS, 2010), which is very low compared to that of other developed countries where the yield was as high as 14.0-15.0 t/ha (Gondane and Bhattia, 2009). Again, biological potential of most varieties ranges from 15 to 16 t/ha. Unfortunately, the crop rarely reaches its yield potential in most of these areas, primarily due to the use of unimproved cultivars (Eshiet and Brisibe, 2015). Again in our country we have only one BARI released HYV of okra (BARI Dherosh-1). Local germplasm may be rich but still unexploited. Most of the varieties found in local market are hybrid varieties developed by private organizations. Their performance trial is very meager in research institute or in universities. Growers in all regions of the country have come across with many problems. Okra Yellow Vein Mosaic Virus (YVMV)

transmitted by white fly (*Bemisia tabaci*) is one of these (Ali et al., 2000). All locally grown recommended varieties of okra are susceptible to this disease (Sastri and Singh, 1994). Varietal resistance is the only effective way to check this loss. Again, Grindal (1980) commented that Okra production is greatly influenced by agronomic practices. Dash *et al.* (2013) said that there is scope of increasing okra yield per unit area with appropriate selection of cultivar. Hence the research is designed with some cultivars to work in field condition with the following objectives:

- To study the morpho-physiological attributes of some cultivars of okra
- Selection of promising okra variety based on growth and yield attributes



Chapter 2
Review of literature

Chapter 2

REVIEW OF LITERATURE

Growth, yield performance and production capability of okra varieties have been extensively studied in various part of the world. But very little work have been done in the agro-ecological condition of Bangladesh. Some related works have been mentioned here:

2.1. Days to 80% germination

Khan *et al.* (2002) in their experiment found non-significant difference among different okra varieties in number of days required for 80% germination. Pusa sawani required minimum 7.33 days for 80% germination. He opined that this might be due to the proper utilization of nutrient which boosted up the performance.

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013). Significant variations were observed among the different Okra cultivars for days to emergence. The cultivars Sarhad Green and Pusa Sawani showed maximum number of days (14) to emergence, while other three cultivars i.e. Sabz pari, Green Star and Pusa Green showed minimum number of 12 days to emergence, statistically behaved alike this was due to methods of storage or due to different seed viability and shelf life. While it may be noticed that each genotype have different characters which was directly affected on days to emergence. The results are also in agreement with Amjad *et al* (2001).

Some agronomic traits and yield components of four cultivars of okra (NHAe-47-4, V35, LD88 and a local variety), were compared by Eshiet *et al.* (2015). First, there were no significant differences (p>0.05) in the mean number of days taken for seedlings of the four varieties of okra to emerge. Cultivars NHAe-47-4 and V35 took a mean number of 4.33 days to emerge while LD88 and the local variety took a mean of 4.20 and 3.25 days, respectively.

2.2. Plant height

Some agronomic traits and yield components of four cultivars of okra (NHAe-47-4, V35, LD88 and a local variety), were compared by Eshiet *et al.* (2015). The growth parameters were significantly affected by the okra variety. Plant growth measured as plant height (in cm) was different among the four okra varieties evaluated. The tallest plants at flowering were recorded for LD88, with a mean value of 128 cm. This was closely followed by those of NHAe-47-4 and V35 with a mean height of 119.67 cm and 118.15 cm, respectively, which were greater than that produced by plants from the local variety with a mean height of 49.75 cm. Mean square estimates for plant height at flowering showed significant (p <0.05) differences amongst the four okra varieties evaluated in the current study.

Field Studies were conducted by Iyagba *et al.* (2012) to determine the influence of weed interference on the growth and yield of three okra (*Abelmochus esculentus* (L) Moench) varieties. Three varieties of okra (NHAe47-4, Lady's

finger and V35) were weeded using five weeding regimes. The growth parameters were significantly affected by the okra variety and the different weeding regime. In both years, Lady's finger was significantly taller than the other two varieties.

Plant height revealed clearly significant variation among Okra cultivars in experiment by Naheed *et al.* (2013). Maximum plant height (116.4 cm) was found in Okra cultivar Sarhad Green whereas the minimum plant height (112.3 cm) was found in Green Star. The variation was may be of different genotypes having different characters. During the study period the temperature was retained up to 34 0C and rainfall was up to 171 mm average. This is probably intake, uptake equivalence to output of growth of the plants. Photosynthetic activity increased during August with the application of Nitrogen were responsible may be for inducing more branches.

Dash et al. (2013) experimented to study the effect of variety and panting date on the growth and yield of okra. Three planting dates (1 February, 15 February and 2 March) and three varieties (BARI Dherosh-1, Arka Anamica and Annie Oakley) were used as treatment variables. Plant height varied significantly among the varieties. Muhammad *et al.* (2001) reported similar results in case of variety Arka Anamica. Significantly variation was found among the different planting date in respect of plant height after different days of sowing. The possible reason could be that in February 1 planting plants received proper

environment, water and other natural resources that results in better growth. The results of the present study are at par with Magar and Nirmal (2010). They also reported that plat height in okra increased in February 21 planting and early (January 15) or late (March 25) planting, reduced the plant height. In an experiment by Biswas *et al.* (2008) the influence of variety on the height of okra and the number of branches was found significant. The Serial okra variety (V2) recorded the highest mean of 10.3 at 2 WAS and 22.1 at 4 WAS whereas the highest mean of 32.2 at 12 WAS was recorded by improved (V1) okra variety. Significant ($p<0.05$) differences were observed among all the means. The local (V3) okra variety was shorter in height as compared to improved and serial varieties. It was also noticed that, the improved and serial varieties performed better during the dry season irrigation with high temperature. These findings agreed with that of Tindal (1983), who reported that taller okra plants were obtained at maximum temperature of 25 to 35°C. High maximum temperature was experienced during the vegetative growth and consequently more assimilates production which probably induced better yield in the dry season. This result supports similar work on okra by Randhawa (1967) who reported that growth and development of okra can be influenced by season.

2.3. Leaves plant^{-1}

Some agronomic traits and yield components of four cultivars of okra (NHAe-47-4, V35, LD88 and a local variety), were compared by Eshiet *et al.* (2015).

Number of leaves also differed significantly (p <0.001) among the okra varieties at flowering. NHAe-47-4 had the highest mean number of leaves (19.33) at flowering, followed by V35 and LD88 with a mean value of 17.09 and 8.2, respectively, while the local variety had the least mean (7.5) number of leaves at flowering. NHAe-47-4 and V35 also produced significantly larger sizes of leaves.

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013).Data regarding number of branches per plant gave significant differences among cultivars. The cultivar Sarhad Green showed maximum number of branches (19.80) per plant and minimum number of branches (13.23) was shown by cultivar Sabz Pari which is closely followed by Pusa Sawani with 14.23 branches per plant. May be this is due to their naturally happen. On the other hand during experiment 185Kg N/ha was applied which was also responsible for the vegetative growth, it has induced more number of branches/plant.

In the experiment by Dash *et al.* (2013) number of branches/plant varied significantly among the varieties. Hussain *et al.* (2006) reported that branch production changed due to change in both environment and varieties. Significant variation was found among the different planting date in respect of number of branches/plant (Table 4). Jaiprakash and Mulge (2004) reported that

number of branches/plant increased in late planting compared to early planting which are at par my results. The environment as well as natural resources such as soil, water etc. was favorable for growth and development of variety Annie Oakley. For this reason Annie Oakley variety produced more branches compared to another variety.

2.4. Days to anthesis

Days taken to flowering was found significant for varietal difference by Khan *et al.*(2002). Maximum value was found for variety Pusa sawani (48.33) followed by penta green and clemeson; 45 and 44.33 days respectively and they were statistically at per with each other.

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013). Days to initial flowering after sowing indicated the non-significant among all cultivars. As there were no significant variations among the treatment means, the variety Pusa Sawani took the maximum days (55) to flowering, closely followed by Green Star with (54.67) days. It indicates that the cultivars behaved statistically alike and stood at par each other.

Dash *et al.*(2013) experimented to study the effect of variety and panting date on the growth and yield of okra. Three planting dates and three varieties (BARI Dherosh-1, Arka Anamica and Annie Oakley) were used as treatment variables.

Days for first flowering varied significantly among the different varieties (Table 3). The variety Annie Oakley produced early flower (36.57 days) and delayed flowering (39.24 days) were observed in variety Arka Anamica. Singh *et al.* (1996) found variation among the varieties for flowering and found that variety Arka Anamica required longer time (40.45 days) for first flowering. Days for first flowering varied significantly among the different planting date in respect of days for first flowering (Table 4). Planting in March 2 produced early flowers (36.67 days) and delayed flowering (38.39 days) was recorded in February 2 planting. Amjad *et al.* (2001) found significant effect of planting date on the days taken to first flowering. They also found that late planting gave early flowering compared to other planting date. Annie Oakley was a hybrid variety. Due to varietal characteristics Annie Oakley gives early flower compare to another variety Arka Anamica. On the other hand, in case of late planting physiological change is rapid and facilitated early flowering.

