# GROWTH AND YIELD OF OKRA AS INFLUENCED BY $GA_3$ AND POTASSIUM

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**GROWTH AND YIELD OF OKRA AS INFLUENCED BY $GA_3$ AND POTASSIUM**

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# CERTIFICATE

*This is to certify that the thesis entitled* ***"Growth and yield of okra as influenced by GA$_3$ and Potassium"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***Master of Science in Horticulture****, embodies the result of a piece of bonafide research work carried out by* ***Jesmin Sultana*** *, Registration No.****14-06286*** *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.*

**Date: June 2021**
**Dhaka, Bangladesh**

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DEDICATED

TO

MY BELOVED PARENTS

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***The Author***

**GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.) AS INFLUENCED BY $GA_3$ AND POTASSIUM**

## ABSTRACT

The field experiment was accomplished at the Horticulture Farm in Sher-e-Bangla Agricultural University, Dhaka, during the period from April to September 2020 to find out the performance of okra in response to $GA_3$ and Potassium fertilizer . In this experiment BARI Dherosh 1 was used as the test crop .The experiment consisted of two factors and followed RCBD design with three replications. Factor A: Growth regulators (three levels) as - $G_0$: Control (no growth regulators/water), $G_1$: (100 ppm $GA_3$) and $G_2$: (120 ppm $GA_3$) and Factor B: Potassium (three levels) as - $K_0$: Control (no $K_2O$ was applied), $K_1$: 80 kg $K_2O$ $ha^{-1}$ and $K_2$: 100 kg $K_2O$ $ha^{-1}$. With the application of $GA_3$, at 20, 40 and 60 DAS the longest plant (15.80 cm, 73.74 cm and 90.70 cm) was recorded from $G_{1,}$ and the shortest plant (13.91 cm, 64.98 cm and 79.55 cm) was found in $G_0$ . The highest yield per hectare (17.69 ton) was recorded from $G_1$,whereas the lowest yield per hectare (14.18 ton) from $G_0$. In case of potassium fertilizer, at 20, 40 and 60 DAS the longest plant (16.67 cm, 77.93 cm, and 90.70 cm) was found in $K_2$ and the shortest plant (13.01 cm,59.02cm and 79.22cm) from $K_{0.}$ The highest yield per hectare (19.13 ton) was obtained from $K_{2,}$ whereas the lowest yield per hectare (11.64 ton) was recorded from $K_0$. In case of combination effect of $GA_3$ and potassium fertilizer, the maximum pods/plant (40.62) and highest yield per hectare (18.41 ton) was found from $G_1K_2$, again the minimum pods/plant (21.72) and lowest yield per hectare (12.91 ton) from $G_0K_0$. In addition, hormone treatment enhanced flowering and fruiting time of okra. The findings of the present study indicate that 100 ppm $GA_3$ with 100kg $K_2O$ $ha^{-1}$ was suitable combination to produce the highest growth and yield of okra.

**LIST OF ABBREVIATED TERMS**

| ABBREVIATION | FULL NAME |
|---|---|
| AEZ | Agro-Ecological Zone |
| BAU | Bangladesh Agricultural University |
| BCR | Benefit Cost Ratio |
| BBS | Bangladesh Bureau of Statistics |
| Cm | Centimeter |
| CV | Co-efficient of Variation |
| °C | Degree Celsius |
| DAS | Date After Seeding |
| df | Degrees Of Freedom |
| DMRT | Duncan’s Multiple Range Test |
| *et al.* | and others |
| Etc. | Etcetera |
| FAO | Food and Agriculture Organization |
| FYM | Farm Yard Manure |
| j. | Journal |
| LSD | Least Significant Differences |
| $m^2$ | Square meter |
| MOP | Muriate of Potash |
| PM | Poultry Manure |
| RCBD | Randomized Complete Block Design |
| SAU | Sher-e-Bangla Agricultural University |
| TSP | Triple Super Phosphate |
| UNDP | United Nations Development Program |
| % | Percentage |
| @ | At the rate of |

## LIST OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# LIST OF APPENDICES

# CHAPTER I

# INTRODUCTION

Okra (*Abelmoschus esculentus*),also known as lady's finger, dherosh or bhindi is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It belongs to the genus *Abelmoschus* and the family Malvaceae. The crop is suitable for cultivation either as a garden crop or commercially large scale. It is a multipurpose crop and its tender delicious pods are rich sources of vitamins, calcium, potassium, and other minerals. Its mucilaginous preparation from the pod may be used as a blood plasma replacement. It plays a vital role in the human diet (Saifullah and Rabbani, 2009). The dried seeds of okra provide protein, oil, vegetable curd and a coffee additive or substitute. Okra dry seeds contain 18-20% oil and 20-23% crude protein. Fully, mature dried fruits and stems containing fibers serve as a source of paper pulp and fuel and its foliage can be used for biomass. To a limited extent ,okra is used in canned, dehydrated or frozen forms .It has an average nutritive value of 3.21% which is higher than tomato ,eggplant and most cucurbits except bitter gourd. Due to its richness in nutrition, taste and medicinal & industrial value okra is accepted as the most popular dish in all sections of people. Although it is cultivated throughout the country, its average national yield is poor, only 3.07 t $ha^{-1}$(Anonymous, 2000). The yield is very low as compared to the yield of $9.7^{-1}$ t $ha^{-1}$ of other developed countries of the world (Ahmed, 1995). It is one of the most important warm-season fruit vegetables grown throughout the tropics and is recognized as one of the world's oldest cultivated crops (Anonymous, 2007; Maity*et al.* 2016).Vegetable production is not uniform around the year in our country and it's plenty in winter but less in quantity in summer. Around 30% of total vegetables are produced during the Kharif season and around 70% in Rabi season(Anon.,1993).

So, okra can be an important vegetable in the summer season. Okra is a nutritious vegetable that plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market .

In Bangladesh, the low yield of okra, however, is not an indication of the 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 and insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices.

Tender green pods of okra are generally marketed as fresh condition which contains approximately 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 01.0% fiber and 0.8% ash . Due to its richness in nutrition, taste , medicinal and industrial value okra is accepted as the most popular dish in all sections of people.

Plant growth regulators (PGR's) are organic substances that, in small amounts somehow modify a given physiological process of a plant. Auxins , gibberellin and cytokinins are such PGR used in agriculture for better growth and development and successful yield responses ultimately affecting crop production . It plays an important role in many aspects of plant growth and development, such as seed germination , stem elongation and flower development (Yamaguchi and Kamiya, 2000). This was observed in many plants after treatment with a minute amount of $GA_3$ . PGR influences plant height, number of leaves per plant, length of the internodes , number of days for first flower initiation, fruit quality, number of fruits per plant, fruit weight per plant, and number of fruits per hectare of okra (Kokare *et al.*, 2006 and Nawalkar*et al.*, 2007).

Gibberellic acid ($GA_3$) or gibberellins comprise a group of naturally occurring plant hormones that play a central role in the early germination processes of seeds by activating enzyme production and mobilizing storage reserves (Mohammadi *et al.* 2014). Additionally, foliar application of gibberellins stimulates and synchronizes flowering and fruit set (Mohammadi *et al.* 2014), as well as enhancing photosynthesis and growth or stimulating growth but not the rate of photosynthesis (Muqtadir *et al.* 2019)

For obtaining considerable production and quality yield for any crop, proper management practices should be done as their proper requirement. Fertilizer is one of the most important inputs contributing to crop production because it increases productivity and improves yield quantity and quality (Muqtadir *et al.* 2019). Generally, a large amount of fertilizer is required for the growth and development of okra (Opena *et al.*, 2001). So, the management of fertilizer especially potassium is the important factor that greatly affects the growth, development and yield of okra. Potassium plays a unique role in osmotic regulation, opening and closing of stomata and improves the color, flavors and size of fruits. Potassium is a very active and important component of soil , it furnishes a large portion of micro and micronutrients, protects the soil against erosion, supplies the cementing substance for desirable aggregate soil formation and loosens the soil.

Now a day many farmers are not aware of the use of potassium. So, the present investigation will be helpful to know the effect of plant growth nutrients such as potassium with proper doses, which help in increasing the growth, development and yield of okra.

**Objectives of the study:**

Therefore, the present investigation was carried out to find out the optimum use of $GA_3$ and Potassium fertilizer and their combination for optimum production of okra with the following objectives:

1. To determine the optimum level of $GA_3$ for higher growth and yield of okra.
2. To find out the optimum doses of potassium for ensuring better growth and yield of okra.
3. To investigate the suitable combination of $GA_3$ and potassium for successful okra production in Bangladesh.

# CHAPTER II

# REVIEW OF LITERATURE

Okra is a popular summer vegetable crop in Bangladesh, valued for its tender and delightful edible pods. The use of fertilizer, particularly potassium, and the advancement of production technology through the use of the plant hormone gibberellic acid are two essential factors that have a significant impact on the growth, development, and output of okra. As a result, it's critical to evaluate the effects of potassium and gibberellic acid on okra development and yield. However, there have been limited research reports on the performance of okra in response to potassium and gibberellic acid in many parts of the world, including Bangladesh, and the work done so far in Bangladesh is insufficient and conclusive. However, some of the most important and useful publications in this area have been reviewed under the following headings:

## 2.1. Effect of $GA_3$ on Growth and Yield of Okra.

Afrose, (2015) was conducted a field experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from April to August 2015 to find out the effect of potassium and gibberellic acid on okra *cv.* BARI Dherosh-1. In the experiment gibberellic acid was used as $G_0$: 0 ppm $GA_3$ (control) $G_1$: 60 ppm $GA_3$, $G_2$: 90 ppm $GA_3$. Experiment results concluded that due to the effect of potassium, the highest yield (17.08t $ha^{-1}$) was found from $G_2$ (90 ppm $GA_3$) and the lowest yield (16.01 t $ha^{-1}$) from $G_0$ (0 ppm $GA_3$).

Ahmed and Tahir (2011) studied the effect of gibberellic acid as foliar on some characters of okra plant. Okra cv. Pusa Kranti grown in pots, was sprayed with 100 ppm $GA_1$ once at 3 weeks after germination, twice (3 and 4 weeks after planting), 3 times (3, 4 and 5 weeks after planting) and 4 times (3, 4, and 6 weeks after planting). Plant height, number of leaves, fresh shoot weight, fresh root weight, number of fruits, and fresh fruit weight were recorded at weekly intervals. The only treatment significantly increased the fruit number weight was 2 applications of $GA_3$. On the other hand, the shoot growth was greatest with 4 applications of $GA_3$.

Abdul *et al*. (2014) reported increased pod length, pod diameter and pod yield of okra plants sprayed with $GA_3$ at different concentrations as compared with the control.

Bello (2015) discovered that pre-soaking okra seeds in $GA_3$ at the rate of 100 ppm for 3- 4 hours increased plant height, number of leaves, leaf area, and dry matter of okra.

Bhagure and Tambe (2013) reported that application of 50 and 100 ppm of $GA_3$ at 30 and 45 DAS increase the height of plants, number of leaves and internodes, induce early flowering, increase the number of flowers, fruit set, number of fruits, and high yield plant$^{-1}$ in okra.

Chormule *et al.* (2017) conducted an investigation to find out the effect of spacing and plant growth regulators on plant growth parameters, seed yield and the attributes of okra (*Abelmoschus esculentus* L. Moench) cv. GJO-3 with two consecutive seasons (Kharif 2015 and Kharif 2016). Experiment results concluded that a combination of wider plant spacing 60 cm x 45 cm and $GA_3$ @ 150 ppm was found the best-suited combination, as it has good field emergence and produced significantly and/or comparatively the maximum plant height, stem diameter, number of branches plant$^{-1}$, number of fruits plant$^{-1}$, fruit length, fruit thickness, number of seeds fruit$^{-1}$ and seed yield plant$^{-1}$.

Chowdhury *et al.* (2014) conducted a study at the Horticulture Farm, Sher-e-Bangla Agricultural University, Bangladesh from April to September 2012 to determine the suitability of selected plant growth regulators and the proper use and effectiveness of selected organic manures and also their suitable combinations for successful okra production. The experiment consisted of two factors: factor A: growth regulators as - $G_0$: control (water), $G_1$: $GA_3$ (100 ppm) and $G_2$: Miraculan (1000 ppm) and factor B: organic manures as - $OM_0$: control (no manure), $OM_1$: vermicompost (9 t ha$^{-1}$) and $OM_2$: poultry manure (11.5 t ha$^{-1}$). The combined use of $GA_3$ and poultry manure produced the tallest plants. Both the growth regulators and organic manures enhanced early flowering. In the case of growth hormone, the highest yield (16.67 t ha$^{-1}$) was recorded from $G_1$ followed by $G_2$ (16.49 t ha$^{-1}$). The highest yield (18.03 t ha$^{-1}$) was found from $OM_2$, closely followed by $OM_1$ (17.59 t ha$^{-1}$). Considering the treatment combinations, the highest yield was harvested from $G_1OM_2$ (19.62 t ha$^{-1}$), followed by $G_1OM_1$ (19.01 t ha$^{-1}$), $G_2OM_1$ (18.42 t ha$^{-1}$) and $G_2OM_2$ (18.30 t ha$^{-1}$), respectively.

Chowdhury *et al.* (2014) reported that the combined use of 100 ppm $GA_3$ and 11.5 t $ha^{-1}$ poultry manure produced the tallest plants in okra.

Dhage *et al.* (2011) revealed that treatment GA3 at 150 ppm had a significant effect on plant height (107.74 cm) and intermodal length (3.1 cm), but treatment IAA at 100 ppm had the highest number of branches (3.53). However, in okra, treatment GA3 at 150 ppm resulted in a much decreased number of days required for initial flowering (39.67 2days). In okra, treatment GA3 at 150 ppm had a significant influence on the minimum number of days required for first harvesting (44.67 days). In the same treatment, the maximum parentage of fruit set (74.79) and fruit output per hectare were found.

Hasan et al. (2016) were carried out an experiment and find out the effect of growth regulators and urea on flowering, fruiting and seed production of okra *cv.* Pusa Sawani in India. Experiment results concluded that the greatest number of pods $plant^{-1}$ was obtained after seed treatment with NAA at 20 ppm + foliar spray of 2 % urea at 30 DAS followed by seed treatment with 150 ppm $GA_3$ and 20 ppm NAA + foliar spray of 4% urea at 30 DAS. They also concluded that soaking of seeds in 150 ppm $GA_3$ and 20 ppm NAA gave the highest seed yields (20.4 and 19.4 t $ha^1$, respectively), which were 7.9 and 6.9 t $ha^{-1}$ higher than the control, respectively. All treatment combinations reduced the number of days to 50% flowering and the number of days to first fruit set than control.

Hoque and Haque (2002) reported that foliar application of $GA_3$ @ 100 ppm resulted into more number of pods $plant^{-1}$, seed yield $plant^{-1}$, 1000 seed weight and seed yield per ha of Mung bean.

Ilias *et al*. (2007) conducted a study to identify the responses of three cultivars of okra (*Abelmoschus esculentus* L.) to exogenous hormones gibberellic acid ($GA_3$) and prohexadione - Ca applied as a foliar spray. They reported that Exogenous $GA_3$ significantly increased stem and leaf dry masses and stem length, however, prohexadione-Ca hindered growth. They also concluded that $GA_3$-treated okra plants took longer to bloom than control and prohexadione-Ca treated okra plants. The administration of the two growth regulators resulted in a drop in fructose content in all cultivars' fruits, while protein content remained nearly the same. The weakening of photochemical processes around the photo system 2 reaction center was suggested by the minor variations in chlorophyll a fluorescence characteristic seen under prohexadione-Ca.

