EFFECT OF GIBBERELLIC ACID ON MORPHO-PHYSIOLOGICAL ATTRIBUTES AND YIELD OF OKRA

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BY

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CERTIFICATE

I feel great pleasure in forwarding '**Effect of Gibberellic Acid on Morpho-Physiological Attributes And Yield of Okra**' submitted by **Farzana Alam Mousumi**, Registration No. **16-07551** the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY**, embodies the results of a piece of bonafide research work 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 been duly acknowledged.

Dated: December, 2017
Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED PARENT

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The Author

EFFECT OF GIBBERELLIC ACID ON MORPHO-PHYSIOLOGICAL ATTRIBUTES AND YIELD OF OKRA

FARZANA ALAM MOUSUMI

ABSTRACT

The experiment was carried out in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka at the period of March to July 2017 to find the growth and yield of okra as influenced by different concentration of gibberellic acid. Seeds of BARI Dherosh 1 and Hybrid Variety were used as planting materials. The experiment consisted of two varieties of okra at levels of GA_3 (5 levels) as- G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3 and G_4: 200 ppm GA_3. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of variety, the tallest plant 28.66, 82.48 and 128.95 cm, respectively was from V_1 variety at 20, 40 and 60 DAS, respectively. Variety V_2 performed the maximum (18.38) number of pods and the highest pod yield (14.23 t ha^{-1}). On the other hand, at 20 DAS, the tallest plant (31.13 cm) was observed from G_3 (150 ppm GA_3) and at 40 and 60 DAS, the tallest plant (90.76 and 135.1 cm, respectively) was observed from G_2 (100 ppm GA_3). The maximum (19.52) number of pods and the highest pod yield (16.18 t ha^{-1}) was contributed by G_2. In The highest pod yield 14.23(t ha^{-1}) was recorded from the application of 100ppm of GA_3 in Hybrid Variety followed by the yield of BARI Dherosh 1 14.01(t ha^{-1}) with 100ppm of GA_3 at optimum harvest date. Both varieties increased the yield of okra at 100ppm. So, 100ppm GA_3 is suitable for okra production.

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SOME COMMONLY ACRONYMS USED

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
Cv	Co-efficient of variation
DAS	Days After Sowing
et al.	(et albeit) and elsewhere
etc.	Etcetera
FAO	Food and Agriculture Organization
IRRI	International Rice Research Institute
J.	Journal
LSD	Least Significance Difference
MoP	Muriate of Potash
Ppm	Parts per million
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
TSP	Triple Superphosphate
BARI	Bangladesh Agricultural Research Institute
DAS	Days After Sowing
GA_3	Gibberellic Acid

ABBREVIATION	FULL WORD
NAA	Napthalene Acetic Acid
IAA	Indole Acetic Acid
DAT	Days After Transplanting
g	Gram
ha	Hectare
hrs	Hours
kg	Kilogram
mm	Millimeter
d.f	Degrees of freedom
m	Meter
cm	Centimeter
%	Percentage
nm	Namometer
^{0}C	Degree Celsius
^{0}E	Degree East
^{0}N	Degree North

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Okra [(*Abelmoschus esculentus* L.) Moench] is frequently known as Lady's finger, Dherosh or Bhendi which belongs to malvaceae family. The crop probably originated in tropical Africa or possibly tropical Asia and now a days it is widely grown as vegetable crop throughout the tropics (Thompson and Kelly, 1959; Purseglove, 1987). It is an important warm season vegetable crop which is cultivated in tropical and sub-tropical regions of the world. It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1999). Okra is specially valued for its tender and delicious edible pods which are rich sources of vitamins and minerals. Tender green pods of okra contains approximately 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). The fruits also have some medicinal value and mucilaginous preparation from the fruits that can be used as a plasma replacement or blood volume expander (Chowdhury, 1993). In Bangladesh the total production of okra is about 54,901 MT production which was produced from 11378.95 hectare of land in the year 2016-17 with average yield about 3.38 t/ha which is very low (BBS, 2018) which is very low compared to that of other developed countries where the yield is as high as 7.0-12.0 t/ha (Yamaguchi, 1998). Okra is a self-pollinated crop, occurrence of out crossing to an extent of 0.34 – 27.30 percent is noticed with the insect assisted pollination (Kalloo, 1994). Tender green fruits are cooked in curry and soup, while crop has not adapted in India as leafy vegetable as in for East countries. It was probably domesticated in the Ethopian region but according to Murdoc it is in West Africa.

In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during kharif season and around 70% in the rabi season (Anon., 1993). Therefore, as vegetable okra can get an importance in kharif season as well as summer season in our country context.

There are variations of the per capita consumption of vegetables in SAARC countries, where it was in Pakistan (69 g), Srilanka (120 g), and India (135 g) and all are higher than that of Bangladesh. Although, many dietitians prescribed that the daily requirements of vegetables for an adult person is approximately 285 g (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and consumption of per capita vegetable in Bangladesh. As a result, malnutrition is very much evident in our country. Successful okra production may contribute partially in solving vegetable scarcity of summer season for the people of Bangladesh. The low yield of okra in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties in appropriate time, fertilizer management, disease & insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices. The application of plant growth regulators is known as one of the most effective treatments used now a days in agriculture, productivity of horticulture crop productions were increased by application of different growth regulators (Jafarullah *et al*., 2007). Growth regulators is the important factor that greatly affects the growth, development and yield of okra.

Plant growth regulators are considered as new generation of agro chemicals after fertilizers, insecticides and herbicides. The use of plant growth regulators has led to intensive scientific activity for their commercial exploitation. Since, 1949 several valuable effects of different plant growth regulators have been studied on a number of horticultural crops (Khan *et al*., 2006).

Plant growth regulators (PGRs) are extensively used in horticultural crops to enhance plant growth and improve yield by increasing fruit number, fruit set and size. Plant growth regulators like promoters, inhibitors or retardants play a key role in controlling internal mechanisms of plant growth by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis (Kumar *et al*., 2014). The most widely available plant growth regulator is GA_3 or gibberellic acid, which is an important growth stimulating substances promote cell elongation and cell division and help in the growth and development of plants (Prasad *et al*., 2013). Gibberellic acid (GA_3) comprise a group of naturally occurring plant hormones which play a central role in the early germination processes of seeds by activating enzyme production and mobilizing storage reserves (Bewley and Black, 1983). Additionally, foliar application of gibberellins stimulates and synchronizes flowering and fruit set, as well as enhancing photosynthesis and growth (Yuan and Xu, 2001), or stimulating growth but not the rate of photosynthesis (Dijkstra and Kuiper, 1989). Dhankhar and Singh (2009) reported that GA_3 application increased okra pod length and diameter.

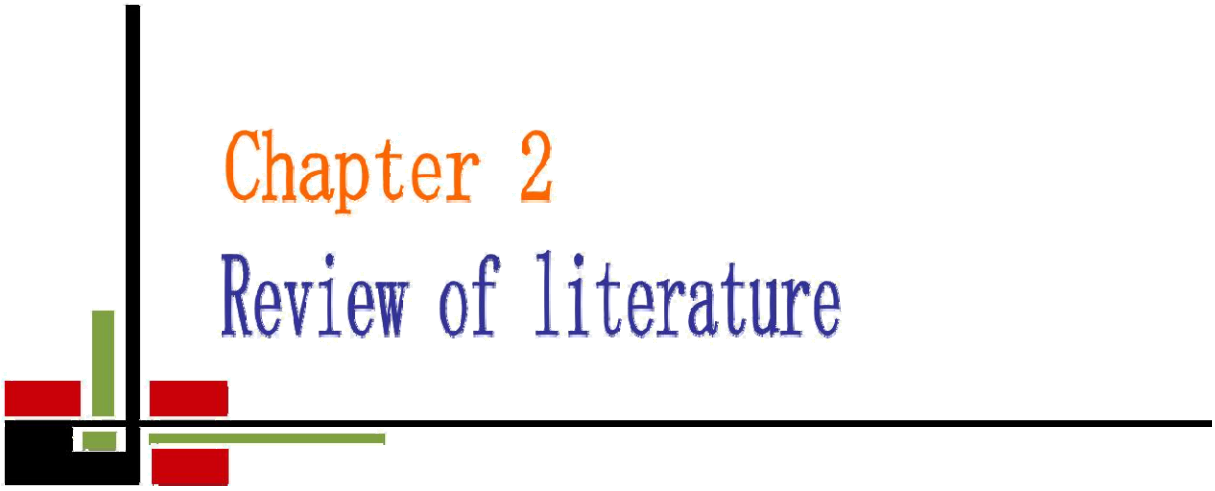
Among the fruit and vegetables, okra is an important vegetables having good demand throughout the year for its tender fruits. In recent years, scientists have given due attention to the idea of vegetating plant growth as third most important factor in improving the growth, yield and quality with the application of plant growth regulators in various ways.

Treatment of seed and foliar spray with plant growth regulator is one of the most popular methods and has been claimed as an effective tool by many workers for improving rate and amount of germination.

The present investigation was therefore to study entitled “ Effect of gibberellic acid morpho-physiological attributes and yield of okra [Abelmoschus esculentus (L.) Moench]” with following objectives :

Objectives:

i. To identify the varietal performance of inbreed and hybrid (Baishakhi) okra.
ii. To know the effects of gibberellic acid on morpho-physiology and yield of okra.
iii. To find out appropriate concentration of gibberellic acid for increasing okra production.



Chapter 2
Review of literature

CHAPTE II

REVIEW OF LITERATURE

The chapter deals with the earlier research work done on the similar line related to the “Effect of gibberellic acid on morpho-physiological attributes and yield of Okra [Abelmoschus esculentus (L.) Moench.]” It includes that application of GA_3 and their effect on morpho-physiological attributes and yield of Okra . Supporting evidence from vegetable and other crops are also incorporated in the review of making interpretation of result easier and broad base.

2.1: Effect of gibberellic acid on morpho-physiological attributes

A field experiment was conducted by Gadade *et al*. (2017) on field of Department of Argicultural Botany, College of Agriculture, Parbhani (M.S.), India; during khar0if to study of plant growth regulators on growth and yield of okra (*Abelmoschus esculentus* L.). The treatments consisted of two growth regulators viz., gibberrllic acid (50, 100, 150 and 200 ppm) and naphthalene acetic acid (50, 100, 150 and 200 ppm). Results revealed that the application of plant growth regulators significantly increased morpho-physiological traits viz. plant height, number of branches per plant, yield per plant and plot as compared to control.

A field experiment was conducted by Meena *et al*. (2017) at Department of Horticulture, MJRP College of Agriculture and Research Achrol, Jaipur. The eight treatment consisting of three levels of GA_3 (10, 20, 30 ppm), three levels of naphthalene acetic acid. Results showed that spray of gibberellic acid significantly influenced the performance of growth attributes viz., plant height, fruit length, fruit diameter, number of fruits per plant, average weight of fruits per plant, yield per plot as well as per hectare.

In okra reported that increased plant height (89.0 cm), longest petiole (29.0 cm), number of leaves (49.0/plant), leaf area (29.7 cm), and number of branches (5.5/plant) was due to foliar spray of GA_3 50 ppm (Mehraj *et al.*, 2015).

According to Bello (2015) revealed that the okra seeds were pre-soaked GA_3 at (100 ppm) for 3-4 hours increase the plant height, number of leaves, leaf area and dry matter (yield) in okra.

Ravat and Makani (2015) concluded that application of GA_3 @ 100 ppm at different growth stages increased plant height, number of leaves, number of internodes per plant, days to flower initiation, days to 50% flowering in okra.
Mohammadi *et al*. (2014) conducted an experiment at the University of Thessaly during the summer season to study the effect of foliar application of gibberellic acid (GA_3) to okra at an early stage of plant growth (3-4 leaves) on plant growth, pod and seed characteristics was studied in relation to harvest time. GA_3 was applied at concentrations of 0 (Control), 50, and 100 mg L^{-1} to four okra cultivars and pods were harvested 30, 35, 40 and 50 days after anthesis (DAA) from the lower part of the plant. From the results it was found that GA_3 application increased plant height irrespective of cultivar and GA_3 concentration (50 and 100 mg L^{-1}), but without increasing flower induction or pod set. Similarly, GA_3 had no effect on pod dimensions (which were determined by genotype) or mean 100 seed weight. Similarly, GA_3 application did not consistently affect seed moisture content, but it did however, increase the number of seeds per pod. Overall, pod characteristics were affected more by genotype and harvest time than by GA_3 application.