2.5. YVMV incidence

Prakasha (2010) conducted an experiment consisting of 55 treatments (ten parents viz and 45 crosses) were raised in randomized block design with three replications on two dates of sowing i.e. (i) the first week of June (2007) for rainy season crop, and (ii) last week of June (2007) for late rainy season crop. Maximum disease incidence was found for Pusa sawani (81.23%), followed by VRO- 5 and Parvani kranti. Fifty five genotypes of okra were screened for

yellow vein mosaic virus (YVMV) disease under field conditions by Prashantha *et al.* (2008).The percent disease incidence ranged from 7.20 to 100.00. The genotypes (IC111479, EC 30-5615 and IC90194) were having high incidence (100%) of YVMV. Further, the genotypes (EC305647, EC 305649, IC 90077 and IC90165) having lesser per cent incidence of YVMV were classified into highly resistant, resistant, moderately resistant and moderately susceptible, respectively.

Fifteen okra varieties (Lucky file 473, KN -OYV- 01, KN-OYV-02, KN-OYV-03, KN-OYV-04, KN-OYV-11, KN-OYV-13, KN-OYV-14, KN-OYV-16, KN-OYV-25, NO 71, OP (control accession), PC 52S5, PJ. 03 and TVRC 064) were experimented by Benchers (2011). Maximum disease incidence was found for OP (100%) followed by Pj 03 (68.05%) and Luck file 473 (67.5%).

Rasid *et al.*(2002) experimented with twelve okra varieties. Among them OK 292 and OK 285 showed minimum disease resistance. On the other hand maximum disease incidence was recorded for OP variety. Ali *et al.*(2005) experimented with four okra varieties namely Saloni F1, Subz Pari, Diksha and Lush Green. Among them the variety Saloni F1 was highly resistant while Subz Pari was moderately resistant. Diksha was the tolerant variety while Lush Green was moderately susceptible.

2.6. Pod length

Pod length differed significantly (p <0.01) among the four okra varieties (NHAe-47-4, V35, LD88 and a local variety) experimented by Eshiet *et al.* (2015). Pods of NHAe-47-4, V35 and LD88 were longer (6.38, 6.23 and 6.83 cm, respectively) than those of the local variety with a mean length of 3.23 cm. Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013). Edible pod length revealed the non-significant variation among the different Okra cultivars. Although, there were not significant maximum and minimum pod length were showed Pusa Green (11.16 cm) and Pusa Sawani (10.72 cm). Very minute differences were checked among the different Okra cultivars. Same genotype belonging to the local cultivars and due to uniform cultural practices and fertilizers doses, the green pod were remained non-significant amongst each other.

In a similar experiment by Khan *et al.* (2002) maximum pod size (17.96 cm^2) was achieved by Pusa green. Very minute difference were checked among the treatment means because of all the cultivars under study were the most productive and uniform cultivars, as Cremson and Penta green provided the pod size of 17.86 and 17.83 cm^2.

In the experiment by Dash et al. (2013) Pod length varied significantly among the varieties (Table 5). The longest length of pods (15.13 cm) and the shortest

length of pods (12.68 cm) were recorded from the variety Annie Oakley and BARI Dherosh-1, respectively. Pod length increased with changed of varieties Mishra *et al.* (2001) reported that variety Annie Oakley gave larger pod length compared to an other Indian variety namely Arka Anamica. Significant variation was found among the different planting date in respect of pod length (Table 6). The results revealed that the maximum pod length (15.28 cm) was found from 15 February planting, while the minimum pod length (12.02 cm) was found from 2 March planting. Amjad *et al.* (2001) found that pod length varied significantly among different planting date used. They also found that maximum pod length was obtained from 15 February planting in case of variety Annie Oakley. Pod length is higher in case of variety Annie Oakley. The possible reason could be that favorable environmental condition. Plants get more nutrients from soil and other natural resources from environment which facilitated for development of pods length.

2.7. Pod breadth

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013). Results showed the significant variation among the different Okra cultivars for pod diameter. The *cv*. Pusa Green showed maximum pod (1.653 cm) diameter over other cultivars while cultivar Green Star showed the lowest pod diameter (1.530 cm). The differences in pod diameter are due to

difference in genetic make of the cultivars and their response to prevailing environmental condition with reference to Sharma *et al.* (1993).

An experiment was conducted by Dash *et al.* (2013) to compare different varieties of okra. Pod diameter varied significantly among the varieties (Table 5). The maximum diameter of pod (1.96 cm) and the minimum diameter of pod (1.59 cm) were obtained from variety Annie Oakley and BARI Dherosh-1, respectively. Mishra *et al.* (2001) reported that variety Annie Oakley gave larger pod diameter compared to another Indian variety namely Arka Anamica. Pod diameter varied significantly among the different planting date (Table 6). The maximum diameter of pod (2.01 cm) was obtained from 15 February planting, while the minimum diameter of pod (1.40 cm) was obtained from 2 March planting. Gupta and Srinivas (1981) reported that breadth of pod was increased gradually in 23 February planting. Pod diameter is higher in case of variety Annie Oakley. The possible reason could be that favorable environmental condition. Plants get more nutrients from soil and other natural resources from environment at optimum planting date which facilitated for development of pods diameter. Arka Anamica. Pod diameter varied significantly among the different planting date (Table 6). The maximum diameter of pod (2.01 cm) was obtained from 15 February planting, while the minimum diameter of pod (1.40 cm) was obtained from 2 March planting. Gupta and Srinivas (1981) reported that breadth of pod was increased gradually in 23 February planting. Pod

diameter is higher in case of variety Annie Oakley. The possible reason could be that favorable environmental condition. Plants get more nutrients from soil and other natural resources from environment at optimum planting date which facilitated for development of pods diameter.

2.8. Pod plant^{-1}

The four varieties of okra evaluated in the study by Eshiet *et al.* (2015) had statistically the same (p >0.05) average number of pods per plant. NHAe-47-4, V35, LD88 and the local variety had a mean number of 5.67, 4.45, 3.20 and 4.0 pods, respectively, per plant. Though there was no statistical difference in fresh fruit yield/plant between NHAe47- 4 and V35, however, NHAe47-4 and V35 in 2012 and 2013 produced more fruits than LD88 and the local variety. Comparatively, yields of NHAe47-4 and V35 did not differ significantly.

In a similar experiment by Khan *et al.* (2002) non-significant differences in the number of okra pods per plant for various cultivars was found. However maximum number (43.42) of pod/plant was found for Pusa green. Minimum value was found for Pusa sawani (33.34). These results are also consistent with Wazir *et al.* (1988) who also stated that Pusa sawani had the lowest number of pods per plant. Although Jan et al. (1999) also reported that number of pods per plant had a non-significant effect on number of pods per plant.

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed *et al.* (2013).The results obtained for number of pod per plant showed the significant differences among cultivars. The cultivar Sarhad Green showed maximum number of pod per plant (14.77) while the cultivar Green Star showed minimum number of pods per plant (12.37). While the other three cultivars Sabz Pari, Pusa Green and Pusa Sawani showed the non- significant variation. Perhaps this was due to temperature during the formation of green pod & may be nutrient uptake among Okra cultivar. Amjad *et al* (2001) evaluated fifty genotypes and already reported significant and marked variation in yield components among the cultivars.

In the experiment by Dash *et al.* (2013) number of pods/plant varied significantly among the varieties. The highest number of pods/plant (10.96) was recorded in the variety Annie Oakley. On the other hand the lowest number of pods/plant (8.25) was recorded in the variety BARI Dherosh-1. The results of the present study are similar with the findings of Shridhar (1996) who found that the variety Annie Oakley produced maximum number of fruits/plant (12.0). Similar results were also reported by Singh *et al.* (1996) in case of the variety Annie Oakley. Significant variation was found among the different planting date in respect of number of pods/plant (Table 6). February 15 planting produced the highest number of pods/plant (11.10) while March 2 planting

produced the lowest number of pods/plant (8.40). The highest number of pods/plant produced with February 15 planting. February 15 planting plant received more nutrients and other natural resources like light, water etc. for which resulted in more lateral growth of the plants as well as higher number of pods/plant. These findings are in close conformity with the results of the previous workers (Amjad *et al*., 2001). They reported that number of pods/plant increased in February 15 planting compared to other planting date. Variety Annie Oakley gives more pods/plant at optimum planting date. The possible reason could be that growth is better of Annie Oakley variety and produced more branches at optimum planting date. As a result number of pods/plant increased.

2.9. Pod yield

Five different Okra cultivars i.e., Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance by Naheed et al. (2013). In a similar experiment by Khan *et al.* (2002) maximum yield was found for Pusa green (17.85 ton/ha). It was followed by Clemson (16.67 t/ha) and Penta green (16.07 t/ha). The results of these three cultivars was statistically at par each other. Minimum pod yield among them was 13.66 ton/ha from the local variety.