Katung *et al*. (2007) conducted an experimented seasonal response of the okra *cv.* White Velvet and Ex-Borno to $GA_3$. The seeds of okra were treated with 0, 75 and 150 ppm of gibberellic acid ($GA_3$) and sown during the wet seasons of 1997 and 1999 and wet seasons of 1998 and 2000. $GA_3$ influenced the number of days to flower, fruit set, and yield of okra cultivars exclusively during the dry season, according to the researchers. In the 1998 and 2000 dry seasons, they detected a reduction in the number of days to bloom in *cv.* White velvet after applying 75 ppm $GA_3$. In 1998 and 2000, the same concentration of $GA_3$ (75 ppm) increased fruit set by 22.9 and 45.5 % in *cv.* White Velvet and 12.2 and 33.6 percent in *cv.* Ex-Borno, respectively, and increased the number of fruits plant$^{-1}$, dry weight fruit$^{-1}$, and fruit yield by 13.7, 12.5 and 40.1 % in *cv.* White Velvet and by 21.9, 42.9, and 20.9 % in *cv.* Ex-Borno. The plant growth regulator at a greater dose (150 ppm) had a significant impact on all of the parameters of the two okra cultivars studied.

Kokare *et al*. (2006) conducted a field experiment to investigate the effects of some plant growth regulators on the growth, yield and quality of okra *cv.* Parbhani Kranthi in Maharashtra, India during Kharif season of 2000-01. They reported that the maximum plant height (117.33 cm) was observed in plots sprayed with $GA_3$ at 200 ppm while spraying the plants with NAA at 200 ppm increased the leaf number (20.00), leaf area (28.10 cm2), plant dry weight (18.55 g plant$^{-1}$), pod number (18.03), pod girth (2.12 cm), pod yield plant$^{-1}$ (187.51), pod yield ha$^{-1}$ (138.89 q) and ascorbic acid content (17.35 mg 100 g$^{-1}$) over the control.

Krishnaveni *et al.* (2016) reported that maximum yield parameters of okra like number of pods plant$^{-1}$, length of pod and seed yield plant$^{-1}$ were recorded with single pinching at 25 DAS and application of $GA_3$ @ 50 ppm.

Khan et al.(2017) investigate a research work and reported that gibberellic acid ($GA_3$) and urea sprays boosted the okra yields. They used a base dose of P: K of 70:60 kg ha$^{-1}$, as well as sprays of 0-3 percent urea and 0-100 ppm $GA_3$. The sprays were administered twice after sowing, at 20 and 50 days. With 50 ppm $GA_3$ + 2% Urea, the best yield of 87.39 q ha$^{-1}$ was achieved.

Mehraj *et al.* (2015) concluded that the tallest plant (89.0 cm), longest petiole (29.0 cm), the maximum number of leaves (49.0 $plant^{-1}$), highest leaf area (29.7 $cm^2$), number of branches (5.5 $plant^{-1}$), fresh weight (84.5 g $plant^{-1}$), dry weight (10.9 g $plant^{-1}$), number of pods (33.4 $plant^{-1}$), pod length (17.5 cm), pod diameter (1.7 cm) and fruit yield (338.1 g $plant^{-1}$, 2.9 kg $plot^{-1}$ and 16.4 t $ha^{-1}$) was obtained from the application of $GA_3$ @ 50 ppm which was statistically identical with the application of NAA @ 50 ppm while minimum from control fresh water. They also reported that $GA_3$ and NAA have the potentiality to increase the yield of okra but $GA_3$ was found to be most effective in the present study.

Mohammadi *et al.* (2014) discovered that applying $GA_3$ to okra plants increased plant height regardless of cultivar or $GA_3$ concentration (50 and 100 mg per liter). He also concluded that $GA_3$ either promoted, inhibited, or had no effect on germination. $GA_3$ was also found to have no effect on pod dimensions or seed weight greater than 100. Similarly, while $GA_3$ application had no consistent effect on seed moisture content, it did increase the number of seeds $pod^{-1}$. Overall, harvest time had a greater impact on pod and seed characteristics than $GA_3$ application.

Munda *et al*. (2000) conducted a field experiment during the rainy season to assess the effect of plant growth regulators on the quality of seeds of Okra (*Abelmoschus esculentus* L. Moench) *cv.* Prabhani Kranti at the department of Horticulture at Bihar Agricultural College Sabour, Bhagalpur, India. Experiment results concluded that the applications of $GA_3$ 100 ppm as seed treatment were found to be most effective where, seeds $pod^{-1}$, weight $pod^{-1}$, the weight of seed $plant^{-1}$, size of the seed, 100-seed weight and seed yield $ha^{-1}$ was significantly superior over the rest of the treatment.

Nawalagatti *et al*. (2006) were conducted an experiment at Kharif 2002, in Dharwad, Karnataka, India, to evaluate the effects of NAA (20 and 40 ppm), $GA_3$ (25 and 50 ppm), Miraculan (triacontanol) (1000 and 2000 ppm), $MnSO_4$ (0.3 and 0.6%), $MgSO_4$ (0.5 and 1.0%) and $FeSO_4$ (0.25 and 0.5%) on okra (*Abelmoschus esculentus*). The findings of the experiments revealed that when $GA_3$ was used instead of other plant growth regulators and micronutrients, the values of all morpho-physiological and biochemical parameters were much higher. They also reported that $GA_3$ had the largest fresh fruit yields at 25 and 50 ppm, with 15.81 and 18.69 t $ha^{-1}$, respectively.

Sarker et al. (2002) studied on the induction of flowering and sex expression on pointed gourd by growth regulators. They observed that maximum number of branches per plant obtained by treatment with 100 ppm IAA followed by 100 ppm $GA_3$ while the minimum number of branches were found in 500 ppm CCC. Maximum no. of female plants were obtained by treatment with 50 ppm and 100 ppm ethrel follower by 25 ppm IAA. Amongst the ethrel treatment, the concentration of 25 ppm produced the maximum female flowers. The maximum yield per plant was obtained in treatment with 25 ppm IAA followed by ethrel 50 ppm..

Patil and Patel (2010), concluded that $GA_3$ @ 15 mg $L^{-1}$ produced the highest percentage of seed germination, stem girth, number of branches, number of leaves plant$^{-1}$, early flowering in okra, highest fruit girth, length, weight, fruit production plant$^{-1}$, and fruit yield ha$^{-1}$, while $GA_3$ @ 45 mg $L^{-1}$ was found to be beneficial in terms of plant height, number of internodes, and intermodal length of okra. They also reported that, $GA_3$ at 30 mg $L^{-1}$ produced the most fruits plant$^{-1}$.

Mohammad *et al.* (2008) investigated the effects of plant growth regulators ($GA_3$ and NAA) on germination, growth, and yield of okra (*Abelmoschus esculentus*). Both growth regulators boosted seed germination, plant development, and yield at 25-30 ppm, according to the researchers.

Poonam *et al.* (2006) investigated the effects of growth regulators and spacing on okra seed productivity and quality in Kanpur, Uttar Pradesh, India, during the Kharif season 2000 and 2001. Investigation results concluded that the treatment with $GA_3$ in wider spacing (60× 45 cm) resulted in a considerable increase in seed yield per plant, as well as a significant improvement in seed quality at harvest, as measured by vigor index and speed of germination. Although the highest yield was achieved with close spacing (45× 30 cm), emergence was unaffected by spacing. $GA_3$ (150 ppm concentration) was discovered to have a considerable favorable effect on seed production.

Sayeed et al. (2017) reported that seed treatment with 10 ppm $GA_3$ and 300 ppm $GA_3$ as a plant spray advanced flowering by 6.33 days, compared with control. They also reported that the longest pods were obtained with 50 ppm IAA seed treatment and 100 ppm IAA as a plant spray. The greatest number of pods and maximum green pod yield were obtained by treating the seeds with 30 ppm $GA_3$ and100 ppm $GA_3$ as a spray.

Ravat and Makani (2015) reported that application of $GA_3$ @ 100 ppm was the best treatment for okra growth characteristics such as plant height (cm), number of leaves, number of internodes plant$^{-1}$, days to flower initiation, and days to 50% flowering.

Saheed and Qader, (2020) conducted a study to investigate the combined effect of ascorbic acid and potassium on okra (*Abelmoschus esculentus*) growth in saline conditions. The results elucidated that a combination of ascorbic acid and potassium increases the height of plants, the number of leaves, shoot water content, protein and proline content of leaves and mineral contents such as nitrogen and sodium content of leaves under salt stress conditions.

Sajindranath *et al*. (2002) evaluated the efficacy of growth regulators and biofertilizers in improving seed germination and seedling vigor in okra *cv*. Parbhani Kranti. The experiment results revealed that the best treatment was $GA_3$ at 10 and 50 ppm, which resulted in 100% seed germination.

Shahid *et al.* (2013) conducted a field experiment to find out the influence of different growth regulators on the growth, yield and seed production of okra. In this experiment different concentrations (0, 50, 100 and 200 ppm) of gibberellic acid ($GA_3$)and naphthalene acetic acid (NAA), alone or in different combinations were sprayed on okra plants at the 2-true leaf stage, as certain their impact on plant growth, pod production, seed yield and seed quality. All variables regarding vegetative and reproductive growth was significantly influenced by different concentrations of the growth regulators except for the number of days taken to flowering. Growth regulators were less effective when applied individually as compared to their combined use ;however, the performance of plants treated with individual PGR was better than the untreated plants. The number of leaves plant$^{-1}$ and plant height was higher in plants when sprayed with $GA_3$ and NAA @ 200+100 ppm as well as with $GA_3$ and NAA @200+200 ppm. The number of pods plant$^{-1}$, pod length, pod fresh and dry weight, seed yield and seed quality (in terms of germination percentage and 1000-seed weight) was maximum in plants receiving foliar spray of both $GA_3$ and NAA @200+200 ppm.

Singh and Mahesh (2005) were conducted a study in Muzaffar Nagar, Uttar Pradesh, India, during summer 2003 to assess the effect of plant growth regulators as seed treatment and foliar spraying of N on the growth and yield of okra *cv.* Pusa A-4. 75 ppm gibberellic acid ($GA_3$), 100 ppm $GA_3$, 150 ppm $GA_3$, 10 ppm NAA, 20 ppm NAA, 2% urea, 4% urea, 100 ppm $GA_3$ + 2% urea, 150 ppm $GA_3$ + 2% urea, 20 ppm NAA+2% urea, 150 ppm $GA_3$ + 20 ppm NAA+4% urea, water and control were used as treatments in this experiment. The seeds treated with 150 ppm $GA_3$ + 20 ppm NAA + 4 % urea had the highest germination rate (73.53 %), according to the results of the experiment. With 75 ppm $GA_3$, the largest number of leaves plant$^{-1}$ was recorded. With 20 ppm NAA + 2% urea, the number of nodes on which the first bloom appears is the smallest, and the number of days necessary to reach 50% flowering is the shortest (40.57). With % urea, the highest weight of green fruits plant$^{-1}$ (336.93) was found. The plants are given 20 ppm NAA + 2 % urea had the highest fruit production (170.60 q ha$^{-1}$). With 150 ppm $GA_3$, the largest number of seeds fruit$^{-1}$ (44.60) and seed yield (20.08 q ha$^{-1}$) were recorded.

Goutom and Paul (2005) conducted a research to investigate the influence of seed treatment on germination, vegetative growth and yield of okra with plant growth regulators ($GA_3$ and IAA). Study results revealed that the germination percentage, plant height, number of branches and spread, number of leaves, leaf area and yield were enhanced by all treatments where, 30 ppm $GA_3$, gave the best results.

Singh *et al.* (2015) worked with gibberellic acid as a pre-sowing seed treatment and different levels of nitrogen to find out the germination, growth, flowering, and yield of okra (*Abelmoschus esculentus*) *cv.* Pusa Sawani. They reported that $GA_3$ at 15 ppm increased seed germination by 23.61 and 19.45 % at 9 and 15 DAS respectively. They also reported that treating seed with 45 ppm $GA_3$ increased plant height by 8.97%, advanced flowering by 3.33 days and increased pod yield by 30%.

Singh *et al.* (2012) discovered that applying 160 ppm $GA_3$ resulted in the shortest number of days to first flower blooming (37.13) and days to 50% flower blooming (41.33) in okra.

Singh *et al.* (2017) conducted a field experiment to assess the effect of $GA_3$ and NAA on the yield and quality of Okra. The study included 16 different treatment combinations combining two different growth regulators with four levels each (0, 25, 50 and 75 ppm). $GA_3$ and NAA at the rate of 75 ppm were discovered to be the most effective in increasing the number of fingers collected plant$^{-1}$ (15.10), the total number of pickings (9.33), and finger thickness (1.54 cm). $GA_3$ @ 75 ppm and NAA @ 50 ppm treatment combinations increased the average weight of the finger (16.28 g) and yield plant$^{-1}$ (0.232 g). The treatment combinations of $GA_3$ and NAA @ 50 ppm each resulted in the maximal length of the finger (15.82 cm).

Chowdhury and Hossen(2013) reported the findings through a field research that the effect of indole acetic acid (IAA) and gibberellic acid ($GA_3$) on the growth and yield of okra. Investigation results concluded that $GA_3$ was more effective than IAA in improving the germination, growth and yield of okra.

Surendra *et al.* (2006) conducted a field experiment in Dharwad, Karnataka, India, during the Kharif of 2002, to investigate the effects of plant growth regulators and micronutrients on okra yield and yield components. The findings of the experiments showed that NAA at 20 and 40 ppm (13.19 and 14.00 t ha$^{-1}$) and $GA_3$ at 25 and 50 ppm (15.81 and 18.69 t ha$^{-1}$) generated the highest fruit yields among the growth regulators. The latter treatments also had the most flowers plant$^{-1}$ (23.2 and 26.8), total fruit number (18.4 and 22.1), harvest index (50.4 and 65.5%), fruit length (21.3 and 23.4 cm), total dry weight of fruits (66.19 and 90.49 g plant$^{-1}$), number of seeds fruit$^{-1}$ (51.0 and 55.0), seed weight fruit$^{-1}$ (4.55 and 6.15) and BCR (4.52 and 5.00).

Unamba *et al.* (2010) evaluated the effect of low concentrations of GA3 (0,1,5,10,20,30 ppm) on the growth of dwarf Okra and found that gibberellic acid significantly increased plant height, internodes elongation, leaf number, and caused a reduction in petiole length. Early flowering was also aided by gibberellic acid. When compared to the seed soaking application strategy, the foliar spray application had a substantial effect on plant height. Although GA3 increased internodes elongation, it had no effect on the number of internodes in both the treated and control plants, suggesting that dwarfism in this okra variety could be attributable to a lack of endogenous gibberellic acid.

Yakoubi *et al.* (2019) conducted a study aimed to evaluate the effect of gibberellic acid ($GA_3$) and abscisic acid (ABA) on the germination of okra seeds (*Abelmoschus* *esculentus* L.) exposed under salinity constraint. The results showed that NaCl reduced seed germination precocity without affecting the final rate; nonetheless, it had a detrimental influence on growth, fresh weight, and seedling water content. $GA_3$ treatment reduced the depressive effect of NaCl on germination by boosting it 20 % and 26.66 % on the first day of planting (after 24 h) under the effects of 5 μM and 10 μM $GA_3$, respectively. The results revealed that this phyto hormone influenced the hypo cotylar length, fresh and dry weight, and water content of okra seedlings in a good way.