Patil and Patel (2010) observed an okra seed highest percentage of seed germination, number of branches, early flowering, fruit length, fruit weight, fruit yield per plant and fruit yield per hectare. Treatments comprised with GA_3 at 15mg/L soaking of seeds in distilled water and control (unsoaked seeds).
Megbo *et al*. (2010) conducted an experiment and reported that gibberellic acid stimulated the elongation of plant internodes. Plants treated with gibberellic acid (GA_3), as the sole plant growth regulator, were at least three (3) folds greater in height in comparison to the Control and seven (7) folds higher than other treatments after 8 weeks of acclimatization. The Control plants, without any

applied growth regulator or inhibitor of gibberellic acid biosynthesis, grew taller than the plants treated with either gibberellic acid (GA_3) and Ancymidol or GA_3 and Paclobutrazol. This result indicates that both Ancymidol and Paclobutrazol inhibited the activity of giberrellic acid in the plant, thereby giving rise to plants with shorter internodes and plant height. Gibberellic acid promoted leaf growth and apical dominance in okra plants.

2.2: Effect of gibberellic acid on yield traits

Chowdhury *et al.* (2014) noticed the application of GA_3 (100 ppm) in okra different days of sowing increasing the yield (16.67 t/ha) as compared to control.

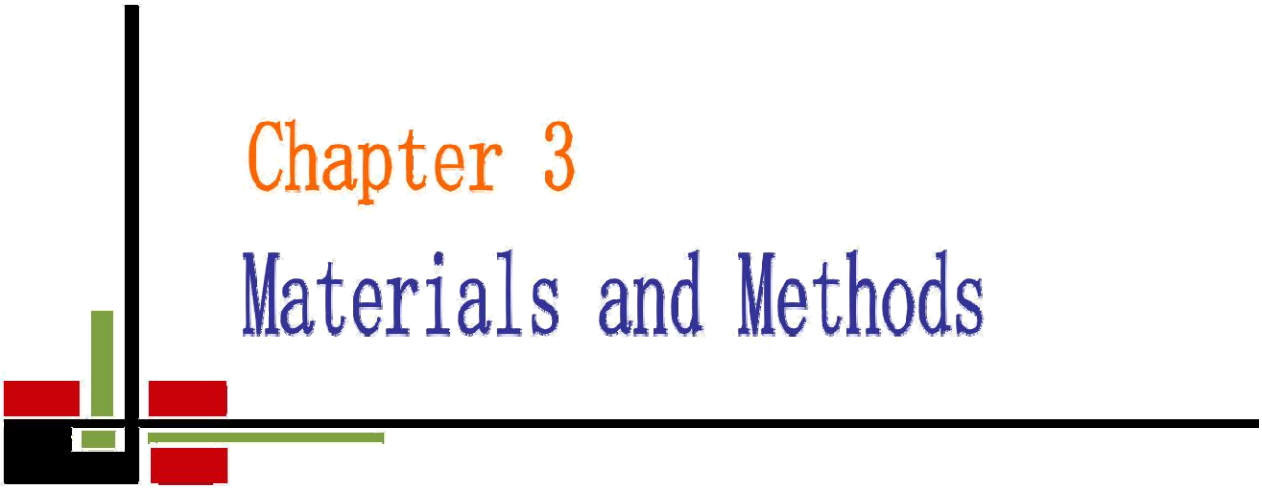
The application of 160 ppm GA_3 resulted in minimum number of days of first flowering (37.13) and days to 50% flowering (41.33) in okra (Singh *et al.*, 2012).

Avinash *et al*. (2011) conducted a field experiment with different concentration of GA_3, IAA and NAA as seed treatment followed by foliar spray 30 DAS in Okra variety Akola Bahar in Randomized Block Design with three replications. The data revealed that significant effect for plant height (107.74 cm), internodal length (3.1 cm) was obtained in treatment GA_3 at 150 ppm. Significantly minimum number of days required for first flowering (39.67 days) and first harvesting (44.67 days) were recorded in treatment GA_3 at 150 ppm. The significantly maximum parentage of fruit set (74.79) and fruit yield per hectare were observed in same treatment.

In okra, it was noticed that significantly minimum number of days required for first flowering (39.67 days) and first harvesting (44.67 days) were recorded in treatment GA_3 at 150 ppm (Dhage *el at.,* 2011).

Patil *et al.* (2008) concluded that length of dried pod, weight of seeds per pod, weight of 100 seeds the treatment GA_3 at 50 ppm showed significantly superior performance over remaining control treatment in okra.

As per the above cited reviews, it may be concluded that GA_3 are the important factors for attaining optimum growth and as well as highest yield of okra. The literature revealed that the effects of GA_3 have not been studied well and have no definite conclusion for the production of okra in the agro climatic condition of Bangladesh.



Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to find the growth and yield of okra as influenced by different levels of gibberellic acid. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of experimental site, experimental details, growing of crops, harvesting, data collection procedure and procedure of data analysis. Details were presented below under the following headings and sub-headings-

A field experiment was conducted in summer/ rainy season 2017 to study the "Effect of gibberellic acid morpho-physiological attributes and yield of okra [Abelmoschus esculentus (L.) Moench]" at the SAU.

The details of material used and methods adopted during the course of investigation are described in this chapter.

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted at the period of March to July 2017.

3.1.2 Experimental location

The present research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The experiment was carried out at in $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Soil condition

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the study. The collected soil was air-dried, grind and passed through 2 mm sieve

and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter capacity 5.6 and 0.78%, respectively and the the soil composed of 27% sand, 43% silt, 30% clay. Details descriptions have been presented in Appendix I.

3.1.4 Climatic and weather condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon, pre-monsoon period or hot season and the monsoon period. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II. During this period the maximum temperature (35.1^0C) was recorded in the month of July 2017, while the minimum temperature (19.5^0C) in the month of March 2017. The highest humidity (81%) was recorded in the month of June, 2017, whereas the highest rainfall (298 mm) was recorded in the month of July, 2017 and highest sunshine hour (7.8 hrs) was recorded in May, 2017.

3.2 Experimental details

3.2.1 Planting materials

Seeds of BARI Dherosh 1 & Hybrid Variety (Baishakhi) were used as planting materials for this experiment.

3.2.2 Treatment of the experiment

The experiment consisted of 2 factors

Factor A: Different Variety (2 Variety) as

i. V_1: BARI Dherosh 1
ii. V_2: Hybrid Variety (Baishakhi)

Factor B: Levels of GA_3 (5 levels)

i. G_0: 0 ppm GA_3(control)
ii. G_1: 50 ppm GA_3
iii. G_2: 100 ppm GA_3
iv. G_3: 150 ppm GA_3
v. G_4: 200 ppm GA_3

There were 10 (5 × 2) treatments combination such as V_1G_0, V_1G_1, V_1G_2, V_1G_3, V_1G_4, V_2G_0, V_2G_1, V_2G_2, V_2G_3 and V_2G_4.

3.2.3 Design and layout of the experiment

The two factorial experiments was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 252 m^2 with length 23 m and width 11.2 m which were divided into three equal blocks. Each block was divided into 10 plots where 10 treatments combination allotted at random. There were 36 unit plots and the size of each plot was 2.4 m × 1.6 m. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.2.4 Preparation of the main field

The selected experimental plot was opened in the 2nd week of March 2017 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done with a country plough followed by laddering to make the land suitable for seeds sowing. All weeds, stubbles and residues were eliminated and finally, a good tilth was achieved. The soil was treated with Cinocarb 3G @ 4 kg/ha at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.2.5 Application of manure and fertilizers

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP and MoP and one-third amount of urea was applied as basal dose at the time of final land preparation dated at 30 March, 2017. The rest amount of urea was applied at 15 and 30 days after sowing (DAS).

Table 1. Dose and method of application of fertilizers in okra field (FRG, 2005)

Fertilizers	Dose/ha	Application (%)		
		Basal	15 DAS	30 DAS
Cowdung	10 tons	100	--	--
Nitrogen (as urea)	100 kg	33.33	33.33	33.33
P_2O_5 (as TSP)	100 kg	100	--	--
K_2O (as MoP)	150 kg	100	--	--

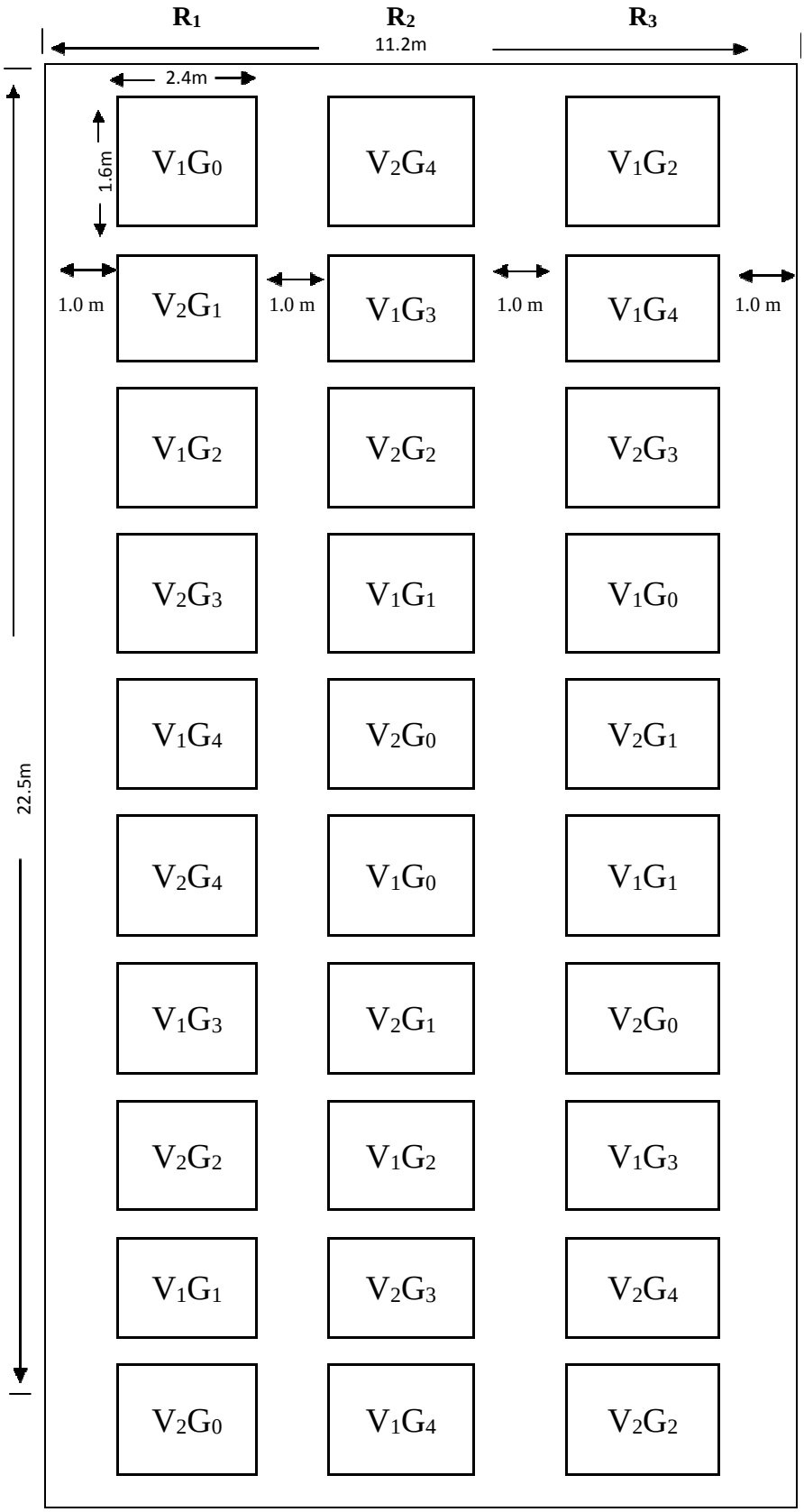
Table 2. Amount of fertilizers per plot

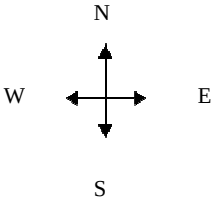
Fertilizers	Kg
Cowdung	3.84
Urea	0.038
TSP	0.038
MOP	0.057