The data regarding yield per hectare (kg) showed non-significant variation among the different Okra cultivars for yield /ha (kg). As the data regarding yield

per hectare was derived from yield per treatment, therefore, the data per hectare presented the same picture of results. The highest yield per hectare (14590.0 Kg/ha) was recorded in cultivar Sarhad Green which was closely followed by cultivar Pusa Sawani (14580. 0 Kg/ha), while the minimum yield per hectare was recorded in cultivar Pusa Green 12690.0 kg/ha. Figure 1 to 5 presented all the agronomic traits of the Okra cultivars graphically. In all traits the cultivar Sarhad Green proven best among all of them. Although, changes in different agro-climatic factors affected the crop with-in the vicinity of district Mansehra. It was revealed highly productive cultivar can be adopted for good yield /good performer and have economically feasible for good net return to the local farmers. The study will be helpful to make it easy for cultivar selection either for the researchers or farmers for further improvement programme genetically or agronomically.

Significant variation was found in respect of pod yield per hectare among the varieties in the experiment by Dash *et al.* (2013). The highest (9.11 t) and the lowest (4.60 t) pod yield/hectare were obtained from okra variety Annie Oakley and BARI Dherosh-1, respectively. Martin and Rhodes (1999) reported that pod yield varied among the varieties. Pod yield per hectare varied significantly among the different planting date (Fig. 2). The highest (8.76 t) and the lowest (5.20 t) pod yield/hectare were recorded from 15 February and 2 March planting, respectively. The highest pod yield per hectare with 21 February

planting had already been reported by the previous workers (Gadakh *et al.,* 1990). The highest pod yield/hectare was obtained from variety Annie Oakley. The possible reason could be that number of pods/plant as well as per plot was higher in case of variety Annie Oakley. All conditions for growth and development of okra variety Annie Oakley was favorable. As a result plants produced more pods/plant. So total pods yield is higher in case of variety Annie Oakley.

2.10. Chlorophyll percentage

Sarker *et al.* (2014) experimented with nine okra varieties viz. BARI dherosh-1, Green finger, Anguli, Tower seed, Raja, Yuvraj, Shyamol bangla, Parvani kranti and Orka onamika. The highest net chlorophyll content per plant was recorded in the *cv.* Parvani kranti (65.10) followed by *cv.* BARI dherosh-1 (60.57) both are statistically identical. The lowest net chlorophyll content per plant was obtained in the *cv.* Anguli (38.17) preceded by *cv.* Tower seed (39.20) and these results are statistically similar with *cv.* Orka onamika (39.97), *cv.* Yuvraj (40.13), *cv.* Raja (42.93), *cv.* Green finger (43.20) and *cv.* Shyamol bangla (45.93) respectively.

2.11. Net assimilation rate

Shill (2005) experimented with four okra varieties viz. BARI-1, Local-1, Local-2, IPSA-1. In the healthy plants of BARI Dherosh-1, rate of photosynthesis was

34.51µmolm^{-2}s^{-1} whereas it varied from 4.11-20.75 µmolm^{-2}s^{-1}. In case of variety Local-2, IPSA-1 and Local-1 rate of photosynthesis were 38.03 µmolm^{-2}s^{-1}, 38.04 µmolm^{-2}s^{-1} and 36.64 µmolm^{-2}s^{-1} respectively depending on stage of infection by YVMV. Sarker (2014) experimented with nine okra varieties viz. BARI dherosh-1, Green finger, Anguli, Tower seed, Raja, Yuvraj, Shyamol bangla, Parvani kranti and Orka onamika. The maximum photosynthesis rate per plant was recorded in *cv.* Parvani kranti (1.683) followed by *cv.* BARI dherosh-1(1.593) both are statistically identical with each other. The minimum photosynthesis rate per plant was recorded in *cv.* Tower seed (0.923) preceded by *cv.* Arka anamika (0.963), they are statistically similar with each other. The comparatively moderate photosynthesis rate per plant was recorded in *cv.* Shyamol bangla (1.047) followed by *cv.* Yuvraj (1.070), *cv.* Green finger (1.073), *cv.* Raja (1.160) and *cv.* Anguli (1.253) respectively, and all they are statistically similar.

2.12. Intercellular CO_2 concentration

Sarker (2014) conducted a similar experiment with nine okra cultivars viz. BARI dherosh-1, Green finger, Anguli, Tower seed, Raja, Yuvraj, Shyamol bangla, Parvani kranti and Orka onamika. The maximum intercellular carbon-di-oxide concentration per plant was recorded in *cv.* Parvani kranti (8.83) followed by *cv.* BARI dherosh-1(8.86), both are statistically identical with each other. The minimum intercellular carbon-di-oxide concentration per plant was

recorded in *cv.* Raja (3.667) preceded by *cv.* Orka onamika (3.667), *cv.* Shyamol bangla (4.000), *cv.* Tower seed (4.667) and *cv.* Green finger (4.667) respectively, these are statistically similar with each other. The moderate intercellular carbon-di-oxide concentration per plant was recorded in the *cv.* Yuvraj(6.66) followed by *cv.* Anguli (5.33) and these are similar with each other.

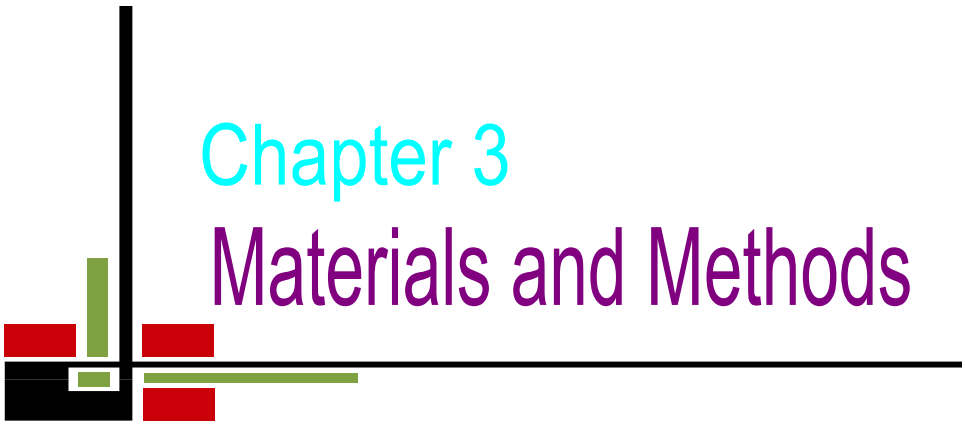
2.13. Respiration rate

In an similar experiment by Sarker (2014) who worked with 9 okra cultivars, The highest respiration rate per plant was recorded in the *cv.* BARI Dherosh-1 (61.93) followed by *cv.* Parvani kranti (59.90), they are statistically identical. The lowest respiration rate per plant was recorded in the *cv.* Shyamol bangla (36.17) preceded by *cv.* Orka onamika (37.23), both results are statistically similar with *cv.* Yuvraj (40.03), *cv.* Tower seed (40.37), *cv.* Raja (41.00) and *cv.* Green finger (42.97) respectively.

2.14. Stomatal conductance

In an similar experiment by Sarker (2014) who worked with 9 okra cultivars, The highest stomatal conductivity per plant was recorded in the *cv.* Parvani kranti (0.62) followed by *cv.* BARI dherosh-1(0.61), both are statistically identical with each other. The minimum stomatal conductivity per plant was recorded in the *cv.* Orka onamika (0.35) preceded by *cv.* Raja (0.36) and both

results are statistically similar with each other. The moderate stomatal conductivity per plant was recorded in the *cv.*. Shyamol bangla (0.39) and *cv.*. Anguli (0.39) followed by *cv.* Yuvraj (0.39), *cv.* Green finger (0.40) and *cv.* Tower seed (0.41) respectively, and all they are statistically similar.



Chapter 3
Materials and Methods

Chapter 3

MATERIALS AND METHOD

This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recordings and there analyses.

3.1. Site description

The experiment was conducted at the research field of Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka under the Agro-ecological zone of Modhupur tract, AEZ-28. The land was situated at 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above sea level.

3.2. Climate

The experimental area was under the sub-tropical regions that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (March to July) associated with moderately low temperature during the Rabi season.

3.3. Soil

The soil of the experiment field belongs to the general soil type,shallow red brown terrace soil under Tejgaon series. Top soils are silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles.

The experiment area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0 to 15 cm depth were collected from experimental field. The analyses were done from Soil Resources And Development Institute (SRDI), Dhaka.

3.4. Planting material

Sixteen different okra varieties viz. Shaymol Bangla, Sarosh-3, BARI Dherosh-1, Porosh Plus, OK-285, Deb-412, Parvani Kranti, Kalatia, Green soft, Arka Anamika, Malvika, Green valley, Toa DK-2, Shehzadi, Gunjon, Kochi were used planting material. Among them BARI Dherosh-1 is the only BARI (Bangladesh Agricultural Research Institute) released variety of okra. Kalatia is a local variety. Other varieties were commercial varieties collected from local markets.