### 2.2. Effect of Potassium on Growth and Yield of Okra

Afrose, (2015) was conducted a field experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from April to August 2015 to find out the effect of potassium and gibberellic acid on okra *cv.* BARI Dherosh-1. In the experiment Potassium fertilizer was used as $K_0$: 0 kg $K_2O$ $ha^{-1}$ (control), $K_1$: 60 kg $K_2O$ $ha^{-1}$, $K_2$: 90 kg $K_2O$ $ha^{-1}$ and $K_3$: 120 kg $K_2O$ $ha^{-1}$. Experiment results concluded that due to the effect of potassium, the highest yield (19.04 t $ha^{-1}$) was obtained with 120 kg $K_2O$ $ha^{-1}$ and the lowest yield (12.11 t $ha^{-1}$) from $K_0$ (control).

Alrawi and Aljumail, (2018) were carried out two field experiments at the College of Agriculture/ University of Baghdad during spring season 2017 on okra "Petra" to study the foliar application of potassium and zinc on growth, green pod yield and seed production of okra. Results were showed that the potassium spray with concentrations of 4000 mg $L^{-1}$ and the zinc spray with 30 mg $L^{-1}$ was superior in plant height (114.36 and111.60 cm. $plant^{-1}$), Leaf area (830, 102 and 267.86 $dcm^2$ $plant^{-1}$), Total chlorophyll (60.54 and 52.11mg $100g^{-1}$ fresh weight), Fresh pods number (59.22 and 56.82 pod. $plant^{-1}$), Fresh pod weight (5.59 and5.15 $gram.pod^{-1}$), Plant yield (331.84 and 301.39 gram. $plant^{-1}$), respectively. While the potassium spray with the concentration of 6000 mg $L^{-1}$ and the zinc spray with 60 mg $L^{-1}$ was superior in seeds germination (92.22 and 90.67 %), Rapidity germination (10.28 and 9.99 days), Specific gravity (98.09and 97.93 seed.5 $gram^{-1}$), Oil in seeds (21.82 and 21.70 %), Carbohydrate in seeds (33.98 and 33.42 %),Protein in seeds (22.01 and 21.70 %), respectively. It could be recommended to use foliar of 4000 mg $L^{-1}$potassium and 30 mg $L^{-1}$ zinc to increase growth and green pod yield and recommended to use foliar of6000 mg $L^{-1}$ potassium and 60 mg $L^{-1}$ zinc to improve seed qualities.

Aslam and Singh (2003) were conducted a study to assess the effect of NPK fertilizers on $NO_3$ accumulation in okra (*Abelmoschus esculentus*) and carrot (*Daucus carota*) in Pakistan. The findings of the experiment showed that increasing fertilizer rates raised $NO_3$ content in okra and carrots compared to the control. However, when N was combined with P, the content of $NO_3$ in okra was lowered. Conversely, when N has applied alone or with P, the $NO_3$ concentration in carrots increased considerably over the control; however, when N and P fertilizers were supplied in a balanced ratio (2:1), the $NO_3$ accumulation was reduced. Furthermore, the NPK fertilizer levels used in this study did not cause any health risks to the participants.

Bamel and Singh (2003) conducted a pot experiment under greenhouse conditions to investigate the effect of different fertilizer sources on *M. incognita* in okra. When a recommended dose of N, P, K, and Zn fertilizers were applied, plant growth was improved and nematode damage was reduced. Individually, higher doses of muriate of potash and potassium sulfate resulted in maximum plant growth. When compared to other treatments, ammonium sulfate and gypsum significantly reduced nematode reproduction. Except for calcium nitrate , muriate of potash, and potassium sulfate, all fertilizers reduced nematode damage with an increase in dose.

Islam et al.(2017) investigated the impact of NPK on okra growth and yield (*Abelmoschus esculentus*). They discovered that increasing N treatment enhanced plant height and width, number of leaves, and green pod production (22.5, 45.0, or 67.5 kg $ha^{-1}$). The best yields were found with N at 120, $P_2O_5$ at 34.88, and K at 49.8kg $ha^{-1}$, according to the researchers.

Gowda *et al*. (2001) conducted a field experiment to determine the response of the okra cultivars Arka Anamika, Varsha, and Vishal to three NPK fertilizer rates (125:75:60 kg $ha^{-1}$, 150:100:75 kg $ha^{-1}$, and 175:125:100 kg $ha^{-1}$) in Bangalore, Karnataka, India. Experiment results revealed that 175:125:100 kg NPK $ha^{-1}$ treatments produced the maximum dry matter in leaves (20.40 g), stems (35.17 g), roots (18.03 g), fruits (31.11 g), and entire plants (104.71 g). They also reported that okra *cv.* Varsha supplemented with 175:125:100 kg NPK $ha^{-1}$ had the highest total dry matter production (1111.48 g plant$^{-1}$), which was comparable to okra *cv.* Arka Anamika treated with 175:125:100 kg NPK ha$^{-1}$.

Khan *et al.* (2019) conducted a study to assess the effect of different levels of nitrogen and potassium on the growth and yield of okra. They stated that nitrogen and potassium levels influence the growth and yield of okra. The results of the experiment revealed that plant height, plant diameter, petiole length, leaves, breadth, number of leaves, number of branch and green pod length, pod diameter, number of green pod plant$^{-1}$, green pod yield plant$^{-1}$ and green pod yield ha$^{-1}$ were significantly influenced by the different levels of nitrogen and potassium except for plant diameter at 40 DAS (days after sowing). The highest levels of Nitrogen (160 kg ha$^{-1}$) produced the highest green pod yield (9.602 t ha$^{-1}$). The highest green pod yield (8.247 t ha$^{-1}$) was observed from 80 kg of K ha$^{-1}$. The combined effect of various levels of nitrogen and potassium levels as well as was also found significant except plant height and diameter at 20 DAS and leaf length and leaf breadths. The use of maximum nitrogen dose 160 kg N ha$^{-1}$ and potassium 80 kg $K_2O$ ha$^{-1}$ produced the highest yield (9.99 t ha$^{-1}$) and the lowest (5.94 t ha$^{-1}$), respectively were recorded from the control treatments. The benefit-cost ratio (BCR) was maximum (2.02) in the treatment combination of (160 kg N ha$^{-1}$ + 80 kg $K_2O$ ha$^{-1}$) whereas the minimum (1.23) was recorded in the control treatment (0 kg N ha$^{-1}$ + 0 kg $K_2O$ ha$^{-1}$).

Meena *et al.* (2017) was conducted a field experiment during summer (zaid) 2015 at the Department of Horticulture, MJRP College of Agriculture & Research, MJRP University Jaipur (Rajasthan). The experiment consisted of eight treatments. Results of the field experiment revealed that the minimum days (39.73)required to open flower from sowing were recorded under application of 90 kg N + 60 kg$P_2O_5$ + 60 $K_2O$ ha$^{-1}$, followed by application of 90 kg Nitrogen ha$^{-1}$ (41.22 days), whereas the maximum days (44.21) were noted under absolute control. Whereas, Plant height has recorded the maximum under application of 90 kg N + 60 kg $P_2O_5$ + 60 $K_2O$ ha$^{-1}$, after 40 days (28.10cm), 60 days (75.40 cm) and 80 days (106 cm) and seed germination (91.96 %). Amongst fruit characters, the maximum length of fruits (13.93 cm), diameter of fruits (2.6 cm), fruit yield plant$^{-1}$(258.18 g) and the number of fruits plant$^{-1}$ (30.54) were recorded under application of 90 kg N + 60kg $P_2O_5$ + 60 kg $K_2O$ ha$^{-1}$. The maximum yield (172.12 q ha$^{-1}$) was obtained under the application of90 kg N + 60 kg $P_2O_5$ + 60 $K_2O$ ha$^{-1}$ followed by the application of 90 kg N +60

$P_2O_5$ $ha^{-1}$ (163.12 $qha^{-1}$) and the maximum number of seeds $fruit^{-1}$ was recorded (56.46) under application of 90 kg N+ 60 kg $P_2O_5$ + 60 $K_2O$ $ha^{-1}$. Application of 90 kg N + 60 kg $P_2O_5$ + 60 $K_2O$ $ha^{-1}$ recorded significantly higher net returns (123084.10 Rs $ha^{-1}$) and B: C ratio (2.13) which was found statistically superior over other treatments.

Mohammed and Miko, (2009) reported that combined application of 80 kg N $ha^{-1}$ with either 30 kg or 60 kg $K_2Oha^{-1}$ produced the highest yields 17272 and 17526 kg $ha^{-1}$,respectively and different K levels had no significant effect on the yield of okra in the absence of nitrogen.

Omotoso and Shittu (2007) conducted a field experiment at the Teaching and Research Farm, the University of Ado-Ekiti in Nigeria to assess the effect of NPK fertilizer application rates and method on the development and yield of okra (*Abelmoschus esculentus* L. Moench). The experiment results showed that NPK considerably increased plant height, leaf area, root length, and the number of leaves, as well as yield and yield components, with an optimum yield of okra obtained from NPK @ 150 kg $ha^{-1}$.

Field experiment were conducted by Philip et al. (2010) at the Teaching and Research Farm of the Department of Crop Science , Adamawa State University , Mubi with the aim of assessing the effect of spacing and NPK fertilizer on yield and yield components of okra. Treatments consisted of four four spacing and four NPK rates (0, 100, 150 and 200 kg $ha^{-1}$ ). Results showed that the number of fruits per plant and length of fruits were significantly influenced by fertilizer levels.

Sunita et al. (2006) was laid out an experiment at the Feirsa Agricultural University ,Ranchi , Jharkand , India , and determined the effect of NPK fertilizer application on the performance of okra. The results revealed that the treatment of 100% recommended dose of fertilizer recorded higher okra equivalent yield (153.16 q $ha^{-1}$).

The study was conducted by Khetran at al. (2016) at Vegetable Seed Production Farm Quetta to investigate the effect of different doses of NPK fertilizer on growth of okra. Data regarding height of plant revealed that $T_5$ (140 kg N /ha ,100 kg p/ha and 60 kg K/ha) had significant superiority over other means. Analysis of variance regarding number of flowers per plant, fruits/plant, pod yield indicated highly significant results

For fertilizer treatments for this factor of study. It was also noted from that with increase of fertilizer applications, number of flower increased accordingly while results expressed the more the fertilizer the better length the green pods. K is needed for good quality of yield.

### 2.3. Combined Effect of $GA_3$ and Potassium on Growth and Yield of Okra

Afrose, (2015) was conducted a field experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from April to August 2015 to find out the effect of potassium and gibberellic acid on okra *cv.* BARI Dherosh-1. In the experiment two factors *viz.,* Potassium fertilizer as $K_0$: 0 kg $K_2O$ $ha^{-1}$ (control), $K_1$: 60 kg $K_2O$ $ha^{-1}$, $K_2$: 90 kg $K_2O$ $ha^{-1}$ and $K_3$: 120 kg $K_2O$ $ha^{-1}$; and Gibberellic acid (3 levels) as $G_0$: 0 ppm $GA_3$ (control) $G_1$: 60 ppm $GA_3$, $G_2$: 90 ppm $GA_3$ respectively. Experiment results concluded that all the parameters were significantly influenced by different levels of potassium and gibberellic acid. Due to the effect of potassium, the highest yield (19.04 t $ha^{-1}$) was observed from $K_3$ and the lowest yield (12.11 t $ha^{-1}$) from $K_0$. In the case of Gibberellic acid, the highest yield (17.08t $ha^{-1}$) was found from $G_2$ and the lowest yield (16.01 t $ha^{-1}$) from $G_0$. For the combined effect, the highest yield (21.50 t $ha^{-1}$) was found from $K_3G_2$ and the lowest yield (11.65 t $ha^{-1}$) from $K_0G_0$. The highest BCR (2.91) was noted from $K_3G_2$ and the lowest (1.30) from $K_0G_2$. From a growth, yield and economic point of view, it is apparent that the application of 120 kg $K_2O$ $ha^{-1}$ with 90 ppm $GA_3$ was the best for the growth and yield of okra.

Ayub *et al.* (2018) investigated to improve salt tolerance abilities in okra (*Abelmoschus esculentus* L.) by foliar application of potassium silicate and seed priming with $GA_3$. A pot experiment was conducted at Awan Nursery Farm, Haripur, to investigate whether seed priming with $GA_3$ and foliar application of potassium silicate could ameliorate the toxic effects of salinity on okra growth. Two okra cultivars Sabz Pari and Mehak Pari were exposed to two levels of NaCl (control and 50 mM) according to the saturation percentage of the soil. Seeds of okra were primed with three levels of $GA_3$ (50mg $L^{-1}$, 75mg $L^{-1}$ and 100mg $L^{-1}$) before sowing. After 18 days of germination okra plants were treated with three levels of potassium silicate (2 mmol, 3 mmol and 4 mmol) exogenously as a foliar spray to protect the plants against salt stress. Data for different growth parameters such as root length, shoot length, plant height, root and shoot fresh weight, root and shoot dry weight were collected. Okra cultivar Sabz Pari showed maximum resistance towards salinity as compared to Mehak Pari. Applications of $GA_3$ decreased the harmful effects of salinity and enhanced the overall growth of okra whereas silicon failed to impart any significant difference on okra.

Jhone *et al. (*2014) performed a trial with growth substances on yield and yield contributing characters of okra. The better yield of okra was obtained after soaking the seeds in the starter 2% NPK solution and spraying the plants with 100 ppm $GA_3$.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted during the period from April to September 2020 at the Horticultural Farm of Sher-e-Bangla Agricultural University. The materials and methods that were used for conducting the experiment are presented under the following headings-

## 3.1 Experimental site

The Research work was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, to find out the performance of okra with the application of $GA_3$ and potassium fertilizer. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

## 3.2 Characteristics of soil

The soil of the experimental area belongs to the Madhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The morphological and chemical properties of soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI , (Khamarbari , Farmgate, Dhaka)and details soil characteristics of the experimental plot were presented in Appendix I.

## 3.3 Climatic condition of the experimental site

The climate of experimental site was subtropical which are characterized by three distinct seasons including winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris*et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and presented in Appendix II.

## 3.4 Planting materials

BARI Dherosh 1 was used as the test crop of this experiment. The seeds of okra were collected from Bangladesh Agricultural Research Institute , Joydebpur ,Gazipur.

### 3.5 Treatment of the experiment

The experiment consisted of two factors:

**Factor A:** Growth regulators (three levels) as

i    $G_0$: Control (no $GA_3$)

ii.    $G_1$: 100 ppm $GA_3$

iv.    $G_2$: 120 ppm $GA_3$

**Factor B:** Potassium Fertilizer (three levels) as

i.    $K_0$: Control (No potassium application)

ii.    $K_1$: 80 kg $K_2O$ $ha^{-1}$

iii.    $K_2$: 100 kg $K_2O$ $ha^{-1}$

There were 9 (3 × 3) treatments combination such as $G_0K_0$, $G_0K_1$, $G_0K_2$, $G_1K_0$, $G_1K_1$, $G_1K_2$, $G_2K_0$, $G_2k_1$ and $G_2K_2$.