Total amount of fertilizers for whole experimental field

CD - 252 kg
Urea - 2.52 kg
TSP - 2.52 kg
MOP – 3.78 kg

Figure-1: Layout of the experimental plot





Plot size: 2.4 m × 1.6 m

Plot spacing: 0.50 m

Between block: 1.00 m

Factor A:Okra Variety(2 variety as)

i. V_1 : BARI Dherosh 1
ii. V_2: Hybrid Variety (Baishakhi)

Factor B: Levels of GA_3 (5 levels) As

i. G_0: 0 ppm GA_3 (control)
ii. G_1: 50 ppm GA_3
iii. G_2: 100 ppm GA_3
iv. G_3: 150 ppm GA_3
v. G_4: 200 ppm GA_3

Exparimental details:

Table 3: Details of layout plan

Location	SAU, 2374N Latitude 9035E Longitude
Group	OKRA
Cultivar	BARI Dherosh 1, Hybrid (Baishakhi)
Season	Kharif
Number of treatments	5
Design	RCBD
Plot size	3.84 m^2
Plant to plant spacing	60 cm
Row to row spacing	40 cm
Date of seed sowing	2 April, 2017

Table 4: Treatment details

SL No.	Symbol Used	Treatment Details
1.	G_0	0 ppm
2.	G_1	50 ppm
3.	G_2	100 ppm
4.	G_3	150 ppm
5.	G_4	200 ppm

3.3 Crop cultivation practices

3.3.1 Collection of seeds

The seed of BARI Dherosh 1 was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur & Hybrid Variety (Baishakhi) was collected from Siddik Bazar, Dhaka.

3.3.2 Seeds sowing

The okra seeds were sown in the main field at 02 April in 2017. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in rows having a depth of 2-3 cm with maintaining distance from 60 cm and 40 cm from plant to plant and row to row, respectively. So there were 16 seeds were sown in a plot.

3.3.3 Collection, preparation and application of GA_3

Plant growth regulator Gibberellic Acid (GA_3) was collected from Hatkhola Road, Dhaka. A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one liter of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 50 ml of this stock solution was diluted in 1 liter of distilled water to get 50 ppm GA_3 solution. In a similar way, 100, 150, 200 ppm stock solutions were diluted to 1 liter of distilled water to get 100, 150, 200 ppm solution. Control solution also prepared only by adding a small quantity of ethanol with distilled water. GA_3 as per treatment were applied at three times 20, 40 and 60 days after sowing (DAS) by a hand sprayer.

3.3.4 Inter-cultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the okra seedlings.

3.3.5 Gap filling

The seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after germination and such seedling were replaced by new seedlings Replacement was done with healthy seedling in the afternoon having a boll of earth which was also planted on the same date by the side of the unit plot. The seedlings were given watering for 7 days starting from germination for their proper establishment.

3.3.6 Weeding

The weeding was done by nirani with roots at 15, 30 and 45 days after sowing to keep the plots free from weeds.

3.3.7 Irrigation

Light watering was given by a watering cane at every morning and afternoon and it was continued for a week for rapid and well establishment of the germinated seedlings.

3.3.8 Plant protection measure

Insect infestation was a serious problem during the period of establishment of seedings in the field. In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some discolored and yellowish diseased leaves were also collected from the plant and removed from the field.

3.4 Harvesting

Fruits were harvested at 3 days interval based on eating quality at soft and green condition. Harvesting was started from 24 May, 2017 and was continued up to the last July 2017.

3.5 Observation to be recorded

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except yields of plots, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves, leaf area and diameter of stem were collected at 20, 40 and 60 days after sowing (DAS). Chlorophyll content of leaf was recorded at 50 and 80 days after sowing (DAS). All other yield contributing characters and yield parameters such as days to flowering, number of pods per plant, weight of individual pods, length of pod, diameter of pod, yield per plot was also recorded as per the suitable time of optimum performance of okra plants.

3.5.1 Morpho-physiology and Growth parameters

3.5.1.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem of five plants and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 60 days to observe the growth rate of plants.

3.5.1.2 Number of leaves plant^{-1}

The total number of leaves plant^{-1} was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 60 DAS at 20 days interval.

3.5.1.3 Leaves area

Leaf area was measured from sample plants in centimeter^2 from the one side to another side of leaf of the longest five leaves and mean value was calculated. Leaf area was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 60 days to observe the growth rate of plants.

3.5.1.4 Stem diameter

Stem diameter was measured from sample plants with a digital calipers-515 (DC-515) from the three different parts of five plants and mean value was calculated. Stem diameter was recorded at 20 days interval starting from 20 days after sowing (DAS) upto 60 days to observe the growth rate of plants.

3.5.1.5 Chlorophyll Content (mg/g FW)

Samples were collected at 50 days after sowing (DAS) and 90 days after sowing (DAS). Leaf samples were weighed separately. The fresh leaf of 0.05g were measured separately by electric balance. Samples were macerated in 80% acetone. These were centrifuged for 5 minutes at 3000 rpm and finally made a volume of 5ml with acetone (80%). The optical density was measured at 645 and 663 nm with a spectrophotometer (Systronics UV-VIS, 118, India).

Leaf chlorophyll was measured using the method of Yoshida el al. (1976). The formula for computing total chlorophyll was as follows:

$$\text{Total Chlorophyll} = (20.2 \times D_{645} + 8.02 \times D_{663}) \times \frac{5}{1000 \times 0.05} \text{ mg/g FW}$$

Where,

D_{663} = absorbance at 663 nm wave length

D_{645} = absorbance at 645 nm wave length

$\frac{5}{1000 \times 0.05}$ = Dilution Water

3.5.2 Yield parameter

3.5.2.1 Days to 1st flowering

Days to starting of flowering was recorded from the date of sowing to the initiation of 1st flower bud.

3.5.2.2 Pod length

The length of pod was measured with a meter scale from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.5.2.3 Pod diameter

Diameter of pod was measured at the middle portion of 10 selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

3.5.2.4 Weight of individual pod

The weight of individual pod was measured with a digital weighing machine from 10 selected marketable fruits from each selected plots and there average was taken and expressed in gram.

3.5.2.5 Number of pods plant^{-1}

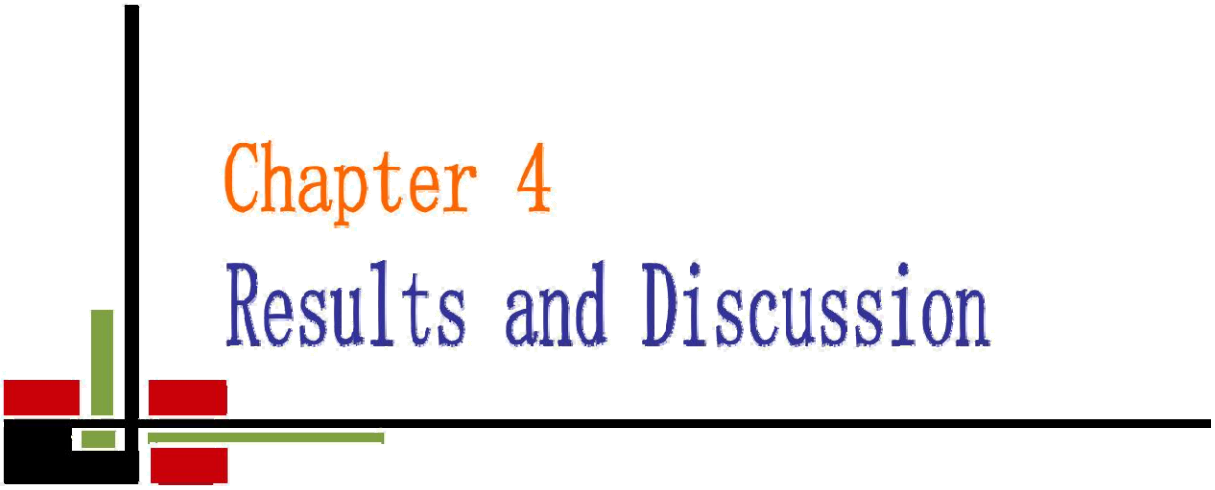
The number of pods plant^{-1} was counted from the sample plants for the whole growing period and the average number of pods produced plant^{-1} was recorded and expressed in pods plant^{-1}.

3.5.2.6 Pod yield per hectare

Pod yield per hectare of okra fruits was estimated by converting the weight of plot yield into hectare and was expressed in ton.

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for levels of nitrogen and GA_3 on growth and yield of okra. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).



Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

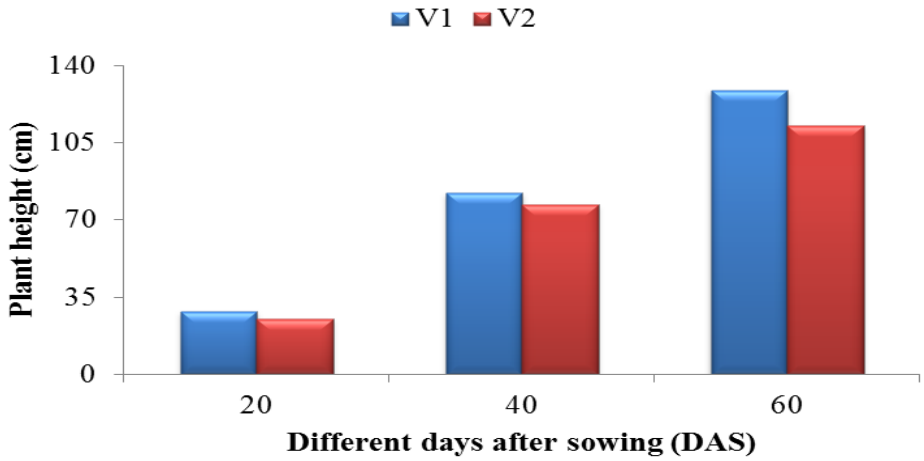
The experiment was conducted to find the growth and yield of okra as influenced by different levels gibberellic acid. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III- IX. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height (cm)

Plant height of okra showed statistically significant differences at 20, 40 and 60 DAS (days after sowing) different variety of okra (Figure 2). At 20, 40 and 60 DAS, the tallest plant (28.66, 82.48 and 128.95 cm, respectively) was recorded from V_1 variety, while the shortest plant (25.17, 77.13 and 113.00 cm, respectively) was found from V_2 variety.

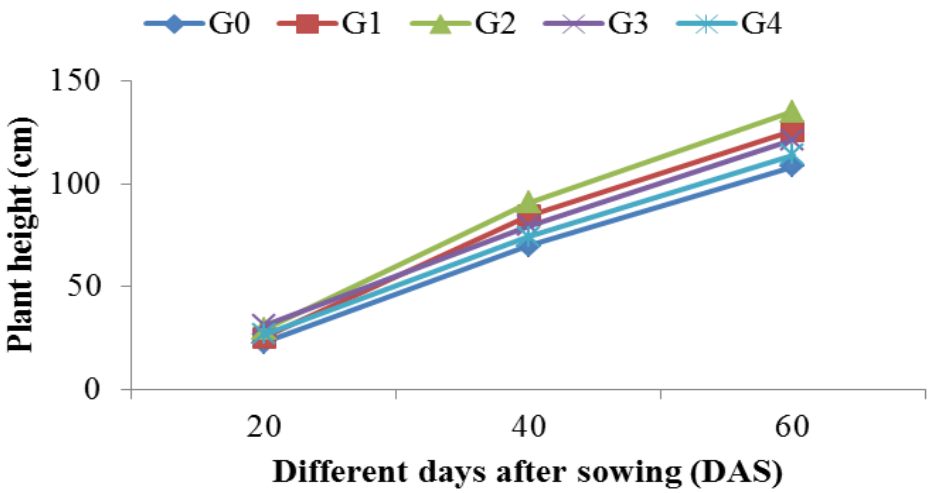
Statistically significant variation was recorded in terms of plant height of okra at 20, 40 and 60 DAS for different levels of gibberellic acid (Figure 3). At 20 DAS, the tallest plant (31.13 cm) was observed from G_3 (150 ppm GA_3), while the shortest plant (22.60 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the tallest plant (90.76 and 135.1 cm, respectively) was observed from G_2 (100 ppm GA_3) which was statistically similar (84.49 and 125.8 cm, respectively) to G_1 (50 ppm GA_3), while the shortest plant (69.90, and 108,5 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). Megbo *et al*. (2010) reported that gibberellic acid promoted apical dominance in okra plants and longest plant.