3.5. The experimental treatment

The experimental treatments consisted of 16 different varieties. Varieties are-

- Shaymol Bangla
- Sarosh-3
- BARI Dherosh-1
- Porosh Plus
- OK-285
- Deb-412
- Parvani Kranti
- Kalatia
- Green soft
- Arka Anamika
- Malvika
- Green valley
- Toa DK-2
- Shehzadi
- Gunjon
- Kochi

3.6. Design and layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising three replications. The size of each unit plot area was 3 x 2 meter. The inter block and rows spaces were used as footpath and irrigation or drainage channels.

3.7. Conducting the experiment

3.7.1. Germination test

Before sowing of the seeds, germination tests were made in the laboratory and germination percentage counted over 92 using the following formula-

$$\text{Percentage of germination} = \frac{\text{number of germinated seed}}{\text{number of seed set for germination}} \times 100$$

3.7.2. Pre- treatment of seeds

Seeds were soaked in water in containers to break down dormancy quickly. The next day it was used for sowing.

3.7.3. Fertilizer application

Cow dung was applied at the rate of 10 t/ha during the land preparation. 60 kg N/ha were applied at two installments in the form of Urea. Other fertilizers were

applied at the rate of 30kg/ha of P, 25kg/ha of K, 5kg/ha of S, 0.34kg/ha of B and 1.8 kg/ha of Zn.

3.7.4. Seed sowing

Seeds of sesame were sown on 10 April, 2014maintaining 30 cm line to line distance @ 8 kg/ha. Seeds were placed around two cm depth and then rows were covered with loose soil property. The seed rate was 8 kg/ha.

3.7.5. Intercultural operation

The following intercultural operations were done for ensuring normal growth of the crop.

3.7.5.1. Weeding

During plant growth period two hand weedings were done using Nirani. First weeding was done at 20 DAS followed by second weeding at 30 DAS.

3.7.5.2. Thinning

Thinning was done with care so as to maintain a uniform plant population in each experimental plot. The job was done in two times at 10 DAS and 20 DAS.

3.7.5.3. Irrigation and drainage

One pre-sowing irrigation was done to maintain the equal seed germination of sesame. After sowing of seeds two irrigations were done during the life cycle of

sesame. Excess water was drained out during the irrigation or natural rainfall during the cropping period of the crop.

3.7.5.4. Plant protection measures

3.8. General observation of the experimental field

The research field looked nice with normal green plants. The plants in the wider spacing appeared to be more vigorous and luxuriant than that of closer spacing. Field was observed 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 was minimized.

3.9. Harvesting

Pods were harvested at every three days interval after first picking. Pods were harvested through hand picking at tender and marketable stage.

3.10. Collection of experimental data

The data were collected on different parameters of okra plants. Five plants were randomly selected from each plot and following data was collected from them:

Morphological attributes

1. Days required for 80% germination
2. Plant height
3. Leaves plant^{-1}

4. Days to anthesis
5. YVMV incidence
6. Pod length
7. Pod breadth
8. Number of pod/plant
9. Pod yield (t/ha)

Physiological attributes

1. Chlorophyll content
2. Net assimilation rate
3. Intercellular CO_2 concentration
4. Respiration rate
5. Stomatal conductivity

A brief outline of the above mentioned parameters of the data recording is given below:

3.10.1. Days required for 80% germination

Number of days required for a variety to germinate 80% of its population considered.

3.10.2. Plant height

Plant height was taken with a measuring stick from top of the plant to ground level on 25 DAS, 35 DAS, 45 DAS, 55 DAS and at harvest.

3.10.3. Number of leaves/plant

Number of leaves per plant was counted at every ten days interval starting from 25 DAS up to harvest.

3.10.4. Days to anthesis

It is the days up to first flowering of the plants. Plants were checked regularly and data was taken carefully.

3.10.5. YVMV incidence

It was counted using the following formula-

$$\text{YVMV incidence (\%)} = \frac{\text{Number of plants affected by YVMV in a plot}}{\text{Total number of plant in a plot}} \text{ X } 100$$

It was expressed in percentage.

3.10.6. Pod length

Green pods were collected from selected plants of each pot as per treatment and length was measured with the help of a meter scale in centimeter (cm).

3.10.7. Pod breadth

Pod breadth was measured with slide calipers.

3.10.8. Pod plant^{-1}

Mean number of green pods of selected plants from each pot as per treatment was recorded.

3.10.9. Pod yield

Pods collected from selected plants were measured with weighing balance and was finally converted into kg/ha.

3.10.10. Chlorophyll content

The average chlorophyll content in the leaves of the selected plants was recorded with the help of "S-PAD" (Figure-2), which is an advanced technology to directly measure the chlorophyll content in plant leaf.

3.10.11. Net assimilation rate

The average Net assimilation rate per plant was recorded from the selected plants by using "LC-Pro+" (Figure-3) machine at 20, 40 and 60 days after sowing (DAS).

3.10.12. Intercellular CO_2 concentration

The average intercellular CO2 concentration per plant was recorded from the selected plants by using "LC-Pro+" machine at 20, 40 and 60 days after sowing (DAS).

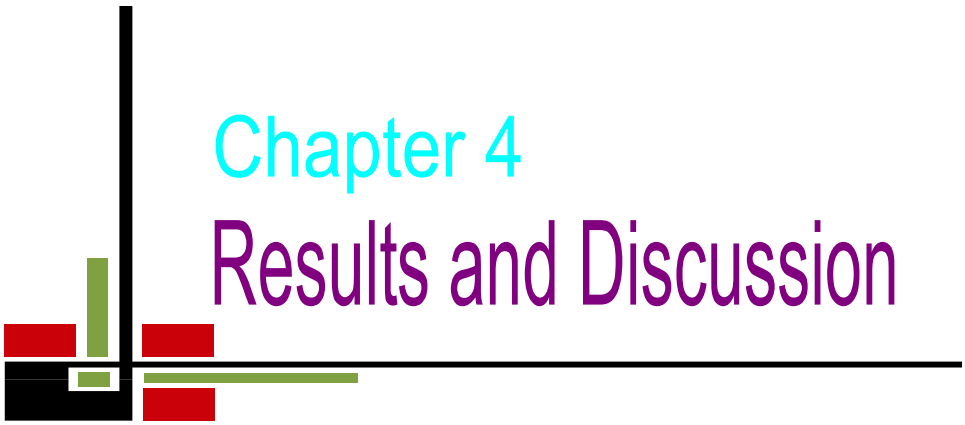
3.10.13. Respiration rate

The average respiration rate per plant was recorded from the selected plants by using "LC-Pro+" machine at 20, 40 and 60 days after sowing (DAS).

3.10.14. Stomatal conductance

The average stomatal conductance per plant was recorded from the selected plants by using “LC-Pro+” machine at 20, 40 and 60 days after sowing (DAS).

All the data collected on different parameters were statistically analyzed following the Analysis of Variance (ANOVA) technique and mean differences were adjudged by Duncan’s Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at 5% level of significance using the MSTAT-C computer package program.



Chapter 4
Results and Discussion

Chapter 4

RESULT AND DISCUSSION

This chapter comprises of the presentation and discussion of the results from the experiment. The data have been presented in tabular and graphical form for the convenience of the reader. The result of each parameter has been discussed and possible interpretations have been made whenever necessary in the following heading and sub-headings:

4.1. Days required for 80% germination

Days required for 80% germination differed significantly with varietal difference. Minimum days (4.33) required for 80% germination was for variety Green Valley. Results were shown in Figure- 1.

Eshiet and Brisibe (2015) experimented with four okra cultivars (NHAe-47-4, V35, LD88 and a local variety) and cultivars NHAe-47-4 and V35 took a mean number of 4.33 days to emerge while LD88 and the local variety took a mean of 4.20 and 3.25 days, respectively.