### 3.6 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In this experimental plot the total area was 183.3 $m^2$ with length 19.5 m and width 9.4 m. The total area was divided into three equal blocks. Each block was divided into 9 plots where 9 treatments combination were allotted at random. There were 27-unit plots altogether in the experiment. Each plot size was 1.5 m × 1.2 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Seeds were sown in the plot with maintaining distance between row to row and plant to plant was 40 cm and 50 cm, respectively. The layout of the experiment is shown in Figure 1.

### 3.7 Land preparation

For conducting the research work firstly, the selected plot was opened in the 1st week of April 2020 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth . Weeds and stubbles were completely cleaned from the land and finally obtained a desirable tilth of soil was for sowing okra seeds.

### 3.8 Application of manure and fertilizers

Muriate of Potash (MP) @ 150 kg per ha and 10 ton/ha cowdung were applied in all the experimental plot as manures.

### 3.9 Intercultural operation

After establishment of seedlings, different intercultural operations such as irrigation, weeding and top dressing etc. were accomplished for better growth and development of the okra seedlings.

### 3.9.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after raising of seedlings .It should be done in every alternate day in the evening up to seedling establishment. Further irrigation was applied when necessary. Excess water was effectively drained out at the time of heavy rain.

### 3.9.2 Weeding

To keep the experimental plots clean and easy aeration of soil weeding is essential which ultimately ensured better growth and development and prevent competition with our desired crop. The newly emerged weeds were uprooted carefully. For breaking the crust of the soil mulching was done if necessary.

### 3.10 Plant protection

Malathion 57 EC @ 2 ml $L^{-1}$was applied. The insecticide application was done fortnightly for a week after seedling raising to a week before first harvesting. As soil insecticide Furadan 10 G was also applied during final land preparation. During foggy weather precautionary measured against disease infection of okra was taken by spraying Dithane M-45 fortnightly @ 2 g/L, at the early vegetative stage. Ridomil gold was also applied @ 2 g/L against blight disease of okra.

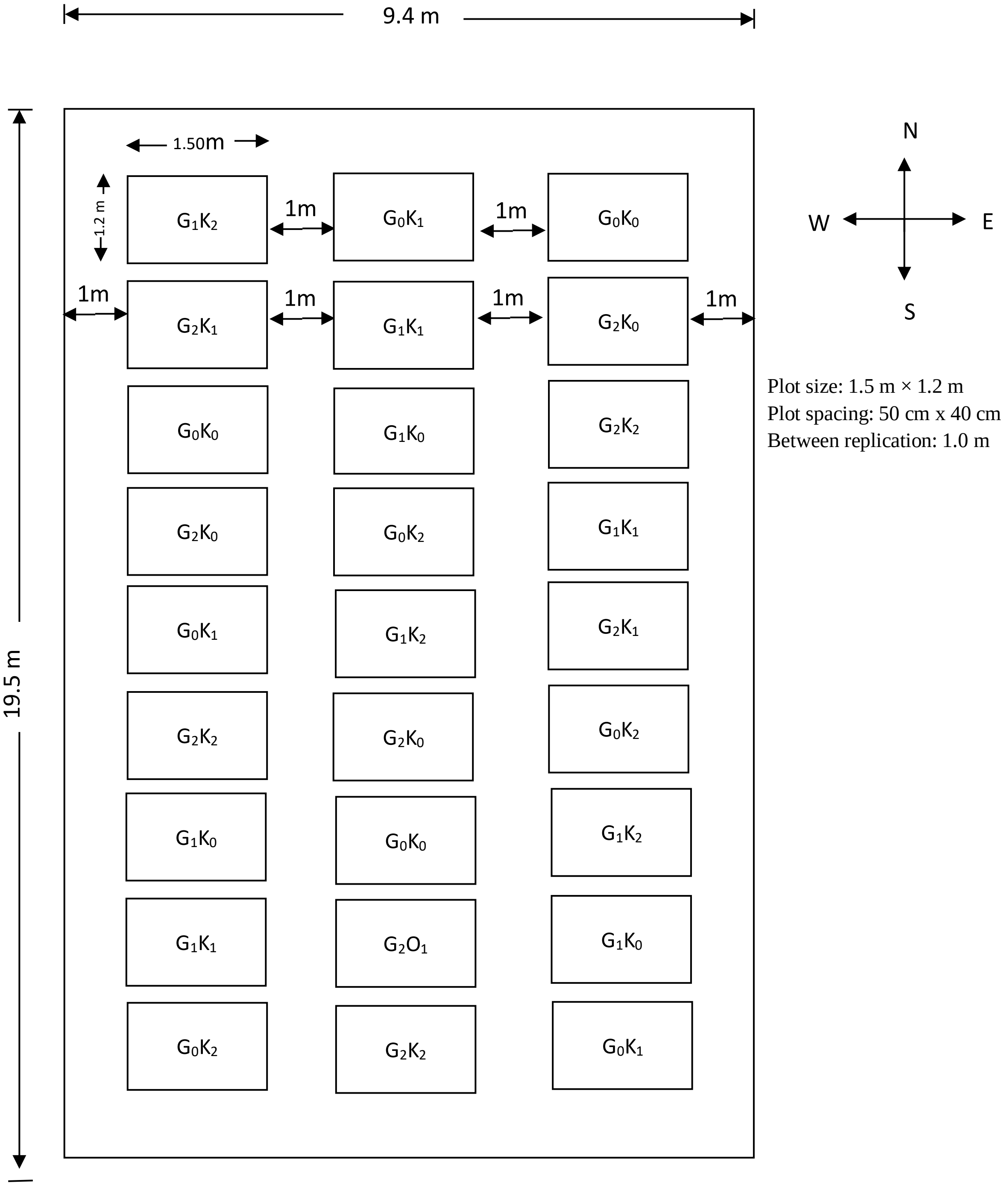


Figure 1: Layout of the experimental plot

### 3.11 Harvesting

Fruit harvesting was done at 3 days interval based on eating quality. Harvesting was started from May 2020 and was continued up to September 2020.

### 3.12 Data collection

For data collection , five plants were randomly selected from each unit plot. The outer rows plants were excluded from the random selection to avoid the border effect.

#### 3.12.1 Plant height

From the ground level to the tip of the longest stem, plant height of okra was determined in centimeter and a mean value was computed. Plant height was also measured from the 20 days after sowing until 60 days at 20 days interval to track plant growth of okra.

#### 3.12.2 Stem diameter

From the sample plants, stem diameter was determined in centimeter using a slide calipers and a mean value was measured. To observe the rate of plant growth ,stem diameter was measured at 20 days interval from the time of seeding till 60 days.

#### 3.12.3 Number of leaves per plant

From each selected plant of okra, the total number of leaves per plant was counted. Data were recorded as The average of 5 plants was randomly chosen from the inner rows of each plot at 20 days interval from 20 DAS to 60 DAS at 20 days interval was used to compile the data.

#### 3.12.4 Number of branches per plant

The total number of branches per plant of okra was determined from each selected plant. The average of 5 plants randomly chosen from the inner rows of each plot at 20 days interval from 20 DAS to 60 DAS was used to compile the data.

#### 3.12.5 Length of petiole

The length of petiole particularly of the longest petiole from the sample plant was measured in centimeter and a mean value was recorded. It was also measured from 20 days after sowing up to 60 days at 20 days interval to observe the plant’s growth rate .

### 3.12.6 Number of internodes per plant

From each selected plant the total number of internodes per plant was computed. The average of 5 plants randomly chosen from the inner rows of each plot data was collected from 20 DAS to 60 DAS at 20 days interval.

### 3.12.7 Length of internodes

Length of internodes of sample okra plants was measured in centimeter from the one side to another side of internodes and mean value was determined. To observe the growth rate ,length of internodes was also recorded starting from 20 days of sowing up to 60 days at 20 days interval.

### 3.12.8 Leaf area

From the sample plants of okra, leaf length and leaf breadth was measured in centimeter and leaf area was measured by multiplying leaf length and leaf breadth. Leaf area was also recorded from 20 days of sowing up to 60 days at 20 days interval to observe the growth rate of plants.

### 3.12.9 Fresh weight of plant

For measuring the fresh weight of plant, it is essential to take the whole plant of okra ant should clean and weight.

### 3.12.10 Dry matter of plant

150 g plant sample previously sliced into very thin pieces were placed in an envelop following harvesting and baked for 72 hours at 70$^0$C tem. After that the sample was transferred into desiccators allowing to cool down at ambient temperature. The final weight of the sample was taken. The plant's dry matter contents were calculated by the following formula:

$$\% \text{ Dry matter content of plant} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

### 3.12.11 Blooming time.

From the date of sowing to the start of flower bud ,the days required for sowing to blooming were tallied and recorded.

### 3.12.12 Number of flower buds per plant

From the sample plants, the number of flower buds per plant was recorded and the average numbers of flower buds produced per plant were calculated.

### 3.12.13 Number of pods per plant

The number of pods per plant was determined from the sample plants and on the basis of pods per plant the average number of pods was recorded .

### 3.12.14 Pod length

From the each plot the pod length was measured using a slide-calipers from the neck of the fruit to the bottom of 10 selected marketable fruits and their average was calculated and expressed in cm.

### 3.12.15 Pod diameter

Diameter of pod was measured at the middle portion of 10 selected marketable fruit from each plot using a slide-calipers and their average was determined and expressed in cm.

### 3.12.16 Yield per plant

Yield of okra per plant was recorded as the whole fruit per plant and was expressed in kilogram.

### 3.12.17 Yield per plot

Yield of okra per plot was recorded as the whole fruit per plot and was expressed in kilogram.

#### 3.12.17 Yield per hectare

Yield per hectare of okra fruits was calculated by converting the weight of plot yield into hectare and was expressed in ton

## 3.13 Preparation of $GA_3$ and application

Gibberellic Acid ($GA_3$),a plant growth regulator, was obtained from Hatkhola Road ,Dhaka. 1g of $GA_3$ in a tiny amount of ethanol was dissolved before being diluted with distilled water in one liter of volumetric flask to make a 1000 ppm stock solution. The stock solution was used to make the needed concentration for various treatment i.e., 100 ml of this stock solution was diluted in 1 liter of distilled water to obtain 100 ppm $GA_3$ solution. 120 ppm stock solution was diluted to 1-liter distilled water in a same way to create 120 ppm solution. Control solution was made by mixing a tiny amount of ethanol with distilled water. A tiny hand sprayer was used to apply $GA_3$ as per requirement at 20 ,30 and 40 days of following seeding.

### 3.14 Statistical analysis

The data collected for various characters were statistically analyzed to determine on yield and yield contributing features of okra using $GA_3$ and potassium fertilizer. The 'F' (variance ratio) test was used to analyze the variance of all recorded characters' mean values. Duncan's Multiple Range Test (DMRT) was used to determine the significance of difference among the means of treatment combinations at a probability level of 5% (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was carried out during the period from April to September to determine the performance of okra as influenced by $GA_3$ and Potassium fertilizer. Data on different growth parameters, yield attributing characters and yield of okra was recorded. The analysis of variance (ANOVA) of the data on the parameters are presented in Appendix III-VII. The results of the study have been presented and discussed with the help of tables and graphs, and possible interpretations are given under the following headings:

## 4.1 Plant height

Plant height of okra showed statistically significant differences with the application of $GA_3$ at 20, 40, and 60 DAS (Appendix III). At 20, 40 and 60 DAS the tallest plant (15.80 cm, 73.44 cm and 90.22 cm) respectively was recorded from $G_1$ ($GA_3$) which was statistically similar (15.45 cm, 73.12 cm and 88.85 cm) respectively to $G_2$ . On the other hand, at the same DAS, the shortest plant (13.91cm, 64.98 cm and 79.55 cm) respectively was obtained from $G_0$ as controlled condition (Figure 1). It was revealed that $GA_3$ increased plant height and the effect of $GA_3$ that were used in this experiment was to be similar in respect of plant height of okra. Singh *et al.* (1999) also examined of the research that plant growth regulators $GA_3$ increased plant height of okra.

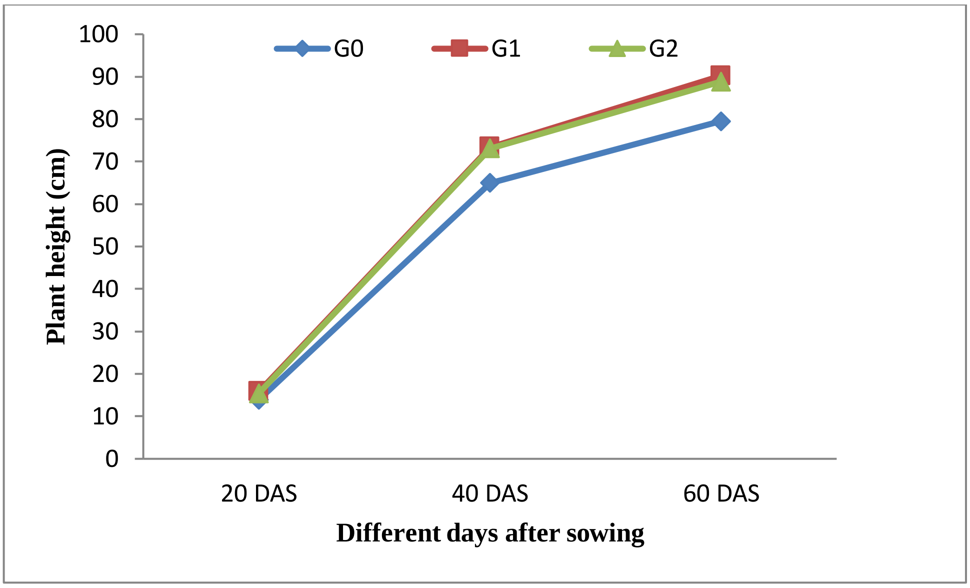


Figure: 2 Effect of $GA_3$ on plant height of Okra at different days after sowing at 5% level of probability ($G_0$= 0 ppm $GA_3$; $G_1$= 100 ppm $GA_3$;$G_3$= 120 ppm $GA_3$)

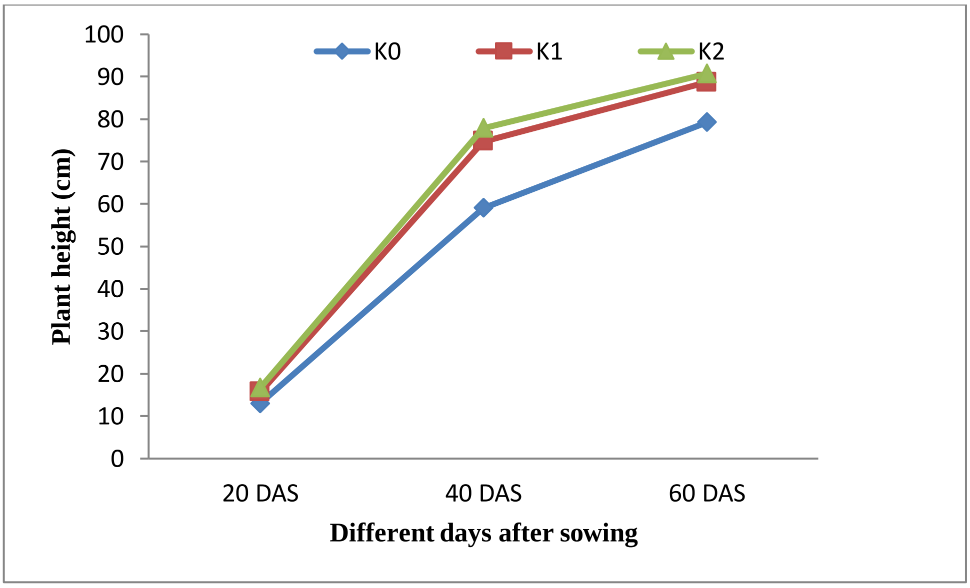


Figure: 3. Effect of potassium on plant height of Okra at different days after sowing at 5% level of probability ($K_0$= 0 kg $K_2O$/ha; $K_1$= 80 kg $K_2O$/ha;$K_2$= 100 kg $K_2O$/ha)

The influence of potassium fertilizer varied significantly on plant height of okra at 20, 40 and 60 DAS respectively. (Appendix III). At 20, 40 and 60 DAS the tallest plant (16.67 cm, 77.93 cm and 90.70 cm) was obtained respectively from $K_2$ (100 kg $K_2O$ $ha^{-1}$) which was statistically identical (15.60 cm, 74.72 cm and 88.70 cm) to $K_1$ (80 kg $K_2O$ $ha^{-1}$). Again, the shortest plant (13.01 cm, 59.02 cm and 79.22 cm) respectively was recorded from the control (Figure 2). Potassium fertilizer helps to improve physical and chemical properties of soil and proper growth and yield of okra plant.