Due to combined effect of different levels variety and gibberellic acid showed statistically significant differences on plant height of okra at 20, 40 and 60 DAS (Table 2). At 20 DAS the tallest plant (32.69cm) was found from V_1G_3 (BARI Dherosh 1 and 150 ppm GA_3), 40 and 60 DAS the tallest plant(92.49 and 143.1 cm, respectively) was found from V_1G_2 (BARI Dherosh 1 and 100 ppm GA_3) and the shortest plant (21.13, 67.74, 101.5 cm, respectively) was recorded from V_2G_0 (Hybrid Variety (Baishakhi) and 0 ppm GA_3 i.e. control condition).



V_1: BARI Dherosh 1 V_2:Hybrid (Baishakhi)

Figure 2. Effect of variety on the plant height of okra at different days after sowing (LSD $_{(0.05)}$ = 1.87, 4.39 and 7.64 at 20, 40 and 60 DAS, respectively)



G_0: 0 ppm GA_3 G_1: 50 ppm GA_3 G_2: 100 ppm GA_3
G_3: 150 ppm GA_3 G_4: 200 ppm GA_3

Figure 3. Effect of different concentration of gibberellic acid on the plant height of okra at different days after sowing (LSD $_{(0.05)}$ = 2.96, 6.94 and 12.09 at 20, 40 and 60 DAS, respectively)

Table 5. Interaction effect of variety and different concentration of gibberellic acid on the plant height of okra at different days after sowing (DAS)

Treatment combinations	Plant height (cm) at different days after sowing (DAS)		
	20	40	60
V_1G_0	24.08 de	72.06 de	115.6 c-f
V_1G_1	26.20 b-d	88.77 ab	134.2 ab
V_1G_2	31.78 a	92.49 a	143.1 a
V_1G_3	32.69 a	83.17 a-c	130.0 a-c
V_1G_4	28.53 a-c	75.91 c-e	121.9 b-e
V_2G_0	21.13 e	67.74 e	101.5 f
V_2G_1	23.79 de	80.21 b-d	117.5 b-f
V_2G_2	26.40 b-d	89.03 ab	127.1 a-d
V_2G_3	29.57 ab	75.94 c-e	112.5 d-f
V_2G_4	24.95 c-e	72.72 de	106.4 ef
LSD $_{(0.05)}$	**4.19**	**9.81**	**17.09**
CV (%)	**9.08**	**7.17**	**8.24**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

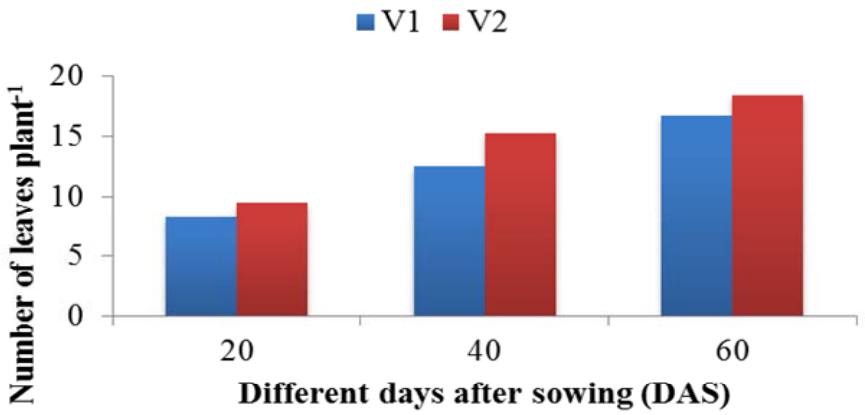
G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.2 Number of leaves plant^{-1}

Number of leaves of okra showed statistically significant differences at 20, 40 and 60 DAS (days after sowing) different variety of okra (Figure 4). At 20, 40 and 60 DAS, the highest number of leaf (9.45, 15.25 and 18.41, respectively) was recorded from V_2 variety, while the lowest number of leaf (8.30, 12.43 and 16.64, respectively) was found from V_1 variety.

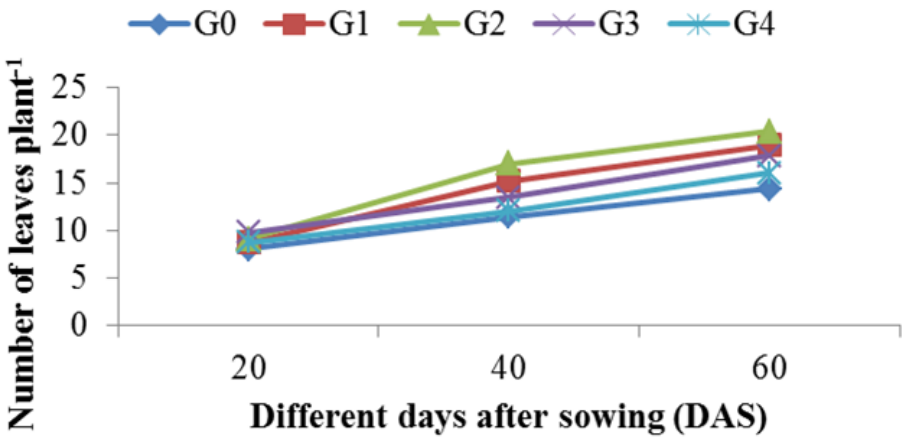
Statistically significant variation was recorded in terms of leaf number of okra at 20, 40 and 60 DAS for different levels of gibberellic acid (Figure 5). At 20 DAS, the highest number of leaf (9.767) was observed from G_3 (150 ppm GA_3) which was statistically similar (9.133) to G_2 (100 ppm GA_3), while the lowest number of leaf (8.067) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the highest number of leaf (17.02 and 20.43, respectively) was observed from G_2 (100 ppm GA3) which was statistically similar (18.98 at 60 DAS) to G_1 (50 ppm GA_3), while the lowest number of leaf (11.45, and 14.38, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition).

Due to combined effect of different levels variety and gibberellic acid showed statistically significant differences on leaf number of okra at 20, 40 and 60 DAS (Table 4). At 20 DAS the highest number of leaf (10.47) was found from V_2G_3 (Hybrid Variety and 150 ppm GA_3), 40 and 60 DAS the highest number of leaf (18.45 and 21, 52 respectively) was found from V_2G_2 (Hybrid Variety and 100 ppm GA_3) and the lowest number of leaf (7.67, 10.17, 13.32 respectively) was recorded from V_1G_0 (BARI Dherosh 1 and 0 ppm GA_3 i.e. control condition).



V_1: BARI Dherosh 1 V_2: Hybrid (Baishakhi)

Figure 4. Effect of variety on the number of leaves plant^{-1} of okra at different days after sowing (LSD $_{(0.05)}$ = 0.61, 0.63 and 1.18 at 20, 40 and 60 DAS, respectively)



G_0: 0 ppm GA_3 G_1: 50 ppm GA_3 G_2: 100 ppm GA_3
G_3: 150 ppm GA_3 G_4: 200 ppm GA_3

Figure 5. Effect of different concentration of gibberellic acid on the number of leaves leaves plant^{-1} of okra at different days after sowing (LSD $_{(0.05)}$ = 0.97, 1.00 and 1.87 at 20, 40 and 60 DAS, respectively)

Table 6. Effect of variety and different concentration of gibberellic acid on the number of leaves plant^{-1} of okra at different days after sowing (DAS)

Variety	20 DAS	40 DAS	60 DAS
V_1	8.30 b	12.43 b	16.64 b
V_2	9.45 a	15.25 a	18.41 a
LSD (0.05)	0.61	0.63	1.18
CV (%)	9.00	5.93	8.80
Treatment	**20 DAS**	**40 DAS**	**60 DAS**
G_0	8.067 c	11.45 d	14.38 d
G_1	8.708 bc	15.20 b	18.98 ab
G_2	9.133 ab	17.02 a	20.43 a
G_3	9.767 a	13.48 c	17.80 bc
G_4	8.700 bc	12.04 d	16.04 cd
LSD $_{(0.05)}$	**0.97**	**1.00**	**1.87**
CV (%)	**9.00**	**5.93**	**8.80**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 7. Interaction effect of variety and different concentration of gibberellic acid on the number of leaves plant^{-1} of okra at different days after sowing (DAS)

Treatment combinations	Number of leaves plant^{-1} at different days after sowing (DAS)		
	20 DAS	40 DAS	60 DAS
V_1G_0	7.67 e	10.17 g	13.32 e
V_1G_1	7.90 de	13.93 de	18.25 bc
V_1G_2	8.40 c-e	15.60 bc	19.33 abc
V_1G_3	9.07 b-d	12.02 f	17.20 bcd
V_1G_4	8.47 c-e	10.42 g	15.10 de
V_2G_0	8.47 c-e	12.73 ef	15.44 de
V_2G_1	9.52 a-c	16.47 b	19.70 ab
V_2G_2	9.87 ab	18.45 a	21.52 a
V_2G_3	10.47 a	14.93 cd	18.40 bc
V_2G_4	8.93 b-e	13.67 de	16.98 cd
LSD $_{(0.05)}$	**1.37**	**1.41**	**2.65**
CV (%)	**9.00**	**5.93**	**8.80**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

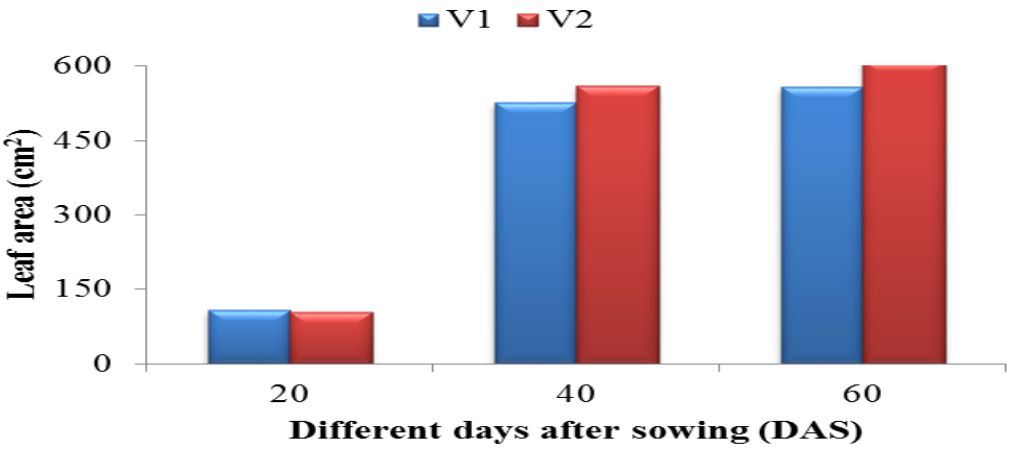
G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.3 Leaf area (cm^2)

Leaf area of okra showed statistically significant differences at 20, 40 and 60 DAS (days after sowing) different variety of okra (Figure 6). At 20 DAS the largest leaf (108.28cm^2) was recorded from V_1 variety, while the smallest leaf (104.40 cm^2) was recorded from V_2 variety. At 40 and 60 DAS the largest leaf (559.57 and 611.5 cm^2, respectively) was recorded from V_2 variety, while the smallest leaf (526.36 and 558.2 cm^2, respectively) was found from V_1 variety.