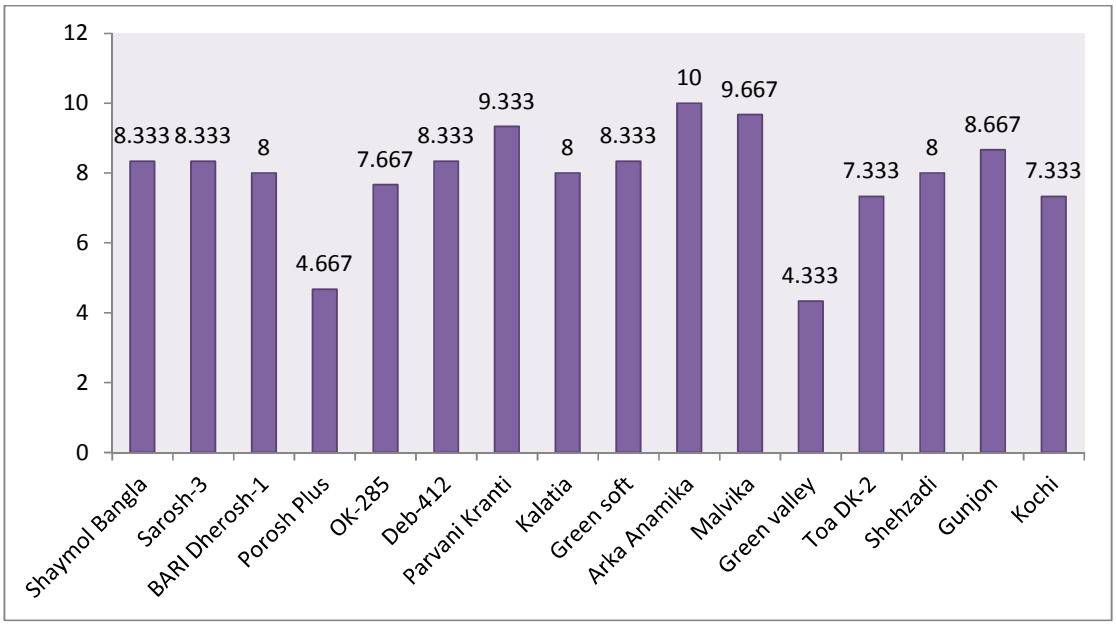


Figure 1. Difference in days required for 80% germination among varieties.

4.2. Plant height

Difference in plant height was not found statistically significant for varietal difference up to some extent (25 DAS, 35 DAS, 45 DAS) but later (55 DAS and at harvest) the difference was found significant. Maximum plant heights were found at harvest for the variety Green Valley (114.83 cm) which was again statistically similar with Parvani kranti, Malvika, Toa DK-2. Results were shown in Figure 2.

Eshiet and Brisibe (2015) experimented with four okra cultivars (NHAe-47-4, V35, LD88 and a local variety) and found plant height differed significantly for varietal difference. Maximum plant height was found for LD88 (128 cm).

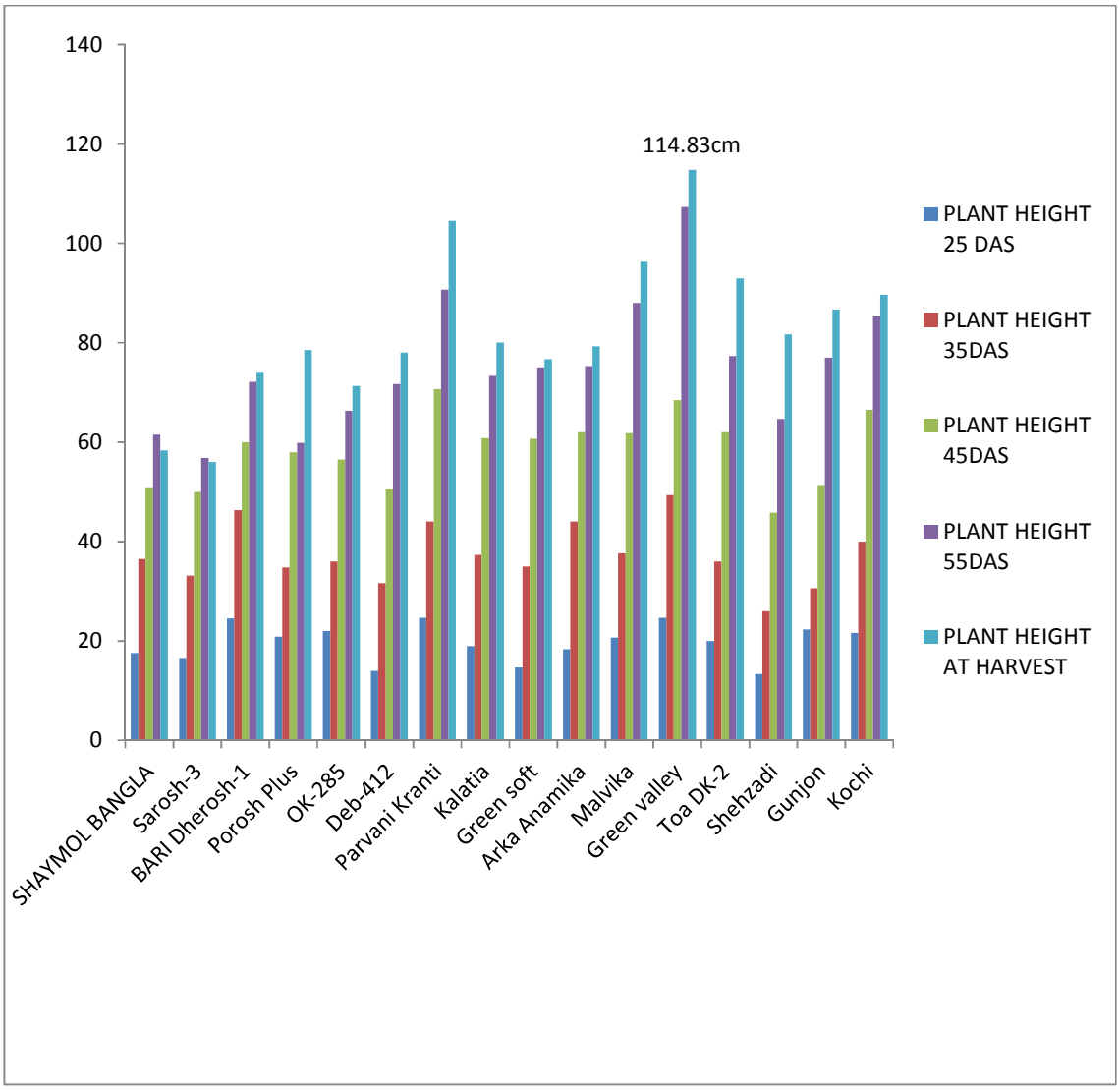


Figure 2. Difference in plant height among varieties

4.3. Leaves plant^{-1}

Number of leaves per plant varied significantly with varietal difference. It increased with increasing number of days after sowing. Maximum number of leaves (74) was found for Parvani kranti at harvest. Minimum number of leaves (6.33) was obtained for Deb 412 at 25 DAS. Results were shown in Figure-3**.**

Mubarak (2012) found that the number of leaves per plant was significantly influenced by varietal difference throughout the sampling periods in both field and pot trials.

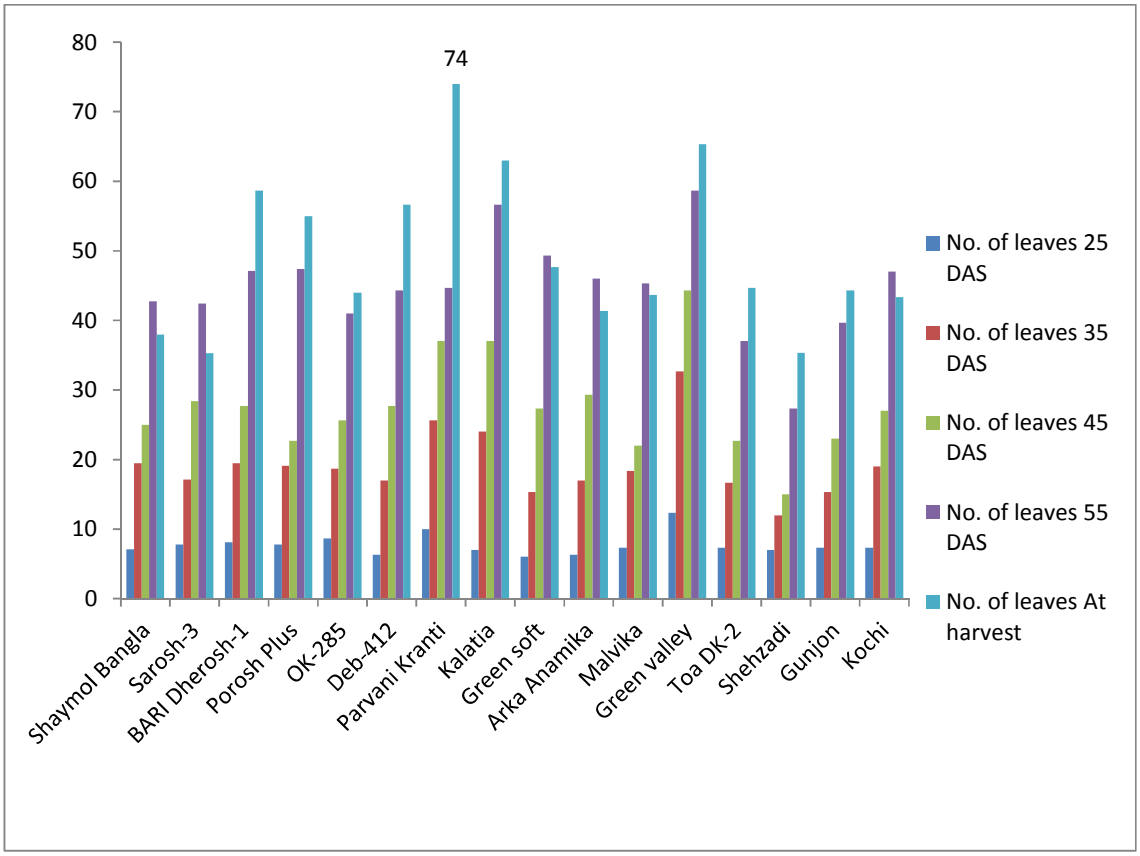


Figure 3. Difference in number of leaves among varieties

4.4. Days to anthesis

Days to anthesis differed significantly with varietal difference. Minimum days (23.667) required to anthesis was for variety OK-285 followed by variety Malvika (25 days). Results were shown in Figure-4.