Statistically significant variation was also recorded due to combined effect of $GA_3$ and potassium fertilizer in terms of plant height of okra at 20, 40 and 60 DAS (Appendix III). The tallest plant (18.34 cm, 85.41 cm and 97.22 cm) respectively was found from $G_1K_2$ ($GA_3$ and 100 kg $K_2O$ $ha^{-1}$) at 20, 40 and 60 DAS respectively. On the contrary, the shortest plant (12.49 cm, 57.52 and 73.22 cm) respectively was obtained from $G_0K_0$ (no $GA_3$ and no potassium fertilizer) (Table 1). It was revealed that combined effect of $GA_3$ and 100 kg $K_2O$ $ha^{-1}$produced the longest plant under this trial.

**Table 1. Combined effect of $GA_3$ and potassium on plant height and stem diameter of okra**

| Treatment | Plant height (cm) at | | | Stem diameter (cm) at | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| $G_0K_0$ | 12.49 ef | 57.52 e | 73.22 f | 2.04 d | 2.43 e | 2.55 e |
| $G_0K_1$ | 14.13 de | 66.81 d | 82.11 e | 2.24 c | 2.54 de | 3.08 c |
| $G_0K_2$ | 15.23 cd | 70.73 cd | 83.44 de | 2.27 c | 2.63cd | 3.18 bc |
| $G_1K_0$ | 11.81 f | 52.69 e | 78.77 ef | 2.08 d | 2.42 e | 2.61 e |
| $G_1K_1$ | 17.38 ab | 81.39 ab | 94.77 ab | 2.45 ab | 2.82 ab | 3.52 a |
| $G_1K_2$ | 18.34 a | 85.41 a | 97.22 a | 2.50 a | 2.92 a | 3.63 a |
| $G_2K_0$ | 14.72 cd | 66.83 d | 85.66 cde | 2.26 c | 2.66 cd | 2.83 d |
| $G_2K_1$ | 15.29 cd | 75.95 bc | 89.21 bcd | 2.33 c | 2.65 bc | 3.32 b |
| $G_2K_2$ | 16.44 bc | 77.66 abc | 91.43 abc | 2.36 bc | 2.81 ab | 3.35 b |
| $LSD_{(0.05)}$ | 1.680 | 7.512 | 6.480 | 0.111 | 0.121 | 0.163 |
| Level of significance | 0.01 | 0.01 | 0.05 | 0.01 | 0.01 | 0.01 |
| CV (%) | 7.90 | 7.26 | 5.93 | 6.97 | 8.01 | 5.75 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ $ha^{-1}$
$K_2$: 100 kg $K_2O$ $ha^{-1}$

### 4.2 Stem diameter

Statistically significant variation was obtained on stem diameter of okra due to the influence of $GA_3$ at 20, 40, and 60 DAS respectively (Appendix III). The highest stem diameter (2.34 cm, 2.72 cm and 3.26 cm) was recorded from $G_1$ which was statistically similar (2.32 cm, 2.72 cm and 3.17 cm) respectively to $G_2$ at 20, 40 and 60 DAS. on the other hand, the lowest stem diameter (2.19 cm, 2.54 cm and 2.94 cm) respectively was observed in $G_0$ at the same DAS (Figure 4).

Due to the application of Potassium fertilizer at 20, 40 and 60 DAS (Appendix III) stem diameter of okra was varied significantly. At 20, 40 and 60 DAS the highest stem diameter (2.38 cm, 2.79 cm and 3.39 cm) respectively was observed from $K_2$ which was statistically similar (2.34 cm, 2.68 cm and 3.31 cm) respectively to $K_1$ while the lowest stem diameter (2.13 cm, 2.50 cm and 2.66 cm) was found from $K_0$ respectively (Figure 5).

Combined effect of $GA_3$ and potassium fertilizer showed statistically significant variation in case of stem diameter of okra at 20, 40 and 60 DAS (Appendix III). The highest stem diameter (2.50 cm, 2.92 cm and 3.63 cm) respectively was found from $G_1K_2$ at 20, 40 and 60 DAS , whereas the lowest stem diameter (2.04 cm, 2.43 and 2.55 cm) respectively was recorded from $G_0K_0$ (Table 1).

### 4.3 Number of leaves plant$^{-1}$

Different levels of $GA_3$ showed significant differences on number of leaves plant$^{-1}$ of okra at 20, 40, and 60 DAS (Appendix IV). The maximum number of leaves plant$^{-1}$ (8.02, 29.23 and 49.75) was found from $G_1$ which was statistically similar (7.96,

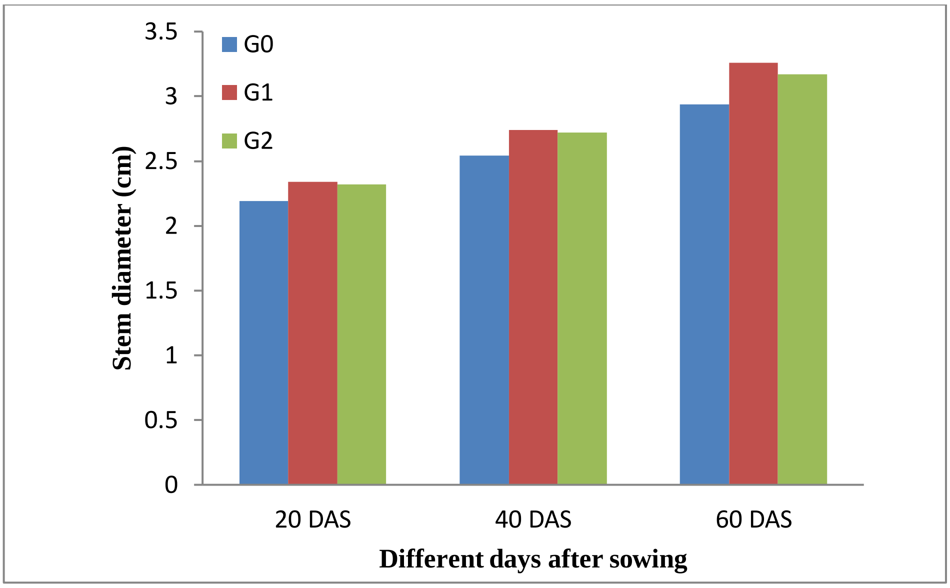


Figure. 4.Effect of $GA_3$on stem diameter of Okra at different days after sowing at 5% level of probability ($G_0$= 0 ppm $GA_3$; $G_1$= 100 ppm $GA_3$;$G_3$= 120 ppm $GA_3$)

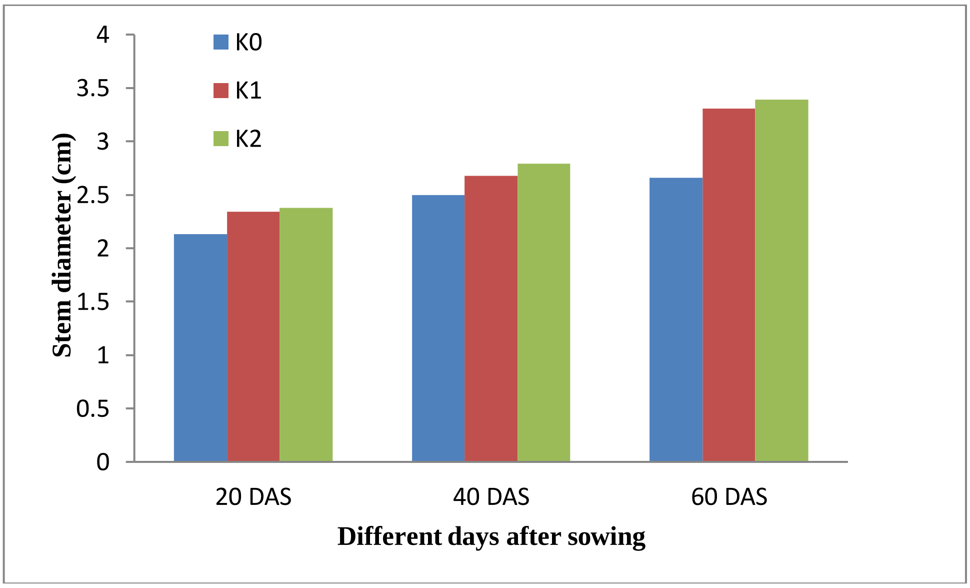


Figure. 5. Effect of potassium on stem diameter of Okra at different days after sowing at 5% level of probability ($K_0$= 0 kg $K_2O$/ha; $K_1$= 80 kg $K_2O$/ha;$K_2$= 100 kg $K_2O$/ha)

26.92 and 49.73) with $G_2$ at 20, 40 and 60 DAS, respectively, again at the same DAS, the minimum number of leaves plant$^{-1}$ (6.68, 22.88 and 44.09) was obtained from $G_0$ (Table 3). Singh and Mahesh (2005) reported the highest number of leaves plant$^{-1}$ with 75 ppm $GA_3$.

Potassium fertilizer showed statistically significant variation for number of leaves plant$^{-1}$ of okra at 20, 40 and 60 DAS (Appendix IV). At 20, 40 and 60 DAS the maximum number of leaves plant$^{-1}$ (8.08, 31.33 and 51.65) was found from $K_2$ which was statistically similar (7.90, 27.66 and 50.12) with $K_1$, respectively, whereas the minimum number of leaves plant$^{-1}$ (6.69, 20.12 and 41.80) was observed from $K_0$ (Table 2).

Due to the Combined effect of $GA_3$ and potassium fertilizer showed significant effect on number of leaves plant$^{-1}$ of okra at 20, 40 and 60 DAS (Appendix IV). The maximum number of leaves plant$^{-1}$ (8.69, 35.95 and 55.72) was obtained from $G_1K_2$ at 20, 40 and 60 DAS, respectively. On the other hand, the minimum number of leaves plant$^{-1}$ (5.85, 19.39 and 42.12) was found from $G_0K_0$, respectively (Table 3).

**Table 2. Effect of growth $GA_3$ and potassium on number of leaves and branches plant$^{-1}$of okra**

| Treatment | Number of leaves plant$^{-1}$ at | | | Number of branches plant$^{-1}$ at | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| **$GA_3$** | | | | | | |
| $G_0$ | 6.68 b | 22.88 b | 44.09 b | 2.72 b | 3.80 b | 5.98 b |
| $G_1$ | 8.02 a | 29.23 a | 49.75 a | 3.05 a | 4.10 a | 6.55 a |
| $G_2$ | 7.96 a | 26.92 a | 49.73 a | 2.92 a | 4.04 a | 6.54 a |
| LSD $_{(0.05)}$ | 0.240 | 4.85 | 1.781 | 0.169 | 0.063 | 0.196 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Potassium fertilizer** | | | | | | |
| $K_0$ | 6.69 b | 20.03 c | 41.80 b | 2.59 c | 3.72 c | 5.75 b |
| $K_1$ | 7.90 a | 27.66 b | 50.12 a | 2.96 b | 4.08 b | 6.59 a |
| $K_2$ | 8.08 a | 30.31 a | 51.65 a | 3.14 a | 4.14 a | 673 a |
| LSD $_{(0.05)}$ | 0.241 | 4.85 | 3.88 | 0.140 | 0.059 | 0.199 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 8.12 | 10.18 | 7.96 | 8.91 | 8.27 | 6.68 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$) — $K_0$: Control (no fertilizer application)
$G_1$: 100 ppm $GA_3$ — $K_1$: 80 kg $K_2O$ ha$^{-1}$
$G_2$: 120 ppm $GA_3$ — $K_2$: 100 kg $K_2O$ ha$^{-1}$

### 4.4 Number of branches plant$^{-1}$

Number of branches plant$^{-1}$ of okra varied significantly due to the effect of $GA_3$ at 20, 40, and 60 DAS (Appendix IV). The maximum number of branches plant$^{-1}$ (3.05, 4.10 and 6.55) was observed from $G_1$ which was statistically similar (2.92, 4.04 and 6.54) with $G_2$ at 20, 40 and 60 DAS, respectively, while at the same DAS, the minimum number of branches plant$^{-1}$ (2.72, 3.80 and 5.98) was found from $G_0$ (Table 4).

Number of branches plant$^{-1}$ of okra differed significantly for potassium under the present trial at 20, 40 and 60 DAS (Appendix IV). At 20, 40 and 60 DAS the maximum number of branches plant$^{-1}$ (3.14, 4.14 and 6.73) was observed from $K_2$.

**Table 3. Combined effect of $GA_3$ and potassium on number of leaves and branches plant$^{-1}$ of okra**

| Treatment | Number of leaves plant$^{-1}$ at | | | Number of branches plant$^{-1}$ at | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| $G_0K_0$ | 5.85 e | 19.39 e | 42.12 cd | 2.55 e | 3.65 d | 5.79 cd |
| $G_0K_1$ | 7.019 cd | 23.99 cde | 43.72 bc | 2.72 cde | 3.82 c | 5.95 bc |
| $G_0K_2$ | 7.19 cd | 26.25 bcd | 46.42 b | 2.89 bcd | 3.92 c | 6.19 b |
| $G_1K_0$ | 6.85 d | 19.65 e | 39.72 d | 2.59 de | 3.62 d | 5.55 d |
| $G_1K_1$ | 8.51 ab | 32.09 ab | 53.82 a | 3.19 ab | 4.32 a | 6.95 a |
| $G_1K_2$ | 8.69 a | 35.95 a | 55.72 a | 3.39 a | 4.35 a | 7.15 a |
| $G_2K_0$ | 7.35 c | 21.05 de | 43.55 bc | 2.62 de | 3.89 c | 5.92 bc |
| $G_2K_1$ | 8.18 b | 27.92 bc | 52.84 a | 2.99 bc | 4.09 b | 6.85 a |
| $G_2k_2$ | 8.35 ab | 31.79 ab | 52.82 a | 3.15 ab | 4.15 b | 6.85 a |
| LSD $_{(0.05)}$ | 0.4169 | 5.515 | 3.105 | 0.2903 | 0.1100 | 0.3369 |
| Level of significance | 0.05 | 0.05 | 0.01 | 0.05 | 0.01 | 0.01 |
| CV (%) | 8.12 | 10.18 | 7.96 | 8.91 | 8.27 | 6.68 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ ha$^{-1}$
$K_2$: 100 kg $K_2O$ ha$^{-1}$

which was statistically similar (2.96, 4.08 and 6.59) with $K_1$, respectively. Again, the minimum number of branches plant$^{-1}$ (2.59, 3.72 and 5.75) was recorded from $K_0$ (Table 2).