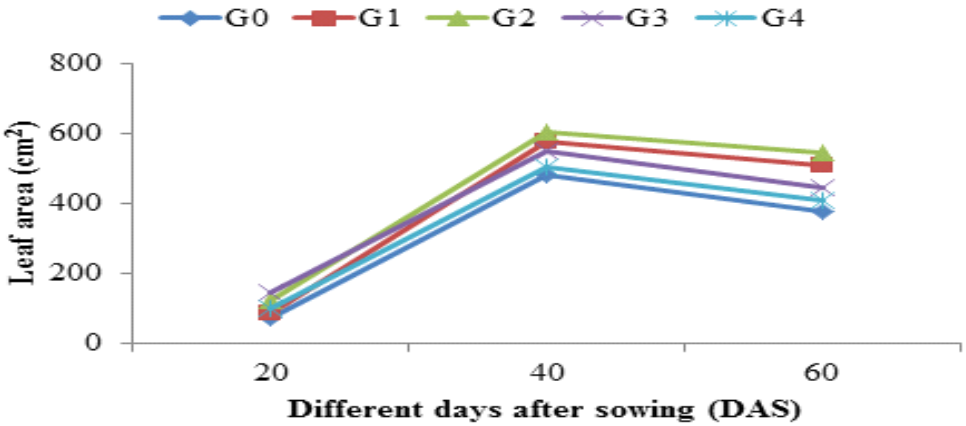
Statistically significant variation was recorded in terms of leaf area of okra at 20, 40 and 60 DAS for different levels of gibberellic acid (Figure 7). At 20 DAS, the largest leaf (147.1 cm^2, respectively) was observed from G_3 (150 ppm GA_3), while the smallest leaf (74.69 cm^2) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 DAS, the largest leaf (603.8 cm^2) was observed from G_2 (100 ppm GA_3) which was statistically similar (574.7 cm^2) to G_1 (50 ppm GA_3). At 60 DAS, the largest leaf (686.8 cm^2) was observed from G_2 (100 ppm GA_3). At 40 and 60 DAS, the smallest leaf (482.1 and 503.6 cm^2, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). Megbo *et al*. (2010) reported that gibberellic acid promoted leaf growth in okra plants.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on leaf area of okra at 20, 40 and 60 DAS (Table 6). At 20 DAS, the largest leaf (157.4 cm^2) was observed from V_2G_3 and the smallest leaf (66.94 cm^2) was obtained from V_2G_0. At 40 and 60 DAS, the largest leaf (620.10 and 746.6 cm^2, respectively) was observed from V_2G_2 and the smallest leaf (468.40, 493.7 cm^2, respectively) was obtained from V_1G_0.



V_1: BARI Dherosh 1 V_2: Hybrid (Baishakhi)

Figure 6. Effect of variety on the leaf area of okra at different days after sowing (LSD $_{(0.05)}$ = NS, 31.55 and 20.20 at 20, 40 and 60 DAS, respectively)



G_0: 0 ppm GA_3 G_1: 50 ppm GA_3 G_2: 100 ppm GA_3
G_3: 150 ppm GA_3 G_4: 200 ppm GA_3

Figure 7. Effect of different concentration of gibberellic acid on the leaf area of okra at different days after sowing (LSD $_{(0.05)}$ = 10.36, 49.88 and 31.94 at 20, 40 and 60 DAS, respectively)

Table 8. Effect of variety and different concentration of gibberellic acid on the leaf area of okra at different days after sowing (DAS)

Treatment	20 DAS	40 DAS	60 DAS
V_1	108.28 a	526.36 b	558.2 b
V_2	104.40 b	559.57 a	611.5 a
LSD (0.05)	NS	31.55	19.6
CV (%)	8.04	7.57	4.36
Treatment	**20 DAS**	**40 DAS**	**60 DAS**
G_0	74.69 e	482.1 d	503.6 e
G_1	86.04 d	574.7 ab	628.0 b
G_2	123.3 b	603.8 a	686.8 a
G_3	147.1 a	549.8 bc	568.7 c
G_4	100.6 c	504.4 cd	537.1 d
LSD $_{(0.05)}$	**10.36**	**49.88**	**30.95**
CV (%)	**8.04**	**7.57**	**4.36**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 9. Interaction effect of variety and different concentration of gibberellic acid on the leaf area of okra at different days after sowing (DAS)

Treatment combinations	Leaf area (cm^2) at different days after sowing (DAS)		
	20	40	60
V_1G_0	82.45 d	468.40 d	493.7 f
V_1G_1	78.80 de	566.20 a-c	607.1 bc
V_1G_2	122.5 bc	587.50 ab	626.9 b
V_1G_3	136.8 b	529.60 b-d	556.9 de
V_1G_4	120.9 c	480.00 d	506.3 f
V_2G_0	66.94 e	495.90 cd	513.5 ef
V_2G_1	93.29 d	583.10 ab	649.0 b
V_2G_2	124.0 bc	620.10 a	746.6 a
V_2G_3	157.4 a	570.00 ab	580.6 cd
V_2G_4	80.42 de	528.80 b-d	567.9 cd
LSD $_{(0.05)}$	**14.66**	**70.54**	**43.77**
CV (%)	**8.04**	**7.57**	**4.36**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

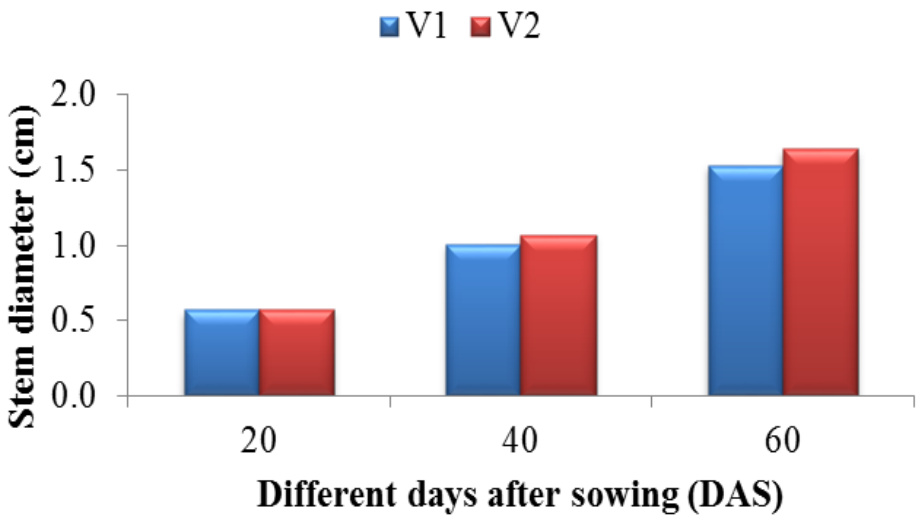
G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.4 Stem diameter (cm)

Stem diameter of okra showed statistically significant differences at 20, 40 and 60 DAS (days after sowing) different variety of okra (Figure 8). At 20 DAS, the equal diameter (0.57 cm) was recorded from V_1 and V_2 variety. At 40 and 60 DAS, the highest stem diameter (1.07 and 1.64 cm, respectively) was recorded from V_2 variety, while the lowest (1.01 and 1.53 cm, respectively) was found from V_1 variety.

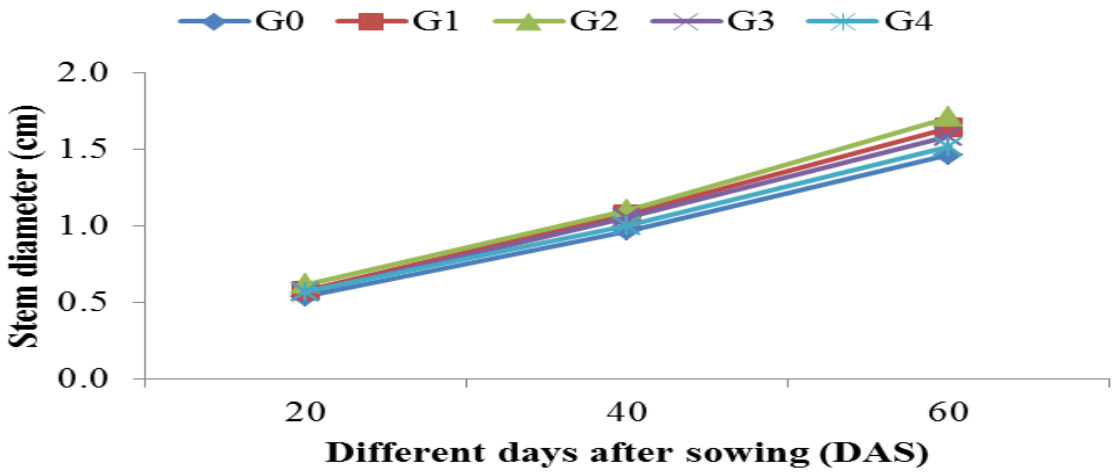
Statistically significant variation was recorded in terms of stem diameter of okra at 20, 40 and 60 DAS for different levels of gibberellic acid (Figure 9). At 20 DAS, the highest stem diameter (0.6183 cm) was observed from G_2 (100 ppm), while the lowest (0.5367 cm) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the highest stem diameter (1.103 and 1.712 cm, respectively) was observed from G_2 (100 ppm), while the lowest (0.9667 and 1.463 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition).

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on stem diameter of okra at 20, 40 and 60 DAS (Table 8). At 20 DAS, the highest stem diameter (0.62 cm) was recorded from both V_1G_2 and V_2G_2 and the lowest (0.51 cm) was obtained from V_1G_0. At 40 and 60 DAS, the highest stem diameter (1.12 and 1.73 cm, respectively) was observed from V_2G_2 and the lowest (0.90 and 1.41 cm, respectively) was obtained from V_1G_0.



V_1: BARI Dherosh 1 V_2: Hybrid (Baishakhi)

Figure 8. Effect of variety on the stem diameter of okra at different days after sowing (LSD $_{(0.05)}$ = NS, 0.03 and 0.03 at 20, 40 and 60 DAS, respectively)



G_0: 0 ppm GA_3 G_1: 50 ppm GA_3 G_2: 100 ppm GA_3

G_3: 150 ppm GA_3 G_4: 200 ppm GA_3

Figure 9. Effect of different concentration of gibberellic acid on the stem diameter of okra at different days after sowing (LSD $_{(0.05)}$ = 0.05, 0.05 and 0.05 at 20, 40 and 60 DAS, respectively)

Table 10. Effect of variety and different concentration of gibberellic acid on the stem diameter of okra at different days after sowing (DAS)

Treatment	20 DAS	40 DAS	60 DAS
V_1	0.57a	1.01 b	1.53 b
V_2	0.57 a	1.07 a	1.64 a
LSD (0.05)	NS	0.03	0.03
CV (%)	6.83	4.17	3.15
Treatment	**20 DAS**	**40 DAS**	**60 DAS**
G_0	0.5367 b	0.9667 c	1.463 e
G_1	0.5750 ab	1.078 a	1.643 b
G_2	0.6183 a	1.103 a	1.712 a
G_3	0.5667 ab	1.053 ab	1.587 c
G_4	0.5683 ab	1.000 bc	1.518 d
LSD $_{(0.05)}$	**0.05**	**0.05**	**0.05**
CV (%)	**6.83**	**4.17**	**3.15**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 11. Interaction effect of variety and different concentration of gibberellic acid on the stem diameter of okra at different days after sowing (DAS)

Treatment combinations	Stem diameter (cm) at different days after sowing (DAS)		
	20	40	60
V_1G_0	0.51 c	0.90 d	1.41 g
V_1G_1	0.56 a-c	1.06 ab	1.58 cde
V_1G_2	0.62 a	1.08 ab	1.69 ab
V_1G_3	0.57 a-c	1.03 b	1.52 def
V_1G_4	0.60 ab	0.95 cd	1.44 fg
V_2G_0	0.56 a-c	1.03 bc	1.51 ef
V_2G_1	0.59 a-c	1.09 ab	1.70 ab
V_2G_2	0.62 a	1.12 a	1.73 a
V_2G_3	0.56 a-c	1.07 ab	1.65 bc
V_2G_4	0.54 bc	1.05 ab	1.59 cd
LSD $_{(0.05)}$	**0.08**	**0.08**	**0.08**
CV (%)	**6.83**	**4.17**	**3.15**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.5 Chlorophyll Content (mg/g FW)

Chlorophyll contents of okra showed statistically significant differences at 50 and 80 DAS (days after sowing) different variety of okra (Figure 10). At 50 DAS, the highest content of chlorophyll (4.35) was recorded from V_2 variety, while the lowest content of chlorophyll (4.04) was recorded from V_1 variety. At 80 DAS, the highest content of chlorophyll (6.61) was recorded from V_1 variety, while the lowest content of chlorophyll (6.38) was recorded from V_2 variety.