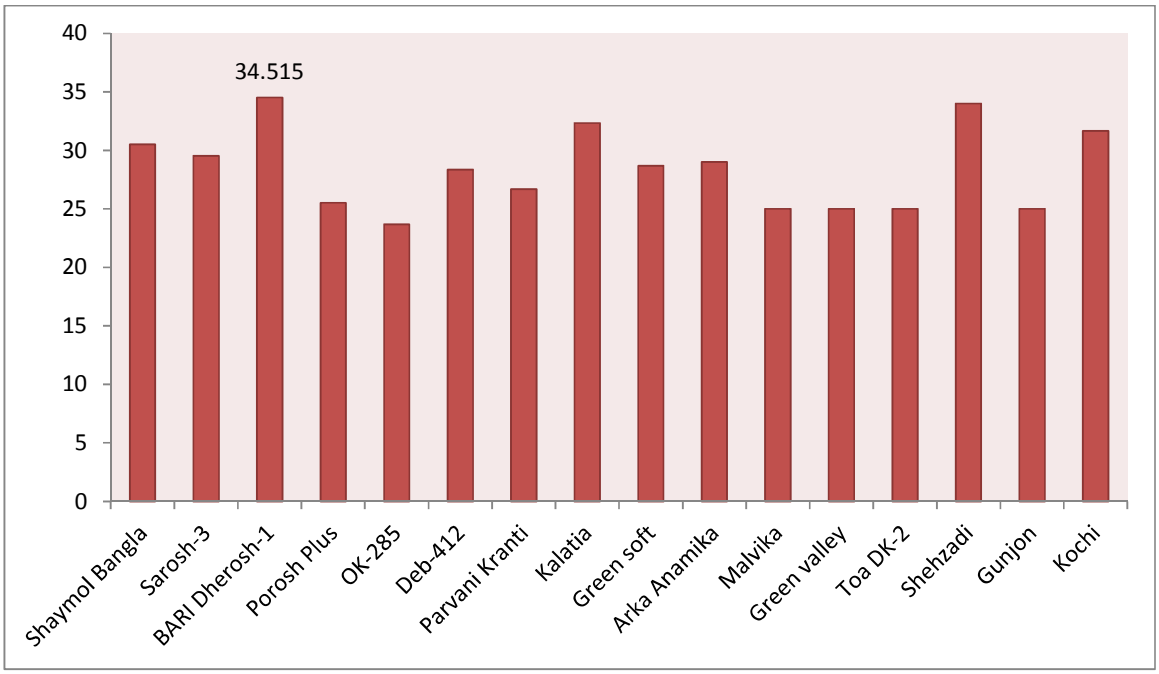


Figure 4. Difference in days to anthesis among varieties

4.5. YVMV incidence

Effect of different varieties on incidence of YVMV was found significant. Minimum incidence of YVMV was found in the variety Sharosh-3 (5.54%). Maximum incidence was found for variety Ok-285. Results were shown in Figure-5.

Similar experiment was conducted by Sarker (2014). In case of % disease incidence, the lowest disease incidence was found in *cv.* Parvani kranti (9.74%) and the highest disease incidence was found in *cv.* Yuvraj (81.14%) followed by Arka anamika (80.81%)

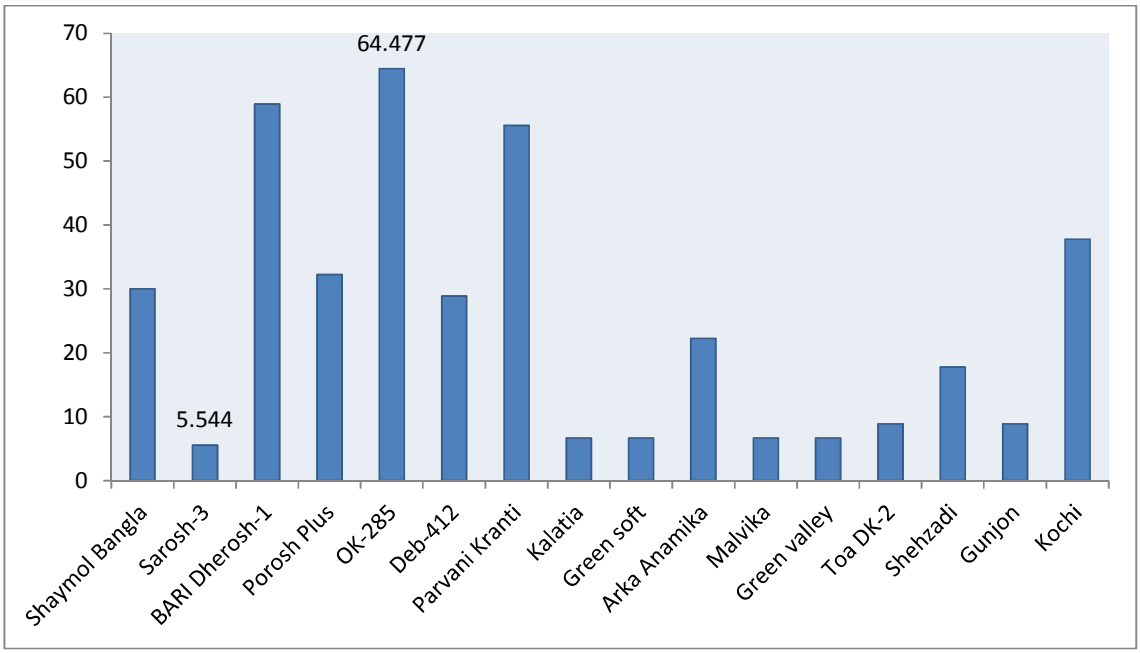


Figure 5. Difference in YVMV incidence among varieties

4.6. Pod length

Effect of different varieties on the length of pod was found significant. Maximum Pod length was found for variety Porosh Plus. Minimum value was found for variety Kochi. Results were shown in Table-1.

Similar experiment was carried out by Sarker *et al.* (2014). The average highest fruit length was recorded from the *cv.* Parvani kranti (17.33) followed by *cv.* BARI dherosh-1(16.87) and both are statistically identical. The average lowest fruit length was recorded in the *cv.* Yuvraj (12.77) preceded by *cv.* Tower seed (12.83) and these are statistically similar with each other.

4.7. Pod breadth

Effect of different varieties on the breadth of pod was found significant. Maximum value was found for variety Shehzadi. Minimum value was found for variety Kalatia. Results were shown in Table-1.

Similar experiment was carried out by Sarker *et al.* (2014). The average highest fruit breadth was obtained in the *cv.* Parvani kranti followed by *cv.* BARI dherosh-1 and both are statistically identical with each other.

4.8. Pods plant^{-1}

Effect of different varieties on Number of Pod/plant was found significant. Maximum value was found for variety Green Valley. Minimum value was found for variety Kalatia. Results were shown in Table-1.

Similar field experiment was conducted by Dash *et al.* (2013). Three varieties (BARI Dherosh-1, Arka Anamica and Annie Oakley) were used as treatment variables. The highest number of pods/plant (10.96) was recorded in the variety Annie Oakley. On the other hand the lowest number of pods/plant (8.25) was recorded in the variety BARI Dherosh-1.

4.9. Pod yield/ha

Effect of different varieties on Pod yield/ha was found significant. Maximum value was found for variety Green Valley followed by variety Porosh Plus. Results were shown in Table-1.

Significant variation was also found in respect of pod yield per hectare among the varieties by Martin and Rhodes (1999) and Dash *et al.*(2013).

Table 1. Difference in morphological attributes of okra for varietal difference.