Number of branches plant$^{-1}$ of okra showed statistically significant variation due to combined effect of $GA_3$ and potassium at 20, 40 and 60 DAS (Appendix IV). The maximum number of branches plant$^{-1}$ (3.39, 4.35 and 7.15) was recorded from $G_1K_2$ at 20, 40 and 60 DAS, respectively, whereas the minimum number of branches plant$^{-1}$ (2.55, 3.65 and 5.79) was recorded from $G_0K_0$, respectively (Table 3).

### 4.5 Length of petiole

Length of petiole of okra varied significantly for different growth hormone at 20, 40, and 60 DAS (Appendix V). The highest length of petiole (14.14 cm, 26.78 cm and 29.90 cm) was recorded from $G_1$ which was statistically similar (13.88 cm, 25.70 cm and 29.76 cm) to $G_2$ at 20, 40 and 60 DAS, respectively, while at the same DAS, the lowest length of petiole (12.61 cm, 22.96 cm and 26.61 cm) was observed from $G_0$ (Figure 6).

Statistically significant variation was recorded for different potassium in terms of length of petiole of okra at 20, 40 and 60 DAS (Appendix V). At 20, 40 and 60 DAS the highest length of petiole (14.50 cm, 27.05 cm and 30.39 cm) was found from $K_2$ which was statistically similar (14.11 cm, 26.04 cm and 30.18 cm) to $K_1$, respectively, while the lowest length of petiole (12.02 cm, 22.35 cm and 25.70 cm) was obtained from $K_0$ (Figure 7).

Statistically significant variation was recorded due to combined effect of $GA_3$ and potassium in terms of length of petiole of okra at 20, 40 and 60 DAS (Appendix V). The highest length of petiole (15.75 cm, 29.99 cm and 31.93 cm) was found from $G_1k_2$ at 20, 40 and 60 DAS, respectively. On the other hand, the lowest length of petiole (11.23 cm, 21.01 cm and 24.16 cm) was recorded from $G_0K_0$, respectively (Table 5).

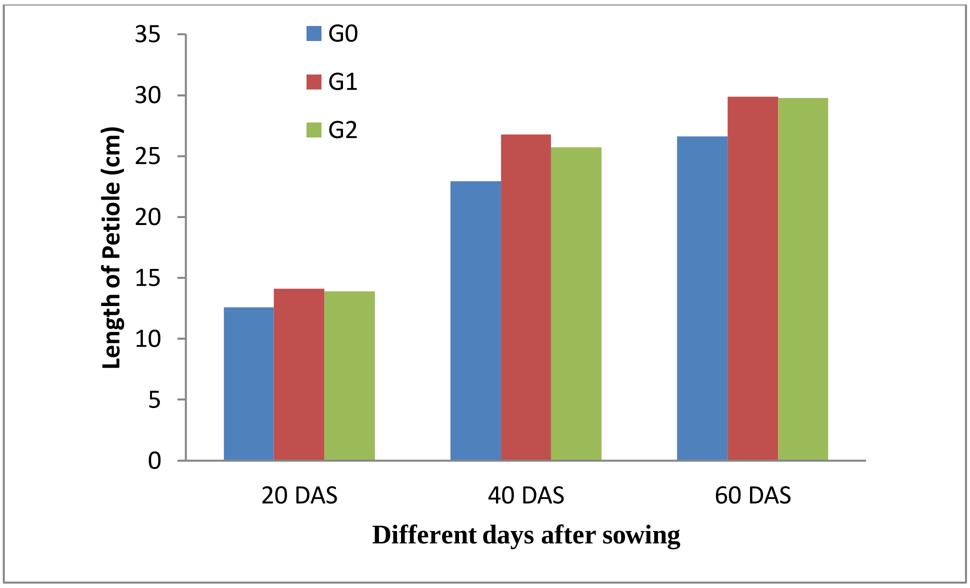


Figure. 6. Effect of $GA_3$ on length of petiole of Okra at different days after sowing at 5% level of probability ($G_0$= 0 ppm $GA_3$; $G_1$= 100 ppm $GA_3$;$G_3$= 120 ppm $GA_3$)

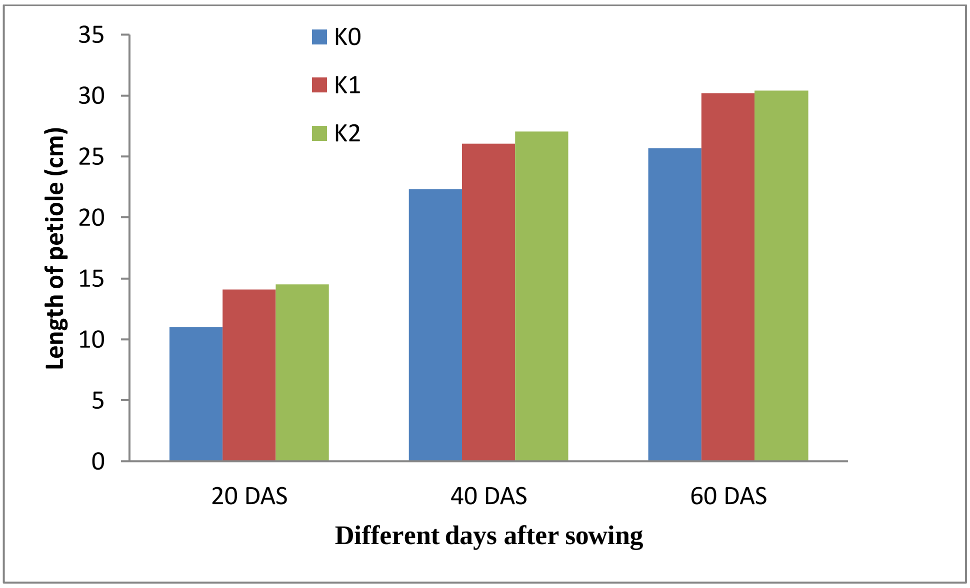


Figure. 7. Effect of potassium on length of petiole of Okra at different days after sowing at 5% level of probability ($K_0$= 0 kg $K_2O$/ha; $K_1$= 80 kg $K_2O$/ha;$K_2$= 100 kg $K_2O$/ha)

**Table 4.Effect of $GA_3$ and Potassium on leaf area of okra**

| Treatment | Leaf Area | | |
|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS |
| Effect of $GA_3$ | | | |
| $G_0$ | 36.76 c | 52.27 c | 59.80b |
| $G_1$ | 44.88 a | 56.89 a | 67.86 a |
| $G_2$ | 39.34 b | 54.64 b | 67.05 a |
| LSD $_{(0.05)}$ | 1.030 | 1.663 | 1.042 |
| Level of significance | 0.01 | 0.01 | 0.01 |
| Effect of potassium | | | |
| $K_0$ | 36.16 b | 48.36 c | 58.83 b |
| $K_1$ | 40.20 a | 56.74 b | 67.85 a |
| $K_2$ | 41.54 a | 58.71 a | 68.04 a |
| LSD $_{(0.05)}$ | 2.030 | 1.840 | 1.562 |
| Level of significance | 0.01 | 0.01 | 0.01 |
| CV (%) | 6.97 | 8.89 | 5.55 |
| | | | |

$G_0$ :Control (no $GA_3$)

$G_1$: 100 ppm $GA_3$

$G_2$: 120 ppm $GA_3$

$K_0$:Conrol (no fertilizer application)

$K_1$: 80 kg $K_2O$ $ha^{-1}$

$K_2$: 100 kg $K_2O$ $ha^{-1}$

**Table 5. Combined effect of $GA_3$ and potassium on length of petiole and leaf area of okra**

| Treatment | Length of petiole (cm) at | | | Leaf area ($cm^2$) at | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| $G_0K_0$ | 11.23 d | 21.01 f | 24.16 d | 33.25 d | 46.63 e | 57.94 b |
| $G_0K_1$ | 13.13 c | 23.28 de | 27.52 b | 38.47 c | 54.91 cd | 598.45 b |
| $G_0K_2$ | 13.46 c | 24.60 bcd | 28.15 b | 38.29 c | 54.27 d | 62.00 b |
| $G_1K_0$ | 11.50 d | 21.73 ef | 26.06 c | 36.48 cd | 47.58 e | 58.60 b |
| $G_1K_1$ | 15.17 ab | 28.62 a | 31.72 a | 45.30 a | 63.04 a | 72.80 a |
| $G_1K_2$ | 15.75 a | 29.99 a | 31.93 a | 43.86ab | 60.00 ab | 72.40 a |
| $G_2K_0$ | 13.34 c | 24.31 cd | 26.89 bc | 38.74 c | 49.85 e | 60.15 b |
| $G_2K_1$ | 14.02 bc | 26.22 bc | 31.30 a | 40.85 bc | 58.18 bc | 71.86 a |
| $G_2K_2$ | 14.28 bc | 26.56 b | 31.09 a | 38.44 c | 55.88 cd | 69.14 a |
| $LSD_{(0.05)}$ | 1.100 | 1.990 | 1.365 | 3.992 | 3.588 | 4.802 |
| Level of significance | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.01 |
| CV (%) | 6.10 | 5.80 | 9.90 | 6.97 | 8.89 | 5.55 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ $ha^{-1}$
$K_2$: 100 kg $K_2O$ $ha^{-1}$

### 4.6 Leaf area

Leaf area of okra showed statistically significant differences for different growth hormone at 20, 40, and 60 DAS (Appendix V). The highest leaf area (44.88 $cm^2$, 56.89 $cm^2$ and 67.86 $cm^2$) was observed from $G_1$ which was statistically similar (39.34 $cm^2$, 54.64 $cm^2$ and 67.05 $cm^2$) with $G_2$ at 20, 40 and 60 DAS, respectively, while at the same DAS, the lowest leaf area (36.67 $cm^2$, 52.27 $cm^2$ and 59.80 cm+2) was recorded from $G_0$ (Table 4).

Potassium fertilizer differed significantly for leaf area of okra at 20, 40 and 60 DAS (Appendix V). At 20, 40 and 60 DAS the highest leaf area (41.54 $cm^2$, 58.71 $cm^2$ and 68.04 $cm^2$) was found from $K_2$ which was statistically similar (40.20 $cm^2$, 56.74 $cm^2$ and 67.85 $cm^2$) with $K_1$, respectively. Again, the lowest leaf area (36.16 $cm^2$, 48.36 $cm^2$ and 58.83 $cm^2$) was obtained from $K_0$ (Table 4).

Statistically significant variation was recorded due to interaction effect of $GA_3$ and potassium fertilizer in terms of leaf area of okra at 20, 40 and 60 DAS (Appendix V). The highest leaf area (45.30 $cm^2$, 63.04 $cm^2$ and 72.80 $cm^2$) was recorded from $G_1K_1$ at 20, 40 and 60 DAS, respectively. Again, the lowest leaf area (33.25 $cm^2$, 47.63 $cm^2$ and 57.94 $cm^2$) was observed in $G_0K_0$, respectively (Table 5).

### 4.7 Number of internodes plant$^{-1}$

Application of $GA_3$ showed statistically significant differences on number of internodes plant$^{-1}$ of okra at 20, 40, and 60 DAS (Appendix VI). The maximum number of internodes plant$^{-1}$ (6.95, 15.18 and 22.63) was recorded from $G_1$ which was statistically similar (6.82, 15.13 and 22.24) with $G_2$ at 20, 40 and 60 DAS, respectively, whereas at the same DAS, the minimum number of internodes plant$^{-1}$ (6.21, 13.96 and 20.39) was recorded from $G_0$ (Table 6).

Number of internodes plant$^{-1}$ of okra varied significantly for inorganic fertilizer at 20, 40 and 60 DAS (Appendix VI). At 20, 40 and 60 DAS the maximum number of internodes plant$^{-1}$(7.23, 15.81 and 22.70) was recorded from $K_2$ which was statistically similar (6.86, 15.35 and 22.34) to $K_1$, respectively. On the other hand, the minimum number of internodes plant$^{-1}$ (5.89, 13.11 and 20.22) was found from $k_0$ (Table 6).

Combined effect of $GA_3$ and potassium showed statistically significant variation in terms of number of internodes plant$^{-1}$ of okra at 20, 40 and 60 DAS (Appendix VI). The maximum number of internodes plant$^{-1}$ (7.89, 18.89 and 24.05) was recorded from $G_1K_2$ at 20, 40 and 60 DAS, respectively, whereas the minimum number of internodes plant$^{-1}$ (5.69, 12.89 and 19.29) was recorded from $G_0K_0$, respectively .

**Table-6: Effect of $GA_3$ and potassium on number & length of internodes and fresh & dry weight per plant of okra**

| Treatment | Number of internodes at | | | Length of internodes (cm) at | | | Fresh weight/ plant (g) | Dry weight/plant (g) |
|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS | | |
| **$GA_3$** | | | | | | | | |
| $G_0$ | 6.21 b | 13.96 b | 20.39 b | 4.42 b | 7.62 b | 11.79 b | 75.40 b | 10.55 b |
| $G_1$ | 6.95 a | 15.18 a | 22.63 a | 5.51 a | 8.75 a | 12.70 a | 85.72 a | 12.11 a |
| $G_2$ | 6.82 a | 15.13 a | 22.24 a | 5.53 a | 8.82 a | 12.93 a | 83.95 a | 11.81 a |
| $LSD_{(0.05)}$ | 0.333 | 0.618 | 0.554 | 0.344 | 0.453 | 0.575 | 5.560 | 0.662 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Potassium fertilizer** | | | | | | | | |
| $K_0$ | 5.89 c | 13.11 b | 20.22 b | 4.68 b | 7.60 b | 11.02 b | 70.95 c | 10.00b |
| $K_1$ | 6.86 | 15.35 a | 22.34a | 5.38 a | 8.71 a | 12.80 a | 84.82 b | 12.01 a |
| $K_2$ | 7.23 a | 15.81 a | 22.70 a | 5.41 a | 8.88 a | 12.71 a | 89.30 a | 12.47 a |
| $LSD_{(0.05)}$ | 0.345 | 0.717 | 0.692 | 0501 | 0.6110 | 0.563 | 4.170 | 08134 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 6.80 | 5.82 | 7.91 | 9.42 | 8.21 | 6.63 | 6.96 | 6.48 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ $ha^{-1}$
$K_2$: 100 kg $K_2O$ $ha^{-1}$

**Table-7: Combined effect of Effect of $GA_3$ and potassium on number & length of internodes and fresh & dry weight per plant of okra**

| Treatment | Number of internodes at | | | Length of internodes (cm) at | | | Fresh weight/ plant (g) | Dry weight/plant (g) |
|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS | | |
| $G_0K_0$ | 5.69 e | 12.89 e | 19.29 e | 3.81 c | 6.78 c | 11.13 b | 67.01 e | 9.45 e |
| $G_0K_1$ | 6.29 d | 14.22 d | 20.85 d | 4.71 b | 8.00 b | 12.11 ab | 77.41 d | 10.82 d |
| $G_0K_2$ | 6.65 cd | 14.79 cd | 21.02 d | 4.74 b | 8.08 b | 12.14 ab | 81.78 cd | 11.39 cd |
| $G_1K_0$ | 5.45 e | 12.19 e | 20.22 d | 5.05 b | 7.97 b | 12.07 ab | 66.82 e | 9.79 e |
| $G_1K_1$ | 7.52 ab | 16.30 ab | 23.62 ab | 5.74 a | 8.94 a | 13.17 a | 93.33 ab | 12.98 ab |
| $G_1K_2$ | 7.89 a | 16.89 a | 24.05 a | 5.74 a | 9.34 a | 12.86 a | 98.02 a | 13.56 a |
| $G_2K_0$ | 6.52 d | 14.25 d | 21.15d | 5.18 ab | 8.06 b | 12.56 a | 80.02 d | 10.75 d |
| $G_2K_1$ | 6.79 cd | 15.52 bc | 22.55 c | 5.69 a | 9.19 a | 13.12 a | 83.73 cd | 12.23 bc |
| $G_2K_2$ | 7.15 bc | 15.75 bc | 23.02 bc | 5.73 a | 9.22 a | 13.13 a | 88.10 bc | 12.46 b |
| $LSD_{(0.05)}$ | 0.565 | 1.062 | 0.934 | 0.575 | 0.742 | 0.980 | 7.231 | 0.951 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.01 | 0.01 | 0.05 |
| CV (%) | 6.80 | 5.82 | 7.91 | 9.42 | 8.21 | 6.63 | 6.96 | 6.48 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ $ha^{-1}$
$K_2$: 100 kg $K_2O$ $ha^{-1}$

### 4.8 Length of internodes

Length of internodes of okra varied significantly due to the effect $GA_3$ at 20, 40, and 60 DAS (Appendix VI). The highest length of internodes (5.53 cm, 8.82 cm and 12.93 cm) was obtained from $G_2$ which was statistically similar (5.51 cm, 8.75 cm and 12.70 cm) with $G_1$ at 20, 40 and 60 DAS, respectively, again at the same DAS, the lowest length of internodes (4.42 cm, 7.62 cm and 11.79 cm) was found from $G_0$ (Table 6).