Statistically significant variation was recorded in terms of content of chlorophyll of okra at 50 and 80 DAS for different levels of gibberellic acid (Figure 11). At 50 DAS, the highest content of chlorophyll (4.560) was observed from G_1 (50 ppm GA_3), while the lowest content of chlorophyll (3.963) was obtained from G_2 (100 ppm GA_3). At 80 DAS, highest content of chlorophyll (7.008) was observed from G_3 (150 ppm GA3), while the lowest content of chlorophyll (5.995) was obtained from G_1 (50 ppm GA_3).

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on chlorophyll index of okra at 50 and 80 DAS (Table 10). At 50 DAS, the highest content of chlorophyll (4.88) was observed from both V_2G_0 and V_2G_4, the lowest (3.38) was obtained from V_2G_2. At 80 DAS, the highest content of chlorophyll (7.50) was observed from V_2G_4, the lowest (4.89) was obtained from V_2G_1.

Table 12. Effect of variety and different concentration of gibberellic acid on the chlorophyll content on leaf of okra at different days after sowing (DAS)

Variety	Chlorophyll index on leaf 50 DAS	Chlorophyll index on leaf 80 DAS
V_1	4.04 b	6.61 a
V_2	4.35 a	6.38 b
LSD $_{(0.05)}$	**0.04**	**0.02**
CV (%)	**1.2**	**0.55**
Treatment	**Chlorophyll index on leaf 50 DAS**	**Chlorophyll index on leaf 80 DAS**
G_0	4.172 c	6.165 d
G_1	4.560 a	5.995 e
G_2	3.963 e	6.383 c
G_3	4.042 d	7.008 a
G_4	4.243 b	6.930 b
LSD $_{(0.05)}$	**0.07**	**0.04**
CV (%)	**1.2**	**0.55**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 13. Interaction effect of variety and different concentration of gibberellic acid on the chlorophyll content on leaf of okra at different days after sowing (DAS)

Treatment combinations	Chlorophyll content on leaf at different days after sowing (DAS)	
	50	80
V_1G_0	3.46 e	6.80 d
V_1G_1	4.57 b	7.10 c
V_1G_2	4.55 b	6.01 f
V_1G_3	4.02 c	6.79 d
V_1G_4	3.61 d	6.36 e
V_2G_0	4.88 a	5.53 g
V_2G_1	4.55 b	4.89 h
V_2G_2	3.38 e	6.75 d
V_2G_3	4.07 c	7.23 b
V_2G_4	4.88 a	7.50 a
LSD (0.05)	**0.09**	**0.05**
CV (%)	**1.2**	**0.55**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.6 Days to 1st flowering

Days to starting of flowering of okra showed no significant differences in different variety of okra (Figure 12). The maximum days to starting of flowering (38.61 days) was recorded from V_2, while the lowest (38.13 days) was found from V_1.

Statistically significant variation was recorded in terms of days to starting of flowering of okra for different levels of gibberellic acid (Figure 13). The maximum days to starting of flowering (39.13 days) was found from G_0, while the lowest (37.90 days) was found from G_3.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on days to starting of flowering of okra (Table 12). The maximum days to starting of flowering (39.33 days) was observed from V_2G_0 and the lowest (37.60 days) was obtained from V_1G_3.

4.7 Pod length (cm)

Pods length of okra showed statistically significant differences in different variety (Table 13). The longest pod (15.06 cm) was recorded from V_2, while the shortest pod (14.30 cm) was found from V_1.

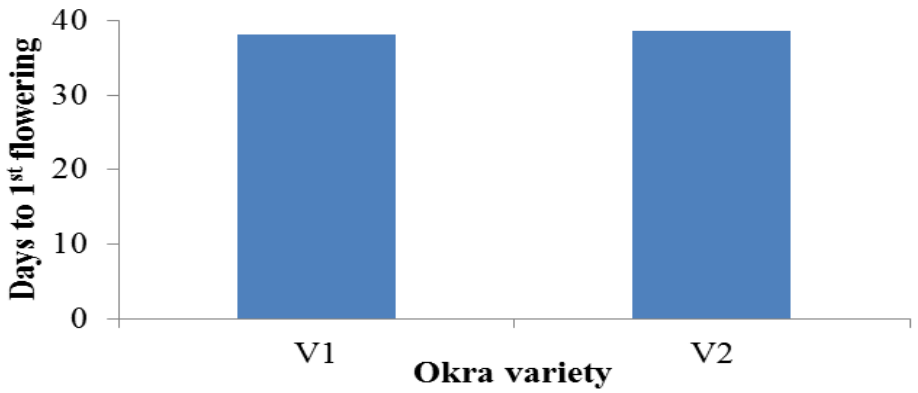
Statistically significant variation was found in terms of pod length of okra for different levels of gebberellic acid (Table 13). The longest pod (15.59 cm) was observed from G_2, while the shortest pod (13.68 cm) was found from G_0. Meena *et al*. (2017) observed that that spray of gibberellic acid significantly influenced the performance of fruit length.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on pod length of okra (Table 14). The longest pod (16.20 cm) was observed from V_2G_2 and the shortest pod (13.26 cm) was obtained from V_1G_0.

4.8 Pod diameter (cm)

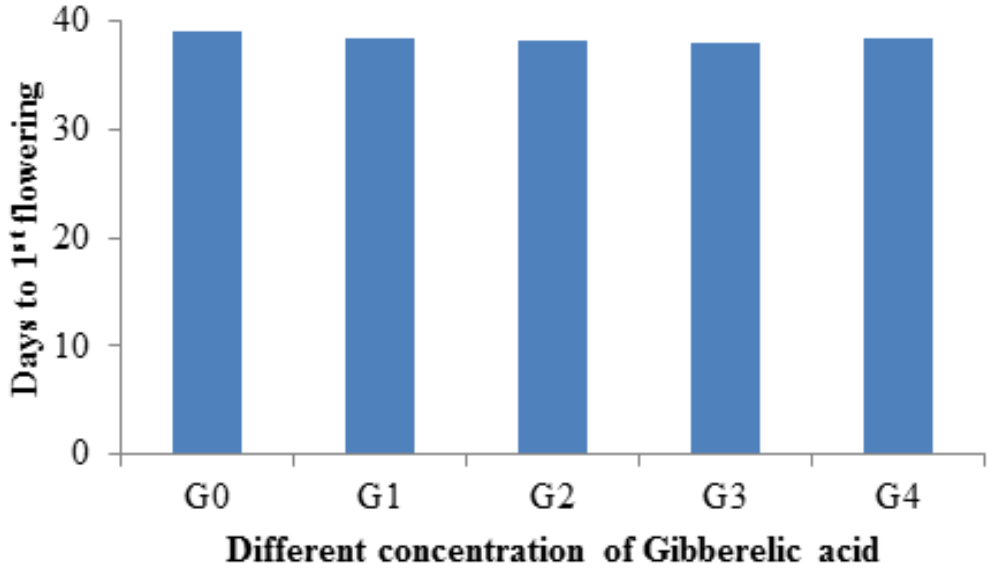
Pods diameter of okra showed statistically significant differences in different variety of okra (Table 14). The highest diameter of pod (1.82 cm) was observed from V_2 variety, while the lowest diameter of pod (1.75 cm) was found from V_1.

Statistically significant variation was found in terms of pod diameter of okra for different levels of gibberellic acid (Table 14). The highest diameter of pod (1.875 cm) was observed From G_2, while the lowest diameter of pod (1.688 cm) was found from G_0. Meena *et al*. (2017) observed that that spray of gibberellic acid significantly influenced the performance of fruit diameter.



V_1: BARI Dherosh 1 V_2: Hybrid (Baishakhi)

Figure 10. Effect of variety on the days to 1st flowering of okra (LSD $_{(0.05)}$ = NS)



G_0: 0 ppm GA_3 G_1: 50 ppm GA_3 G_2: 100 ppm GA_3
G_3: 150 ppm GA_3 G_4: 200 ppm GA_3

Figure 11. Effect of different concentration of gibberellic acid on the days to 1st flowering of okra (LSD $_{(0.05)}$ = 0.64)

Table 14. Effect of variety and different concentration of gibberellic acid on 1st flowering of okra

Variety	Days to 1st flowering
V_1	38.13
V_2	38.61
LSD (0.05)	**NS**
CV (%)	**1.38**
Treatment	**Days to 1st flowering**
G_0	39.13 a
G_1	38.30 b
G_2	38.20 b
G_3	37.90 b
G_4	38.33 b
LSD (0.05)	**0.64**
CV (%)	**1.38**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 15. Interaction effect of variety and different concentration of gibberellic acid on 1st flowering of okra

Treatment Combination	Days to 1st flowering
V_1G_0	38.93 ab
V_1G_1	38.07 bcd
V_1G_2	37.87 cd
V_1G_3	37.60 d
V_1G_4	38.20 bcd
V_2G_0	39.33 a
V_2G_1	38.53 abc
V_2G_2	38.53 abc
V_2G_3	38.20 bcd
V_2G_4	38.47 abcd
LSD (0.05)	**0.91**
CV (%)	**1.38**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on pod diameter of okra (Table 14). The highest diameter of pod (1.91 cm) was observed from V_2G_2 and the lowest diameter of pod (1.640 cm) was obtained from V_1G_0.

4.9 Weight of individual pod (g)

Weight of individual pod of okra showed statistically significant differences in different variety of okra (Table 13). The highest weight of individual pod (19.43 g) was observed from V_2 variety, while the lowest weight of individual pod (17.77 g) was found from V_1.

Statistically significant variation was found in terms of weight of individual pod of okra for different levels of gibberellic acid (Table 13). The highest weight of individual pod (21.53 g) was observed from G_2, while the lowest weight of individual pod (15.64 g) was found from G_0.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on weight of individual pod of okra (Table 14). The highest weight of individual pod (22.60 g) was observed from V_2G_2 and the lowest weight of individual pod (15.21 g) was obtained from V_1G_0.

4.10 Number of pods plant^{-1}

Pod per plant of okra showed statistically significant differences in different variety of okra (Table 13). The highest number of pod (18.38) was observed from V_2 variety, while the lowest weight of individual pod (16.97) was found from V_1.

Statistically significant variation was found in terms of pod per plant of okra for different levels of gibberellic acid (Table 13). The highest number of pod number (19.52) was observed from G_2, while the lowest number of pod (16.06) was found from G_0.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on pod yield per hectare of okra (Table 14). The highest number of pod (20.13) was observed from V_2G_2 and the lowest pod number (15.35) was obtained from V_1G_0.