Treatment	Yield Attributes			
	Pod Length (cm)	Pod Breadth (cm)	Pod Per Plant	Pod Yield (t/ha)
Shaymol	8.722 bc	1.5333 cd	20.543 b	5.991 e
Bangla Sarosh-3	7.056 cd	1.3866 fg	20.209 b	6.025 e
BARI Dherosh-1	7.722 cd	1.4766 de	19.543 b	5.391 e
Porosh Plus	**13.056** a	1.3899 fg	30.876 a	10.225 b
OK-285	8 bcd	1.253 h	20 b	6.533 de
Deb-412	12.667 a	1.4 efg	19.667 b	5.767 e
Parvani Kranti	8 bcd	1.4 efg	20 b	5.233 e
Kalatia	9 bcd	1.2433 h	21 b	8.267 cd
Green soft	10 bcd	1.3433 g	22.333 b	6.467 e
Arka Anamika	11 bcd	1.5867 abc	21.333 b	8.8 bc
Malvika	11bcd	1.62 ab	19 b	6.833 de
Green valley	10 b	1.56 bc	**32.333** a	**14.267** a
Toa DK-2	7 cd	1.4733 de	19.667 b	6.433 e
Shehzadi	7.333 cd	**1.6533 a**	24 b	6.8 de
Gunjon	8.667 bcd	1.5333 cd	22.667 b	6.4 e
Kochi	6.667 d	1.4567 def	22.667 b	6.433 e
$LSD_{0.05}$	2.02	0.08	6.00	1.79
CV.%	14.14	3.35	16.19	14.84

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test.

4.10. Chlorophyll content

Varietal difference produced significant difference on chlorophyll percentage. Maximum Chlorophyll percentage (65.3µ mol m^{-2} s^{-1})was obtained for variety Green valley. Minimum value (27.273µ mol m^{-2} s^{-1}) was obtained for OK-285. It differed mainly due to difference in level of infestation of leaves of different varieties by YVMV. Results were shown in Figure-6**.**

Similar results were obtained by Sarkar (2014) in an experiment with nine okra cultivars viz. BARI dherosh-1, Green finger, Anguli, Tower seed, Raja, Yuvraj, Shyamol bangla, Parvani kranti and Orka onamika were used as treatments. Maximum value was 65.103µ mol m^{-2} s^{-1} for Parvani kanti.

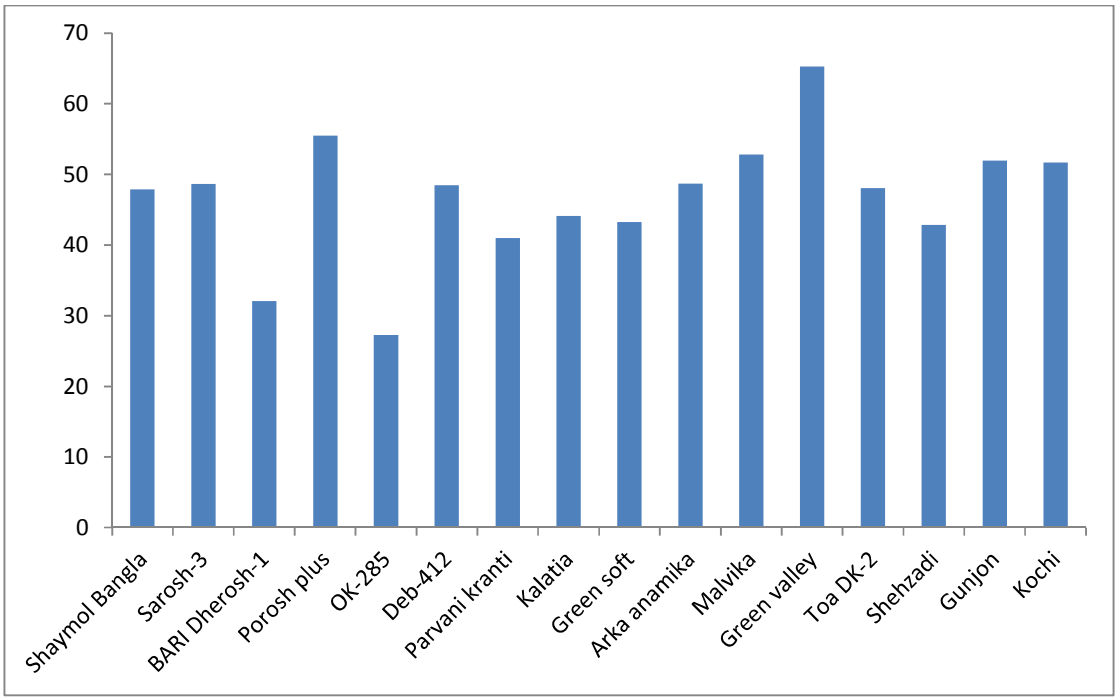


Figure 6. Difference in chlorophyll percentage among varieties

4.11. Net assimilation rate

The maximum net assimilation rate per plant was recorded in *cv.* Green valley (1.683) followed by *cv.* Gunjon (1.55). The minimum net assimilation rate per plant was recorded in *cv.* Shaymol bangla (1.02) preceded by *cv.* Kalatia (1.09). The results are presented in Table-2.

4.12. Intercellular Carbon-di-oxide concentration

The maximum intercellular carbon-di-oxide concentration per plant was recorded in *cv.* Green valley (8.63) followed by *cv.* Green soft (7.11). The minimum intercellular carbon-di-oxide concentration per plant was recorded in *cv.* Kalatia (3.95) preceded by *cv.* Shaymol bangla (4.02). The results are presented in Table-2.

4.13. Respiration rate

The highest respiration rate per plant was recorded in the *cv.* BARI Dherosh-1 (65.40) followed by *cv.* Kochi (59.38). The lowest respiration rate per plant was recorded in the *cv.* Shyamol bangla (39.42) preceded by *cv.* Kalatia (44.6). The results are presented in Table 2.

4.14. Stomatal conductivity

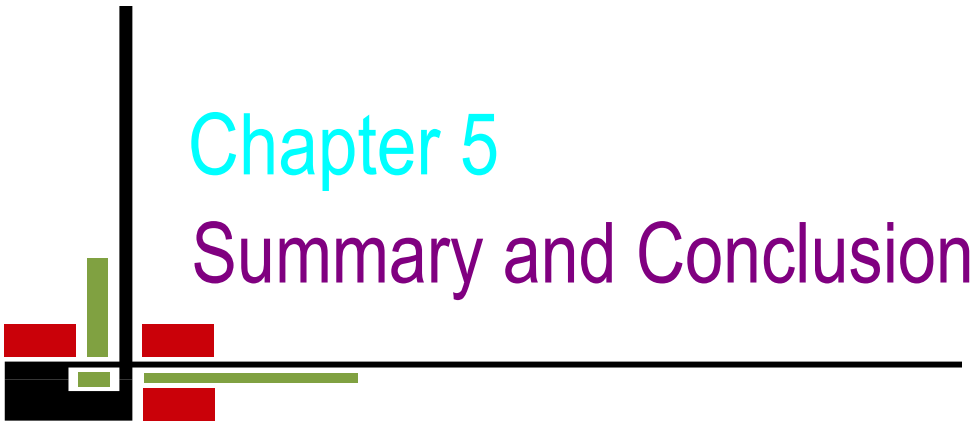
The highest stomatal conductivity per plant was recorded in the *cv.* Green valley (0.64) followed by Toa DK-2(0.46). The minimum stomatal conductivity per

plant was recorded in the *cv.* Shaymol bangla (0.3100). The results are presented in Table 2.

Table 2. Difference in physiological attributes of okra for varietal difference.

Treatment	Yield Attributes			
	Net assimilation rate ($g\ m^{-2}d^{-1}$)	Intercellular CO_2 concentration (ppm)	Respiration rate (ppt/s)	Stomatal conductance ($mol\ m^{-2}s^{-1}$)
Shaymol Bangla	1.02 k	4.02 n	39.42 m	0.3100 h
Sarosh-3	1.27 fgh	5.42 f	45.30 k	0.3533 ef
BARI Dherosh-1	1.39 cd	6.33 d	50.19 i	0.3400 fg
Porosh Plus	1.39 cd	6.41 c	52.72 g	0.4133 d
OK-285	1.22 hi	4.30 k	48.77 j	0.3767 e
Deb-412	1.29 fg	5.31 g	54.59 f	0.4433 bc
Parvani Kranti	1.33 ef	6.42 c	55.74 e	.6300 a
Kalatia	1.09 j	3.95 o	44.06 l	.4333 cd
Green soft	1.41 c	7.11 b	59.74 b	.4433 bc
Arka Anamika	1.17 i	4.14 m	50.74 h	0.4367 bcd
Malvika	1.24 gh	4.21 l	56.20 d	0.4167 cd
Green valley	**1.72 a**	**8.63 a**	**65.40 a**	**0.6400 a**
Toa DK-2	1.35 de	5.51 e	58.21 c	0.4633 b
Shehzadi	1.27 fgh	4.43 j	56.27 d	0.3333 gh
Gunjon	1.55 b	4.95 h	58.40 c	0.3167 gh
Kochi	1.28 fg	4.87 i	59.38 b	0.3400 fg
$LSD_{0.05}$	0.05	0.03	0.43	0.02
CV.%	2.69	0.42	0.49	3.94

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test.