Length of internodes of okra showed statistically significant variation for potassium at 20, 40 and 60 DAS (Appendix VI). At 20, 40 and 60 DAS the highest length of internodes (5.41 cm, 8.88 cm and 12.71 cm) was observed from $K_2$ which was statistically similar (5.38 cm, 8.71 cm and 12.80 cm) with $K_1$, respectively, whereas the lowest length of internodes (4.68 cm, 7.60 cm and 11.92 cm) was recorded in $K_0$ (Table 6).

$GA_3$ and potassium fertilizer showed statistically significant variation due to their combined effect of in terms of length of internodes of okra at 20, 40 and 60 DAS (Appendix VI). The highest length of internodes (5.74 cm, 9.34 cm and 12.86 cm) was found from $G_1K_2$ at 20, 40 and 60 DAS, respectively. On the other hand, the lowest length of internodes (3.81 cm, 6.78 cm and 11.13 cm) was observed from $G_0K_0$, respectively (Table 7).

### 4.9 Fresh weight of plant

Statistically significant difference was recorded for fresh weight of plant of okra for different growth hormone (Appendix VI). The highest fresh weight of plant (85.72 g) was obtained from $G_1$ which was statistically similar (83.95 g) with $G_2$, whereas the lowest weight (75.40 g) was found from $G_0$ (Table 6).

Potassium fertilizer differed significantly for fresh weight of plant of okra (Appendix VI). The highest fresh weight of plant (89.30 g) was recorded from $K_2$ which was closely followed (84.82 g) by $K_1$ whereas, the lowest weight (70.95 g) was found from $K_0$ (Table 6).

Combined effect of growth hormone and organic fertilizer showed statistically significant variation in terms of fresh weight of plant (Appendix VI). The highest fresh weight of plant (98.02 g) was recorded from $G_1K_2$, whereas the lowest weight (67.01 g) was recorded from $G_0K_0$ (Table 7).

### 4.10 Dry weight of plant

Dry weight of plant of okra showed statistically significant differences due to the effect of $GA_3$ (Appendix VI). The highest dry weight of plant (12.11 g) was found from $G_1$ which was statistically similar (11.81 g) with $G_2$, again the lowest weight (10.55 g) was obtained from $G_0$ (Table 6). Vijayaraghavan (1999) reported that 50 ppm gibberellic acid produced maximum total dry matter than the control.

Potassium fertilizer differed significantly for dry weight of plant of okra (Appendix VI). The highest dry weight of plant (12.47 g) was observed from $K_2$ which was similar (12.01 g) to $K_1$, while the lowest weight (10.00 g) found from $K_0$ (Table 6).

Statistically significant variation was recorded due to combined effect of $GA_3$ and potassium in terms of dry weight of plant (Appendix VI). The highest dry weight of plant (13.56 g) was obtained from $G_1K_2$. On the other hand, the lowest weight (9.45 g) was recorded from $G_0K_0$ (Table 7).

### 4.11 Days required to blooming

Days required to blooming of okra varied significantly for $GA_3$ (Appendix VII). The highest days required to blooming (48.13) was recorded from $G_0$, while the lowest days (44.24) was found from $G_1$ which was statistically similar (44.91) with $G_2$ (Table 8). Katung*et al*. (2007) reported that $GA_3$ affected the number of days to flowering.

Statistically significant variation was recorded for potassium in terms of days required to blooming of okra (Appendix VII). The highest days required to blooming (48.46) were obtained from $K_0$ while, the lowest days (42.24) was recorded from $K_1$ which was similar (44.58) to $K_2$ (Table 8).

Days required to blooming showed statistically significant variation due to combined effect of $GA_3$ and potassium in terms of (Appendix VII). The highest days required to blooming (51.02) were obtained from $G_0K_0$, again the lowest days (41.02) were found from $G_2K_1$ (Table 9).

### 4.12 Flower buds plant$^{-1}$

Flower buds/plant of okra showed significant differences for $GA_3$ (Appendix VII). The maximum flower buds plant$^{-1}$ (44.88) was recorded from $G_2$ which was statistically similar (44.00) with $G_1$. On the other hand, the minimum (37.20) was recorded from $G_0$ (Table 8).

Significant variation was recorded for flower buds plant$^{-1}$ of okra for the application of different levels of potassium fertilizer (Appendix VII). The maximum flower buds/plant (44.15) was observed from $K_1$ which was similar (43.68) to $K_{2,}$ while the minimum (38.24) was obtained from $K_0$ (Table 8).

Flower Buds/Plant showed statistically significant variation due to interaction effect of $GA_3$ and potassium in terms of (Appendix VII). The maximum flower buds plant$^{-1}$ (46.55) was observed from $G_1K_2$. On the other hand, the minimum (34.45) was found from $G_0K_0$ (Table 9 ).

### 4.13 Number of pods plant$^{-1}$

Statistically significant variation was recorded for pods plant$^{-1}$of okra due to the application of different levels of $GA_3$ (Appendix VII). The maximum pods plant$^{-1}$ (34.79) was recorded from $G_1$ which was closely followed (32.59) by $G_2$, whereas the minimum (25.32) was observed from $G_0$ (Table 8). Vijayaraghavan (1999) reported that 50 ppm gibberellic acid produced the highest fruits plant$^{-1}$.

Significant variation was recorded due to the application of different levels of on pods plant$^{-1}$ of okra (Appendix VII). The maximum pods plant$^{-1}$ (34.89) was found from $K_2$ which was similar (33.66) to $K_{1,}$ whereas the minimum (24.14) was recorded from $K_0$ (Table 8).

Statistically significant variation was recorded due to interaction effect of different levels of $GA_3$ and potassium on pods plant$^{-1}$ (Appendix VII). The maximum pods plant$^{-1}$ (40.62) was found from $G_1K_2$, again the minimum (21.72) was observed from $G_0K_0$ (Table 9).

### 4.14 Pxod length

Pod length of okra showed statistically significant differences for different levels of $GA_3$ (Appendix VII). The longest pod (18.68 cm) was observed from $G_1$ which was statistically similar (18.63 cm) with $G_2$. On the other hand, the shortest pod (16.35 cm) was found from $G_0$ (Table 8).

Potassium fertilizer differed significantly for pod length of okra (Appendix VII). The longest pod (18.74 cm) was observed from $K_2$ which was similar (18.24 cm) to $K_1$ whereas, the shortest pod (16.69 cm) was recorded from $K_0$ (Table 8).

Statistically significant variation was recorded due to combined effect of growth hormone and potassium in terms of pod length (Appendix VII). The longest pod (19.69 cm) was recorded from $G_1K_2$, while the shortest pod (14.85 cm) was recorded from $G_0K_0$ (Table 9).

### 4.15 Pod diameter

Significant variation was recorded for pod diameter of okra for different concentration of $GA_3$ (Appendix VII). The highest pod diameter (2.79 cm) was recorded from $G_1$ which was statistically similar (2.72 cm) with $G_2$,whereas the lowest pod diameter (2.35 cm) was recorded from $G_0$ (Table 8).

Pod diameter of okra showed statistically significant variation due to application of different levels of potassium (Appendix VII). The highest pod diameter (2.86 cm) was recorded from $K_2$ which was closely followed (2.76 cm) by $K_1$ whereas, the lowest pod diameter (2.24 cm) was found from $K_0$ (Table 8).

Combined effect of $GA_3$ and potassium fertilizer showed statistically significant variation in terms of pod diameter (Appendix VII). The highest pod diameter (3.13cm) was recorded from $G_1K_2$, whereas the lowest pod diameter (2.06 cm) was obtained from $G_0K_0$ (Table9).

### 4.16 Yield plant$^{-1}$

Yield plant$^{-1}$ of okra showed statistically significant differences due to application of different levels of $GA_3$ (Appendix VII). The highest yield plant$^{-1}$ (342.69 g) was observed from $G_1$ which was statistically similar (339.09 g) with $G_2$, whereas the lowest yield plant$^{-1}$ (289.36 g) was found from $G_0$ (Table 8). Munda *et al*. (2000) reported that $GA_3$ @ 100 ppm as seed treatment was found to be most effective for weight of pod plant$^{-1}$.

Potassium fertilizer differed significantly for yield plant$^{-1}$ of okra (Appendix VII). The highest yield plant$^{-1}$ (370.04 g) was found from $K_2$ which was statistically identical (360.97 g) with $K_{1,}$ while the lowest yield plant$^{-1}$ (240.13 g) was obtained from $K_0$ (Table 8).

Statistically significant variation was recorded due to combined effect of different levels of $GA_3$ and potassium fertilizer in terms of yield plant$^{-1}$ (Appendix VII). The highest yield plant$^{-1}$ (356.50 g) was obtained from $G_1K_2$, while the lowest yield plant$^{-1}$ (264.74 g) was observed from $G_0K_0$ (Table9).

### 4.17 Yield plot$^{-1}$

Yield plot$^{-1}$ of okra showed statistically significant differences for different growth hormone (Appendix VII). The highest yield plot$^{-1}$ (3.05 kg) was obtained from $G_1$ which was statistically similar (2.99 kg) with $G_2$,whereas the lowest yield plot$^{-1}$ (2.56 kg) was recorded from $G_0$ (Table 8).

Potassium fertilizer differed significantly for yield plot$^{-1}$ of okra (Appendix VII). The highest yield plot$^{-1}$ (3.30 kg) was recorded from $K_2$ which was statistically identical (3.26 kg) with $K_{1,}$ while the lowest yield plot$^{-1}$ (2.10 kg) was found from $K_0$ (Table 8).

Statistically significant variation was recorded due to combined effect of $GA_3$ and potassium fertilizer in terms of yield plot$^{-1}$ (Appendix VII). The highest yield plot$^{-1}$ (4.55 kg) was recorded from $G_1K_2$, while the lowest yield plot$^{-1}$(2.95 kg) was recorded from $G_0K_0$ (Table 9).

### 4.18 Yield hectare$^{-1}$

Different levels of $GA_3$ showed statistically significant variation for yield of okra (Appendix VII). The highest yield (17.69 ton ha$^{-1}$) was observed from $G_1$ which was statistically similar (17.51 tha$^{-1}$) with $G_2$, whereas the lowest yield (14.18 ton ha$^{-1}$) was attained from $G_0$ (Table 8). Our result as in agreement with the findings of Vijayaraghavan (1999) who reported that 50 ppm gibberellic acid produced the highest fruit yield of 15.7 $tha^{-1}$ and the control yield was 8.07 $tha^{-1}$. Surendra*et al*. (2006) also reported that $GA_3$ at 25 and 50 ppm (15.81 and 18.69 $tha^{-1}$) gave the highest fruit yields.

Statistically significant variation was recorded due to the application of potassium fertilizer for yield of okra (Appendix VII). The highest yield (19.13 $tha^{-1}$) was recorded from $K_2$ which was statistically identical (18.61 ton $ha^{-1}$) with $K_1$, while the lowest yield (11.64 $tha^{-1}$) was found from $K_0$ (Table 8).

**Table 8: Effect of $GA_3$ and potassium on yield contributing characters and yield of okra**

| Treatment | Days required for blooming | Number of Flower buds plant$^{-1}$ | Number of Pods plant$^{-1}$ | Pod length (cm) | Pod diameter (cm) | Yield (gm plant$^{-1}$) | Yield (kg plot$^{-1}$) | Yield (tha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **$GA_3$** | | | | | | | | |
| $G_0$ | 48.13 a | 37.20 b | 25.32 c | 16.55 b | 2.35 b | 289.36 c | 2.56 b | 14.18 b |
| $G_1$ | 44.24 b | 44.00 a | 34.79 a | 18.68 a | 2.79 a | 342.69 a | 3.05 a | 17.69 a |
| $G_2$ | 44.91 b | 44.88 a | 32.59 b | 18.63 a | 2.72 a | 339.09 b | 2.99 a | 17.51 a |
| LSD $_{(0.05)}$ | 2.281 | 1.138 | 1.880 | 0.695 | 0.889 | .0656 | 0.160 | 0.888 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Potassium fertilizer** | | | | | | | | |
| $K_0$ | 48.46 a | 38.24 b | 24.14 b | 16.69 b | 2.24 c | 240;13 c | 2.10 b | 11.64 b |
| $K_1$ | 44.24 b | 44.15 a | 33.66 a | 18.24 a | 2.76 b | 360.99 b | 3.26 a | 18.61 a |
| $K_2$ | 44.58 b | 43.68 a | 34.89 a | 18.74 a | 2.86 a | 370.04 a | 3.30 a | 19.13 a |
| LSD $_{(0.05)}$ | 2.282 | 1.136 | 1.900 | 0.698 | 0.088 | 1.875 | 0.166 | 0.889 |
| Level of significance | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 5.55 | 7.79 | 7.26 | 5.59 | 6.48 | 8.82 | 6.96 | 6.77 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

| | |
|---|---|
| $G_0$: Control (no $GA_3$) | $K_0$: Control (no fertilizer application) |
| $G_1$: 100 ppm $GA_3$ | $K_1$: 80 kg $K_2O$ ha$^{-1}$ |
| $G_2$: 120 ppm $GA_3$ | $K_2$: 100 kg $K_2O$ ha$^{-1}$ |

Due to the combined effect of different levels of $GA_3$ and potassium showed statistically significant variation on yield (Appendix VII). The highest yield (18.32 $tha^{-1}$) was recorded from $G_1K_2$, while the lowest yield (12.91 $tha^{-1}$) was observed from $G_0K_0$ (Table 9).