Table 16. Effect of variety and different concentration of gibberellic acid on the yield and yield contributing characters of okra

Variety	Pod length(cm)	Pod diameter(cm)	Individual pod weight(g)	Pod/plant	Pod yield(t ha^{-1})
V_1	14.30 b	1.75 b	17.77 b	16.97 b	14.01 b
V_2	15.06 a	1.82 a	19.43 a	18.38 a	14.23 a
LSD $_{(0.05)}$	**0.69**	**0.06**	**0.95**	**0.99**	**NS**
CV (%)	**6.15**	**4.58**	**6.64**	**7.33**	**4.88**
Treatment	**Pod length(cm)**	**Pod diameter(cm)**	**individual pod weight(g)**	**Pod/plant**	**Pod yield(t ha^{-1})**
G_0	13.68 c	1.688 c	15.64 d	16.06 c	12.23 d
G_1	15.06 ab	1.827 ab	19.78 b	18.62 ab	14.92 b
G_2	15.59 a	1.875 a	21.53 a	19.52 a	16.18 a
G_3	14.67 abc	1.783 abc	18.69 bc	17.51 bc	13.99 c
G_4	14.41 bc	1.748 bc	17.34 c	16.66 c	13.27 c
LSD $_{(0.05)}$	**1.10**	**0.10**	**1.497**	**1.572**	**0.84**
CV (%)	**6.15**	**4.58**	**6.64**	**7.33**	**4.88**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

Table 17. Interaction effect of variety and different concentration of gibberellic acid on the yield and yield contributing characters of okra

Treatment	Pod length(cm)	Pod diameter(cm)	Individual pod weight (g)	Number of pods plant^{-1}	Pod yield (t ha^{-1})
V_1G_0	13.26 c	1.64 d	15.21 e	15.35 e	12.14 e
V_1G_1	14.65 bc	1.80 a-c	18.89 bc	17.95 a-d	14.74 bc
V_1G_2	14.98 ab	1.84 a-c	20.45 b	18.91 a-c	15.84 ab
V_1G_3	14.43 bc	1.76 a-d	17.64 cd	16.79 c-e	14.05 cd
V_1G_4	14.19 bc	1.71 cd	16.64 de	15.86 de	13.27 de
V_2G_0	14.10 bc	1.74 b-d	16.07 de	16.77 c-e	12.31 e
V_2G_1	15.46 ab	1.85 ab	20.67 ab	19.28 ab	15.10 bc
V_2G_2	16.20 a	1.91 a	22.60 a	20.13 a	16.51 a
V_2G_3	14.91 ab	1.80 a-c	19.74 bc	18.23 a-c	13.94 cd
V_2G_4	14.63 bc	1.79 a-c	18.04 cd	17.47 b-e	13.26 de
LSD $_{(0.05)}$	**1.55**	**0.14**	**2.12**	**2.22**	**1.18**
CV (%)	**6.15**	**4.58**	**6.64**	**7.33**	**4.88**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

V_1: BARI Dherosh 1
V_2: Hybrid (Baishakhi)

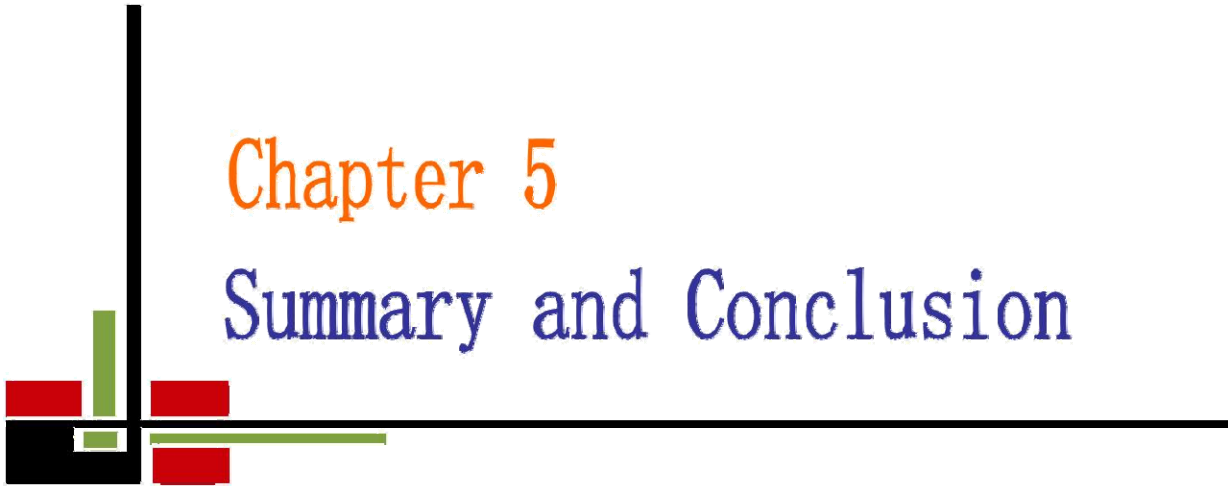
G_0: 0 ppm GA_3
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3
G_4: 200 ppm GA_3

4.11 Pod yield (t ha^{-1})

Weight of individual pod of okra showed statistically significant differences in different variety of okra (Table 13). The highes pod yield (14.23 t ha^{-1}) was observed from V_2 variety, while the lowest pod yield (14.01 t ha^{-1}) was found from V_1.

Statistically significant variation was found in terms of pod yield per hectare of okra for different levels of gibberellic acid (Table 13). The highest pod yield (16.18 t ha^{-1}) was observed from G_2, while the lowest pod yield (12.23 t ha^{-1}) was found from G_0. Meena *et al*. (2017) observed that that spray of gibberellic acid significantly influenced the performance of per hectare.

Combined effect of different levels of gibberellic acid and variety showed statistically significant differences on pod yield per hectare of okra (Table 14). The highest pod yield (16.51 t ha^{-1}) was observed from V_2G_2 and the lowest pod yield (12.14 t ha^{-1}) was obtained from V_1G_0.



Chapter 5

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka at the period of March to July 2016 to find the growth and yield of okra as influenced by different variety and gibberellic acid. Seeds of BARI Dherosh 1 and Hybrid (Baishakhi) Variety were used as planting materials. The experiment consisted of two factors: Factor A: V_1: BARI Dherosh 1 and V_2: Hybrid (Baishakhi) Variety; Factor B: Levels of GA_3 (5 levels) as- G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3 and G_4: 200 ppm GA_3. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameter and yield of okra were recorded and significant variation was observed for different treatment.

In case of variety, at 20, 40 and 60 DAS, the tallest plant (28.66, 82.48 and 128.95 cm, respectively) was recorded from V_1 variety, while the shortest plant (25.17, 77.13 and 113.00 cm, respectively) was found from V_2 variety.). At 20, 40 and 60 DAS, the highest number of leaf (9.45, 15.25 and 18.41, respectively) was recorded from V_2 variety, while the lowest number of leaf (8.30, 12.43 and 18.41, respectively) was found from V_1 variety. At 20 DAS the largest leaf (108.28$cm^{2)}$ was recorded from V_1 variety, while the smallest leaf (104.40 cm^2) was recorded from V_2 variety. At 40 and 60 DAS the largest leaf (559.57 and 611.5 cm^2, respectively) was recorded from V_2 variety, while the smallest leaf (526.36 and 558.2 cm^2, respectively) was found from V_1 variety. At 20 DAS, the equal stem diameter (0.57 cm) was recorded from V_1 and V_2 variety. At 40 and 60 DAS, the highest stem diameter (1.07 and 1.64 cm, respectively) was recorded from V_2 variety, while the lowest (1.01 and 1.53 cm, respectively) was found from V_1 variety. At 50 DAS, the highest content of chlorophyll (4.35) was recorded from V_2 variety, while the lowest

content of chlorophyll (4.04) was recorded from V_1 variety. At 80 DAS, the highest content of chlorophyll (6.61) was recorded from V_1 variety, while the lowest content of chlorophyll (6.38) was recorded from V_2 variety.

The maximum days to starting of flowering (38.61 days) was recorded from V_2, while the lowest (38.13 days) was found from V_1. The longest pod (15.06 cm) was recorded from V_2, while the shortest pod (14.30 cm) was found from V_1. The highest diameter of pod (1.82 cm) was observed from V_2 variety, while the lowest diameter of pod (1.75 cm) was found from V_1. The highest weight of individual pod (19.43 g) was observed from V_2 variety, while the lowest weight of individual pod (17.77 g) was found from V_1. The highest number of pod (18.38) was observed from V_2 variety, while the lowest number of pod (16.97) was found from V_1. The highest pod yield (14.23 t ha^{-1}) was observed from G_2, while the lowest pod yield (14.01 t ha^{-1}) was found from G_0.

In case of gibberellic acid, At 20 DAS, the tallest plant (31.13 cm) was observed from G_3 (150 ppm GA_3), while the shortest plant (22.60 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the tallest plant (90.76 and 135.1 cm, respectively) was observed from G_2 (100 ppm GA_3), while the shortest plant (69.90, and 108,5 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 20 DAS, the highest number of leaf (9.767) was observed from G_3 (150 ppm GA_3), while the lowest number of leaf (8.067) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the highest number of leaf (17.02 and 20.43, respectively) was observed from G_2 (100 ppm GA_3), while the lowest number of leaf (11.45, and 14.38, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 20 DAS, the largest leaf (147.1 cm^2, respectively) was observed from G_3 (150 ppm GA_3), while the smallest leaf (74.69 cm^2, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the largest leaf (603.8 and 686.8 cm^2, respectively) was observed from G_2 (100 ppm GA_3), while the smallest leaf

(482.1, and 503.6 cm^2, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition. At 20 DAS, the highest stem diameter (0.6183 cm) was observed from G_2 (100 ppm), while the lowest (0.5367 cm) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 40 and 60 DAS, the highest stem diameter (1.103 and 1.712 cm, respectively) was observed from G_2 (100 ppm), while the lowest (0.9667 and 1.463 cm, respectively) was obtained from G_0 (0 ppm GA_3 i.e. control condition). At 50 DAS, the highest content of chlorophyll (4.560) was observed from G_1 (50 ppm GA_3), while the lowest content of chlorophyll (3.963) was obtained from G_2 (100 ppm GA_3). At 80 DAS, highest content of chlorophyll (7.008) was observed from G_3 (150 ppm GA_3), while the lowest content of chlorophyll (5.995) was obtained from G_1 (50 ppm GA_3).

The maximum days to starting of flowering (39.13 days), while the lowest (37.90 days) was found from G_2. The longest pod (15.59 cm) was observed from G_2, while the shortest pod (13.68 cm) was found from G_0. The highest diameter of pod (1.875 cm) was observed from G_2, while the lowest diameter of pod (1.688 cm) was found from G_0. The highest weight of individual pod (21.53 g) was observed from G_2, while the lowest weight of individual pod (15.64 g) was found from G_0. The highest number of pod (19.52) was observed from G_2, while the lowest number of pod (16.06) was found from G_0. The highest pod yield (16.18 t ha^{-1}) was observed from G_2, while the lowest pod yield (12.23 t ha^{-1}) was found from G_0.

Due to the combined effect of different levels of gibberellic acid and variety at 20 DAS the tallest plant (32.69cm) was found from V_1G_3 (BARI Dherosh 1 and 150 ppm GA_3), 40 and 60 DAS the tallest plant (92.49 and 143.1 cm, respectively) was found from V_1G_2 (BARI Dherosh 1 and 100 ppm GA_3) and the shortest plant (21.13, 67.74, 101.5 cm, respectively) was recorded from V_2G_0 (Hybrid (Baishakhi) Variety and 0 ppm GA_3 i.e. control condition). At 20 DAS the highest number of leaf (10.47) was found from V_2G_3 (Hybrid (Baishakhi) Variety and 150 ppm GA_3), 40 and 60 DAS the highest number of

leaf (18.45 and 21, 52 respectively) was found from V_2G_2 (Hybrid (Baishakhi) Variety and 100 ppm GA_3) and the lowest number of leaf (7.67, 10.17, 13.32 respectively) was recorded from V_1G_0 (BARI Dherosh 1 and 0 ppm GA_3 i.e. control condition). At 20 DAS, the largest leaf (157.4 cm^2) was observed from V_2G_3 and the smallest leaf (66.94 cm^2) was obtained from V_2G_0.

At 40 and 60 DAS, the largest leaf (620.10 and 575.7 cm^2, respectively) was observed from V_2G_2 and the smallest leaf (468.4 and 370.3 cm^2, respectively) was obtained from V_1G_0. At 20 DAS, the highest stem diameter (0.62 cm) was recorded from both V_1G_2 and V_2G_2 and the lowest (0.51 cm) was obtained from V_1G_0. At 40 and 60 DAS, the highest stem diameter (1.12 and 1.73 cm, respectively) was observed from V_2G_2 and the lowest (0.90 and 1.41 cm, respectively) was obtained from V_1G_0. At 50 DAS, the highest content of chlorophyll (4.88) was observed from both V_2G_0 and V_2G_4, the lowest (3.38) was obtained from V_2G_2. At 80 DAS, the highest content of chlorophyll (7.50) was observed from V_2G_4, the lowest (4.89) was obtained from V_2G_1.