Chapter 5

Summary and Conclusion

Chapter 5
SUMMARY AND CONCLUSION

The research experiment was conducted at the research farm of Agronomy, Sher-e-Bangla Agricultural University, and Dhaka during the period from 10 April to 25 July, 2014 to study "Screening of okra germplasm based on morphological and physiological characteristics". This is a single factor experiment with 16 different varieties as different treatments.

The experiment was laid out in Randomized Complete Block Design (RCBD) comprising three replications in 12 treatments combination. The unit plot size was 3m x 2m and fertilizers were applied as per the recommended dose.

The data were recorded on the basis of sesame Plant height (cm), Number of leaves/plant, Chlorophyll percentage (%), Days to anthesis, Days required for 80% germination, YVMV incidence, Net assimilation rate, Pod length, Number of pod/plant, Pod yield (t/ha).

Data were analyzed using MSTAT-C software package program. The mean differences among the treatments were compared by Duncan's Multiple Range Test at 5% level of significance.

Maximum plant heights were found at harvest for the variety Green Valley (114.83 cm) which was again statistically similar with Parvani kranti, Malvika, Toa DK-2. Maximum number of leaves (74) was found for Parvani kranti at harvest.

Maximum Chlorophyll percentage (65.3%) was obtained for variety Green valley. Minimum days (23.667) required to anthesis was for variety OK-285. Minimum days (4.33) required for 80% germination was for variety Green Valley. Minimum incidence of YVMV was found in the variety Sharosh-3 (5.54%). Maximum Net assimilation rate was found for variety Green Valley (40.33). Maximum Pod length was found for variety Porosh Plus (13.06 cm). Maximum value was found for variety Shehzadi (1.65 cm). Maximum number of pod/plant was found for variety Green Valley (32.33) and maximum value was found for variety Green Valley (14.27 t/ha).

Although different varieties showed promising result in different characters, Green Valley was superior in most of the morphological attributes (viz. plant height, days required for 80% germination, number of pod/plant and most importantly pod yield) and physiological attributes (viz. Chlorophyll percentage, Net assimilation rate, Intercellular CO_2 concentration, respiration rate and stomatal conductivity).

Further research with this promising variety can bring in outstanding result.

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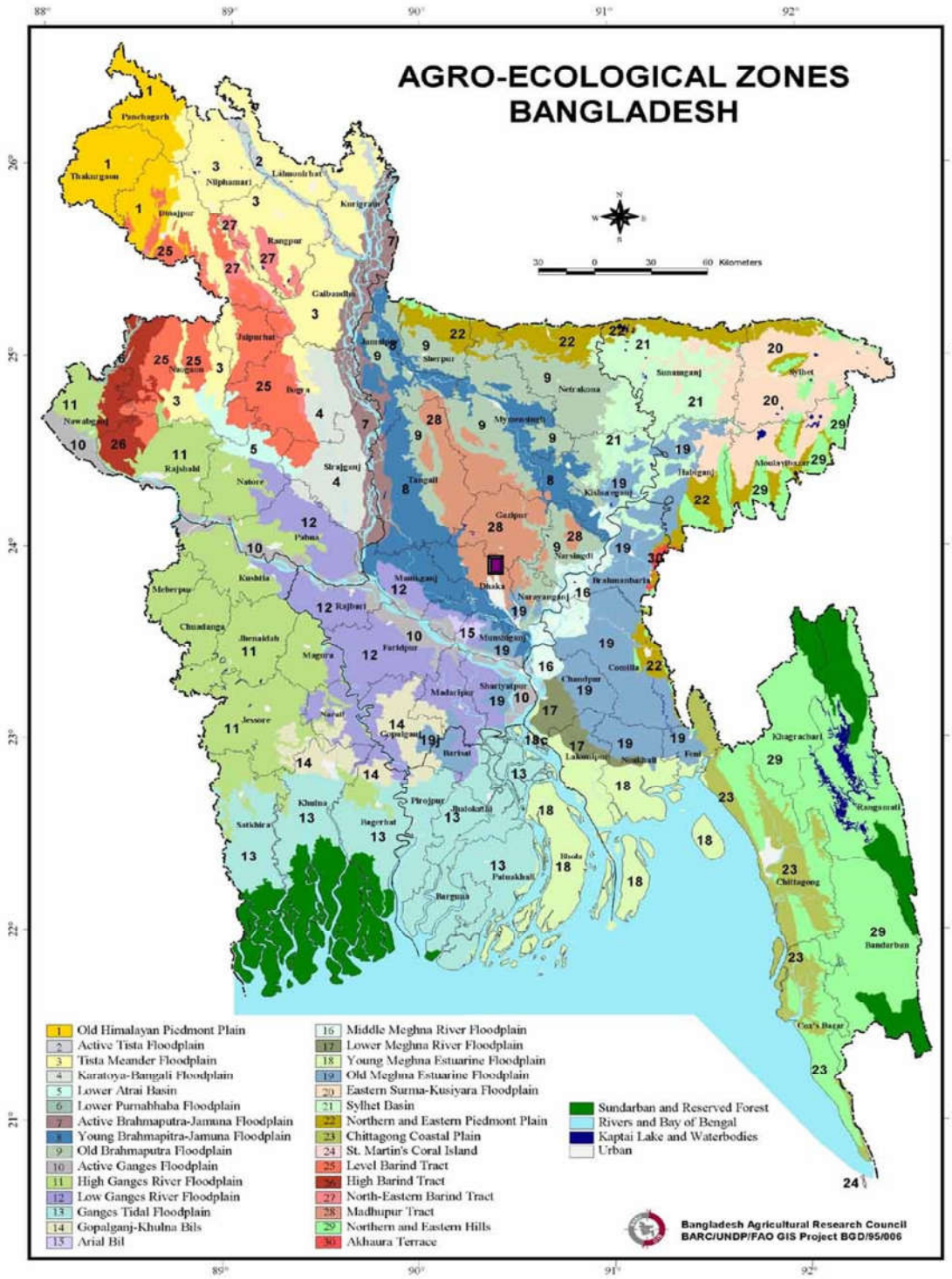
Appendices

APPENDICES

Appendix I. Experimental Location on the map of Agro- ecological zones of Bangladesh.



Appendix II: Characteristics ofsoil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Physical and chemical properties of the initial soil

Characteristics	**Value**
%Sand	27
%Silt	43
%clay	30
Textural class	Silt-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10

Monthly average of Temperature, Relative humidity, total Rainfall and sunshine hour of the experiment site during the period from july 2014 to December 2014

Month(2013)	Air temperature (^{o}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
June	35.4	22.5	80	577
July	36	24.6	83	563
August	36	23.6	81	319
September	34.8	24.4	81	279
October	26.5	19.4	81	22

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Summary of analysis of variance on yield attributes of okra.

Treatment	df	Mean square				
		Plant height				
		25 DAS	35 DAS	45 DAS	55 DAS	At harvest
Replication	2	17.08	55.45	39.41	157.833	403.923
Variety	15	41.32^{NS}	111.843^{NS}	151.92^{NS}	481.954*	658.336*
Error	30	43.99	103.342	126.707	171.221	199.194
Total	47					
CV.%		33.71	27.18	19.24	17.41	17.12

Treatment	df	Mean square				
		Number of leaves/plant				
		25 DAS	35 DAS	45 DAS	55 DAS	At harvest
Replication	2	5.77	38.03	54.4	55.26	6.752
Variety	15	7.27**	69.89**	145.78**	157.82**	390.08**
Error	30	1.75	36.86	68.84	79.23	121.217
Total	47					
CV.%		17.09	31.66	30.05	19.87	22.29

Treatment	df	Mean square				
		Chlorophyll content	**Days to anthesis**	**Days to 80% germination**	**YVMV incidence**	**Net assimilation rate**
Replication	2	101.286	10.14	1.02	76.24	1.63
Variety	15	236.778**	35.83**	6.97**	1233.46**	163.507**
Error	30	44.117	14.86	1.07	383.45	6.236
Total	47					
CV.%		14.18	13.57	13.07	78.44	9.46

Treatment	df	Mean square			
		Pod length	**Pod breadth**	**No. of pod/plant**	**Pod yield**
Replication	2	0.28	0.0015	3.97	0.11
Variety	15	10.21**	0.044**	46.03**	15.56**
Error	30	1.47	0.002	12.96	1.15
Total	47				
CV.%		14.14	3.35	16.19	14.84

Treatment	df	Mean square		
		Intercellular CO_2 concentration	**Respiration rate**	**Stomatal conductance**
Replication	2	95.67	88.4	27.2
Variety	15	227.38	123.45	220.4
Error	30	41.32	26.44	32.2
Total	47			
CV.%		23.0	12.4	18.4