The maximum days to starting of flowering (39.33 days) was observed from V_2G_0 and the lowest (37.60 days) was obtained from V_1G_3. The longest pod (16.20 cm) was observed from V_2G_2 and the shortest pod (13.26 cm) was obtained from V_1G_0. The highest diameter of pod (1.907 cm) was observed from V_2G_2 and the lowest diameter of pod (1.640 cm) was obtained from V_1G_0. The highest weight of individual pod (22.60 g) was observed from V_2G_2 and the lowest weight of individual pod (15.21 g) was obtained from V_1G_0. The highest number of pod (20.13) was observed from V_2G_2 and the lowest pod number (15.35) was obtained from V_1G_0. The highest pod yield (16.51 t ha^{-1}) was observed from V_2G_2 and the lowest pod yield (12.14 t ha^{-1}) was obtained from V_1G_0.

Conclusion

1. V_2 variety shows better yield than V_1 variety ;
2. Among the different concentration of GA_3, okra shows better response with 100 ppm of GA_3 and
3. Finally, V_2 variety with 100 ppm GA_3 encouraged superior growth, yield contributing characters and yield of okra.

Future line of work

Considering the findings of the present experiment, further studies in the following areas may be suggested:

1. Another commercial varieties, other management practices and cropping season may be used in future study.
2. Another higher level of GA_3 need to be considered in different agro-ecological zones of Bangladesh for regional trial before final recommendation.
3. The present investigation was conducted for one season only. Therefore, the experiment should be repeated for few more years/ seasons in different location to draw a definite conclusion.

References

REFERENCES

Anonymous. 1993. Pod development and germination studies in okra (*Abelmoschus esculentus* L. Moench). *Indian J. Agril. Sci*., **41**(10): 852-856.

Avinash, A., Dhage, P.K. Nagre, K.K. and Anand, K.P. 2011. Effect of plant growth regulators on growth and yield parameters of okra. *The Asian J. Hort*., **6**(1): 170-172.

BBS (Bangladesh Bureau of Statistics). 2011. Monthly Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. Government of the People's Republic of Bangladesh, Dhaka. p. 42.

Bello OA. 2015. Influence of hormones and imbibition on the growth and yield of *Abelmoschus esculentus* (Okra), *Researcher,* **7**(11): 73-76.

Bewley, J. D. and Black, M. 1983. Physiology and biochemistry of seeds in relation to germination. New York: Springer-Verlag.

Chowdhury, B. 1993. Vegetables National Book Trust. New Delhi, p. 172.

Chowdhury MS, Hasan Z, Kabir K, Shah JM and Kabir MH. 2014. Response of Okra (*Abelmoschus esculentus* L.) to Growth Regulators and Organic Manures, *The Agriculturists,* **12**(2): 56-63.

Dhage A, Nagre PK, Bhangre KK, and Pappu AK. 2011. Effect of plant growth regulators on growth and yield parameters of okra, *The Asian Journal of Horticulture,* **6**(1):170-172.

Dhankhar, B. S. and Singh, R. 2009. Okra hand book, global production, processing and crop improvement. HNB publishing. p. 475.

Dijkstra, P. and Kuiper, P.J.C. 1989. Effects of exogenously applied growth regulators on shoot growth of inbred lines of Plantago major differing in relative growth rate: Differential response to gibberellic acid and (2-chloroethyl) -trimethyl-ammonium chloride. *Physiologia Plantarum*, **77**: 512-518.

Gadade, S.B., Shinde, V.S., Deosarkar, D.B. and Shinde, S.S. 2017. Effect of plant growth regulators on growth and yield of okra (*Abelmoschus esculentus* L.). *Plant Archives*, **17**(1): 177-180.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research (2nd edn.). *Int. Rice Res. Inst., A Willey Int. Sci.*, **3**: 28-192.

Jafarullah, M.D., Abdul Fattah, Q. and Feroza, H. 2007. Response of growth, yield attributes and yield to the application of KNP and NAA in Cowpea (*Vigna aunguiculata* L. WALP). *Bangladesh J. of Bot.*, **36**(2): 127-132.

Kalloo, G. (1994). Vegetable Breeding. Published by Panima Educational Book Agency New Delhi, Combined Edition I, II & III. pp 6 – 21.

Khan MMA, Gautam G, Mohammad F, Siddiqui MH, Naeem M and Khan MN. 2006. Effect of gibberellic acid spray on performance of tomato, *Turkish Journal of Botany*, **30**(2): 11-16

Kumar, A., Biswas, T.K., Singh, N. and Lal, E.P. 2014. Effect of gibberellic acid on growth, quality and yield of tokra. *J. Agric. Vet. Sci.,* **7**(7): 28-30.

Meena, R.K., Dhaka, R.S. Meena, N.K. and Meena, S. (2017). Effect of Foliar Application of NAA and GA3 on Growth and Yield of Okra [*Abelmoschus esculentus* (L.) Moench] cv. Arka Anamika. *Intl. J. Pure App. Biosci.* **5**(2): 1057-1062.

Megbo, B.C. 2010. Manipulation of Okra plant height using Gibberellic acid and its biosynthesis inhibitors. *Intl. J. Scientific & Engineering Res.*, **1**(1): 25-28.

Mehraj H, Taufique T, Ali MR, Sikder RK and Jamal Uddin AFM. 2015. Impact of GA3 and NAA on horticultural traits of *Abelmoschus esculentus, World Applied Sciences Journal,* **33**(11): 1712-1717.

Mohammadi, G., Ebrahim M.K., Petropoulos, S.A., Dimosthenis, B., Akbari, C.F. and Yarsi, G. 2014. Effect of gibberellic acid and harvesting time on the seed quality of four okra cultivars. *J. Agril. Sci.*, **6**(7): 200-211.

Patil DR, and Patel MN. 2010. Effect of seed treatment with GA3 and NAA on growth and yield of okra [*Abmelmoschus esculentus* (L.) Moench] cv. GO-2, *The Asian Journal of Horticulture,* **5**(2): 269-272.

Patil CN, Mahorkar VK, Dod VN, Peshattiwar PD, Kayande NV and Gomase DG.2008. Effect of seed treatment with gibberellic acid and maleic hydrazide on growth, seed yield and quality of okra cv. Parbhani Kranti, *The Asian Journal of Horticulture*, **3**(1):74-78.

Prasad, R.N., Singh, S.K., Yadava, R.B. and Chaurasia, S.N.S. 2013. Effect of GA3 and NAA on growth and yield of okra. *Veg. Sci*., **40**(2): 195-197.

Purseglove, J.W. 1987. Tropical crops dicotyledons. Longman Singapore publishers (Ptv.) Ltd. p. 369.

Ramphall, C. and Gill, H.S. 1990. Demand and supply of vegetables and pulses in South Asia. *In:* Vegetable research and development in South Asia: Proceeding of a workshop held at Islamabad, Pakistan, 24-29 September, 1990. AVRDC pub. No. 90-331. AVRDC, Tainan, Taiwan.

Rashid, M. 1990. Effect of nitrogen and phosphorus levels on seed production of okra (*Abelmoschus esculentus* L. Moench). *Haryana J. Hort. Sci*., **9**: 3-4.

Rashid , M.M. 1999. Sabji Biggan. Rashid Publishing. House. 94, Old DOHS. Dhaka1206. p. 476.

Ravat AK and Makani N. 2015. Influence of plant growth regulators on growth, seed yield and seed quality in okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO-5 under middle Gujarat condition, *International Journal of Agricultural Sciences* **1**(1): 151-157.

Singh J, Singh BK, Singh AK, Panwar M, and Singh B. 2012. Effect of foliar spray of GA3 and IBA on plant characters and yield of okra [*Abelmoschus esculentus* (L.) Moench], *Environment & Ecology*, **30**(4): 1351-1353.

Tahkur, M.K. and Arora, S.K. 1986. In: Vegetable Crops in India, ed. TK Bose and MG Som, Naya Prokash, Calcutta. p. 606.

Thompson, H.C. and Kelly, E. 1959. Vegetable crops. McGraw Hill Book Co. Inc., New York. P. 562.

Yamaguchi, Y. 1998. Effect of nitrogen, phosphorus and potassium on bhindi (*Abelmoschus esculentus* L. Moench). *Prog. Hort*., **10**(4): 21-30.

Yuan, L. and Xu, D.Q. 2001. Stimulation effect of gibberellic acid short term treatment on leaf photosynthesis related to the increase in Rubisco content in broad bean and soybean. *Photosynthesis Res*., **68**: 39-47.

Appendices

APPENDICES

Appendix I. Characteristics of the soil of experimental field

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Expeimental 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from March to July 2016

Month (2016)	Air temperature (^{0}C)		Relative Humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
March	28.1	19.5	68	00	6.8
April	33.4	23.2	67	78	6.9
May	34.7	25.9	70	185	7.8
June	32.4	25.5	81	228	5.7
July	35.1	22.4	67	298	5.9

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height of okra at different days after sowing (DAS) as influenced by different concentration of gibberellic acid and variety.

Source of variation	Degrees of freedom	Mean square		
		Plant height (cm) at		
		20 DAS	40 DAS	60 DAS
Replication	2	9.733	146.331	198.569
Variety (A)	1	91.281*	214.669*	1908.817*
Gibberellic acid (B)	4	67.196*	405.490*	636.624*
Interaction (A×B)	4	1.939*	8.675*	2.450*
Error	18	5.971	32.724	99.300

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves plant^{-1} of okra at different days after sowing (DAS) as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Number of leaves plant^{-1} at		
		20 DAS	40 DAS	60 DAS
Replication	2	0.325	11.369	5.683
Variety (A)	1	9.919*	59.784*	23.444*
Gibberellic acid (B)	4	2.360*	31.610*	34.034*
Interaction (A×B)	4	0.364*	0.128*	0.276*
Error	18	0.638	0.674	2.377

*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on leaf area of okra at different days after sowing (DAS) as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Leaf Area (cm^2) at		
		20 DAS	40 DAS	60 DAS
Replication	2	321.145	9626.228	4582.947
Variety (A)	1	113.141*	8271.784*	21346.140*
Gibberellic acid (B)	4	5085.440*	14901.643*	32087.960*
Interaction (A×B)	4	913.719*	222.565*	2474.155*
Error	18	73.008	1690.826	650.957

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on stem diameter of okra at different days after sowing (DAS) as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Stem diameter (cm) at		
		20 DAS	40 DAS	60 DAS
Replication	2	0.004	0.006	0.075
Variety (A)	1	0.001*	0.033*	0.090*
Gibberellic acid (B)	4	0.005*	0.019*	0.058*
Interaction (A×B)	4	0.003*	0.003*	0.003*
Error	18	0.002	0.002	0.002

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on Chlorophyll Content of okra at different days after sowing (DAS) as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Chlorophyll Index at		
		50 DAS	80 DAS	60 DAS
Replication	2	0.001	0.001	0.102
Variety (A)	1	0.724*	0.411*	20.580**
Gibberellic acid (B)	4	0.320*	1.236*	7.981**
Interaction (A×B)	4	1.691*	3.121*	1.208*
Error	18	0.003	0.001	0.436

*: Significant at 0.05 level of s probability

Appendix VIII. Analysis of variance of the data on yield contributing characters of okra as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Days to 1st flowering	Pod length (cm)	Pod diameter (cm)
Replication	2	0.145	0.222	0.002
Variety (A)	1	1.728*	4.332*	0.034^{NS}
Gibberellic acid (B)	4	1.258*	3.054*	0.031*
Interaction (A×B)	4	0.038*	0.147*	0.001*
Error	18	0.279	0.815	0.007

*: Significant at 0.05 level of probability *: NS =Non Significant

Appendix IX. Analysis of variance of the data on yield and yield contributing characters of okra as influenced by different concentration of gibberellic acid and variety

Source of variation	Degrees of freedom	Mean square		
		Individual pod weight (g)	Pod/plant	Pod yield (t ha^{-1})
Replication	2	8.319	3.849	4.285
Variety (A)	1	20.601*	14.798*	0.350*
Gibberellic acid (B)	4	30.460*	11.903*	13.807*
Interaction (A×B)	4	0.434*	0.032*	0.147*
Error	18	1.523	1.679	0.476

*: Significant at 0.05 level of probability