**Table 9. Combined effect of $GA_3$ and potassium on yield contributing characters and yield of okra**

| Treatment | Days required for blooming | Number of Flower buds plant$^{-1}$ | Number of Pods plant$^{-1}$ | Pod length (cm) | Pod diameter (cm) | Yield (gm plant$^{-1}$) | Yield (kg plot$^{-1}$) | Yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $G_0K_0$ | 51.02 a | 34.45 d | 21.72 e | 14.85 d | 2.06 e | 264.74 h | 2.95 d | 12.91 d |
| $G_0K_1$ | 46.69 b | 39.09. c | 26.99 d | 17.01 c | 2.45 d | 325.16 f | 3.78 b | 16.35 b |
| $G_0K_2$ | 46.68 b | 38.05 c | 27.25 d | 17.19 c | 2.56 d | 329.70 d | 3.93 b | 16.65 b |
| $G_1K_0$ | 42.69 bc | 39.09 c | 24.65 de | 17.85 | 2.20e | 291.41 e | 3.07 cd | 14.66 cd |
| $G_1K_1$ | 45.02 bc | 46.35 a | 39.09 ab | 18.51 | 3.03 ab | 351.83 b | 4.44 a | 18.15 a |
| $G_1K_2$ | 45.03 bc | 46.55 a | 40.62 a | 19.69 a | 3.13 a | 356.50 a | 4.55 a | 18.41 a |
| $G_2K_0$ | 51.69 a | 41.19 b | 26.05 d | 17.35 | 2.45 d | 289.61 g | 3.31 c | 14.57 c |
| $G_2K_1$ | 41.02 c | 47.02 a | 34.92 c | 19.19 a | 2.81 c | 349.73 c | 4.34 a | 18.06 a |
| $G_2K_2$ | 42.02 c | 46.42 a | 36.79 bc | 19.35 a | 2.89 bc | 354.56 a | 4.31 a | 18.32 a |
| LSD $_{(0.05)}$ | 3.951 | 1.991 | 3.231 | 1.207 | 0.155 | 1.993 | 0.278 | 1.560 |
| Level of | 0.01 | 0.05 | 0.01 | 0.05 | 0.01 | | 0.05 | 0.05 |
| CV (%) | 5.55 | 7.79 | 7.26 | 5.59 | 6.48 | 8.82 | 6.96 | 6.77 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

$G_0$: Control (no $GA_3$)
$G_1$: 100 ppm $GA_3$
$G_2$: 120 ppm $GA_3$

$K_0$: Control (no fertilizer application)
$K_1$: 80 kg $K_2O$ ha$^{-1}$
$K_2$: 100 kg $K_2O$ ha$^{-1}$

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was carried out in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka - 1207, Bangladesh during the period from April to September, 2020 to determine the performance of okra in response to $GA_3$ and potassium. BARI Dherosh1 was used as the test crop of this experiment. The experiment consisted of two factors: Factor A: $GA_3$ (three levels) as - $G_0$: Control (no $GA_3$ used),$G_1$: 100 ppm $GA_3$ and $G_2$: 120 ppm $GA_3$ and Factor B: Potassium (three levels) as - $K_0$: Control (No potassium application), $K_1$: 80 kg $K_2O$ $ha^{-1}$ and $K_2$: 100 kg $K_2O$ $ha^{-1}$. There were 9 (3 × 3) treatments combination. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameter, yield attributing characters and yield of okra was recorded and significant variation was recorded for all the characters that recorded.

At 20, 40 and 60 DAS the longest plant (15.80 cm, 73.44 cm and 90.22 cm) was recorded from $G_1$ ($GA_3$) from $G_1$ and the shortest plant (13.91cm, 64.98 cm and 79.55 cm) was measured from $G_0$ as control condition. The highest stem diameter (2.34 cm, 2.72 cm and 3.26 cm) was found from $G_1$, again, the lowest (2.19 cm, 2.54 cm and 2.94 cm) from $G_0$. The maximum number of leaves/plant (8.02, 29.23 and 49.75) was recorded from $G_1$, again the minimum number (6.68, 22.88 and 44.09) from $G_0$. The maximum number of branches/plant (3.05, 4.10 and 6.55)) was observed from $G_1$, while the minimum number (2.72, 3.80 and 5.98) was found from $G_0$. The highest length of petiole (14.14 cm, 26.78 cm and 29.90 cm) was recorded from $G_1$, while the lowest (12.61 cm, 22.96 cm and 26.61 cm) from $G_0$. The highest leaf area (44.88 $cm^2$, 56.89 $cm^2$ and 67.86 $cm^2$) was observed from $G_1$, while the lowest (36.67 $cm^2$, 52.27 $cm^2$ and 59.80 cm) was recorded from $G_0$. The maximum number of internodes/plant (6.95, 15.18 and 22.63) was recorded from $G_1$, whereas the minimum number (6.21, 13.96 and 20.39) was recorded from $G_0$. The highest length of internodes (5.53 cm, 8.82 cm and 12.93 cm) was obtained from $G_2$, again the lowest length (4.42 cm, 7.62 cm and 11.79 cm) from $G_0$. The highest fresh weight of plant (85.72 g) was obtained from $G_1$, whereas the lowest weight (75.40 g) from $G_0$. The highest dry weight of plant (12.11 g) was found from $G_1$, again the lowest weight (10.55 g) from $G_0$. The highest days required to blooming (48.13was recorded from $G_0$, while the lowest days

(44.24) from $G_1$. The maximum flower buds/plant (44.88) was recorded from $G_2$ and the minimum (37.20) from $G_0$. The maximum pods/plant (34.79) was recorded from $G_1$, whereas the minimum (25.32) from $G_0$. The longest pod (18.68 cm) was observed from $G_1$ and the shortest pod (16.35 cm) was found from $G_0$. The highest pod diameter (2.79 cm) was recorded from $G_1$, whereas the lowest (2.35 cm) from $G_0$. The highest yield per plant (342.69 g) was observed from $G_1$, whereas the lowest (290.38 g) from $G_0$. The highest yield per plot (3.05 kg) was obtained from $G_1$, whereas the lowest (2.56 kg) from $G_0$. The highest yield per hectare (17.69 ton) was observed from $G_1$,whereas the lowest (14.18 ton) from $G_0$.

At 20, 40 and 60 DAS the longest plant (16.67 cm, 77.93 cm and 90.70 cm) was recorded from $K_2$ again, the shortest plant (13.01 cm, 59.02 cm and 79.22 cm, from $K_0$. The highest stem diameter (2.38 cm, 2.79 cm and 3.39 cm) was observed from k2, while the lowest (2.13 cm, 2.50 cm and 2.66) from $K_0$. The maximum number of leaves/plant (8.08, 31.33 and 51.65) was found from $K_2$, whereas the minimum number (6.69, 20.12 and 41.80) from $K_0$. The maximum number of branches/plant (3.14, 4.14 and 6.73) was observed from $K_2$ again, the minimum number (2.59, 3.72 and 5.75) from $K_0$. The highest length of petiole (14.50 cm, 27.05 cm and 30.39 cm) was found from $K_2$, while the lowest (12.02 cm, 22.35 cm and 25.70 cm) from $K_0$. The highest leaf area (41.54 $cm^2$, 58.71 $cm^2$ and 68.04 $cm^2$) was found from $K_2$ again, the lowest (36.16 $cm^2$, 48.36 $cm^2$ and 58.83 $cm^2$) from $K_0$. The maximum number of internodes/plant (7.23, 15.81 and 22.70) was recorded from $K_2$ and the minimum number (5.89, 13.11 and 20.22) from $K_0$. The highest length of internodes (5.41 cm, 8.88 cm and 12.71 cm) was observed from $K_2$, whereas the lowest (4.68 cm, 7.60 cm and 11.92 cm) in $K_0$. The highest fresh weight of plant (89.30 g) was recorded from $K_2$ whereas, the lowest weight (70.95 g) from $K_0$. The highest dry weight of plant (12.47 g) was observed from $K_2$, while the lowest weight (10.00 g) from $K_0$. The highest days required to blooming (48.46) were obtained from $K_0$ while, the lowest days (42.24) from $K_1$. The maximum flower buds/plant (44.15) was observed from $K_{1,}$ while the minimum (38.24) from $K_0$. The maximum pods/plant (34.89) was found from $K_{2,}$ whereas the minimum (24.14) from $K_0$. The longest pod (18.74 cm) was observed from $K_2$, whereas the shortest pod (16.69 cm) from $K_0$. The highest pod diameter (2.86 cm) was recorded from $K_2$, whereas the lowest (2.24 cm) from $K_0$. The highest yield per plant (370.04 g) was found from $K_{2,}$ while the lowest (240.13 g) from $K_0$. The highest yield per plot (3.30 kg) was recorded from $K_{2,}$ while the lowest (2.10 kg) from $K_0$. The highest yield per hectare (19.13 ton) was recorded from $K_{2,}$ while the lowest (11.64 ton) from $K_0$.

At 20, 40 and 60 DAS the longest plant (18.34 cm, 85.41 cm and 97.22) was recorded from $G_1K_2$, respectively and the shortest plant (12.49 cm, 57.52 and 73.22 cm) from $G_0K_0$. The highest stem diameter (2.50 cm, 2.92 cm and 3.63 cm) was found from $G_1K_2$, whereas the lowest (2.04 cm, 2.43 and 2.55 cm) from $G_0K_0$, respectively. The maximum number of leaves/plant (8.69, 35.95 and 55.72) was obtained from $G_1K_2$ and the minimum (5.85, 19.39 and 42.12) from $G_0k_0$. The maximum number of branches plant$^{-1}$ (3.05, 4.10 and 6.55) was recorded from $G_1K_2$, whereas the minimum (2.72, 3.80 and 5.98) from $G_0k_0$. The highest length of petiole (14.14 cm, 26.78 cm and 29.90 cm was found from $G_1K_2$ and the lowest (14.14 cm, 26.78 cm and 29.90 cm) from $G_0k_0$. The highest leaf area (44.88 cm$^2$, 56.89 cm$^2$ and 67.86 cm$^2$ was recorded from $G_1k_1$ again, the lowest9(36.67 cm$^2$, 52.27 cm$^2$ and 59.80 cm$^2$) in $G_0k_0$. The maximum number of internodes/plant (6.95, 15.18 and 22.63) was recorded from $G_1k_2$, whereas the minimum number of internodes/plant (6.21, 13.96 and 20.39) from $G_0k_0$. The highest length of internodes (5.53 cm, 8.82 cm and 12.93 cm) was found from $G_1k_2$ and the lowest length of internodes cm (4.42 cm, 7.62 cm and 11.79 cm)) from $G_0k_0$. The highest fresh weight of plant (85.72 g) was recorded from $G_1k_2$, whereas the lowest (75.40 g) from $G_0k_0$. The highest dry weight of plant (12.11 g) was obtained from $G_1k_2$ and the lowest (10.55 g) from $G_0k_0$. The highest days required to blooming (48.13) was obtained from $G_0k_0$, again the lowest days (44.24) from $G_2k_1$. The maximum flower buds/plant (44.88) was observed from $G_1K_2$ and the minimum (37.20) from $G_0K_0$. The maximum pods/plant (34.79) was found from $G_1K_2$, again the minimum (25.32) from $G_0K_0$. The longest pod (18.68 cm) was recorded from $G_1K_2$, while the shortest (16.35 cm) from $G_0K_0$. The highest pod diameter (2.79 cm was recorded from $G_1K_2$, whereas the lowest (2.35 cm) from $G_0K_0$. The highest yield per plant (342.69 g) was obtained from $G_1K_2$, while the lowest (289.36 g) from $G_0K_0$. The highest yield per plot (3.05 kg) was recorded from $G_1K_2$, while the lowest (2.56 kg from $G_0K_0$. The highest yield per hectare (17.69 ton) was recorded from $G_1K_2$, while the lowest (14.18 ton) from $G_0K_0$. It is apparent from the above findings that the combination of $G_1K_2$ was more profitable than rest of the combination.

**CONCLUSION:**

From the above results, it can be concluded that among the different treatment combinations $G_1K_2$ treatment combination had the best significant positive effect on growth and yield of okra .

**RECOMMENDATION**:

Considering the situation of the present study, the following areas may be suggested for further studies:

1. In future trial other growth hormone with different concentration may be used.
2. Again potassium fertilizer with different doses may be used for further experiment.
3. The next experiment should be laid out at different agro-ecological zone of Bangladesh for better findings.

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# APPENDICES

**Appendix I. Soil Characteristics of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka**

## A. Morphological characteristics of the soil of experimental field

| Morphological features | Characteristics |
|---|---|
| Experimental site | Horticultural Farm , 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 | 28 |
| % Silt | 44 |
| % Clay | 31 |
| Textural class | Silty-clay |
| pH | 5.6 |
| Organic carbon (%) | 0.47 |
| Organic matter (%) | 0.80 |
| Total N (%) | 0.04 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 45 |

**Source**: SRDI

**Appendix II. Monthly record of air temperature, rainfall, relative humidity, rainfall and Sunshine of the experimental site during the period from April to September 2020**

| Month (2012) | *Air temperature (ºc) | | *Relative humidity (%) | *Rain fall (mm) | *Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| April | 33.5 | 23.5 | 69.5 | 164 | 6.5 |
| May | 34.6 | 25.8 | 70.27 | 186 | 7.7 |
| June | 33.4 | 25.4 | 81 | 228 | 5.5 |
| July | 35.2 | 22.4 | 67 | 298 | 5.9 |
| August | 31.6 | 18.6 | 64 | 101 | 6.3 |
| September | 33.6 | 23.6 | 69.20 | 163 | 6.1 |

* Monthly average,

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

**Appendix III. Analysis of variance of the data on plant height and stem diameter at days after sowing (DAS) as influenced by of $GA_3$ and potassium fertilizer**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plant height (cm) at | | | Stem diameter (cm) at | | |
| | | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| Replication | 2 | 0.231 | 2.178 | 0.703 | 0.0001 | 0.001 | 0.002 |
| $GA_3$ (A) | 2 | 9.090** | 206.931** | 300.399** | 0.063** | 0.102** | 0.242** |
| Potassium fertilizer (B) | 2 | 31.949** | 922.495** | 338.467** | 0.162** | 0.185** | 1.416** |
| Interaction (A×B) | 4 | 6.662** | 136.424** | 40.349* | 0.025** | 0.035** | 0.063** |
| Error | 16 | 0.947 | 18.856 | 14.020 | 0.004 | 0.005 | 0.009 |

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

**Appendix IV. Analysis of variance of the data on number of leaves and braches/plant at days after sowing (DAS) as influenced by of $GA_3$ and potassium fertilizer**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of leaves/plant at | | | Number of branches/plant at | | |
| | | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| Replication | 2 | 0.120 | 3.514 | 0.784 | 0.010 | 0.002 | 0.006 |
| $GA_3$ (A) | 2 | 5.126** | 93.138** | 95.957** | 0.255** | 0.230** | 0.983** |
| Potassium fertilizer (B) | 2 | 5.161** | 299.103** | 253.114** | 0.723** | 0.468** | 2.507** |
| Interaction (A×B) | 4 | 0.175* | 21.278* | 38.069** | 0.051* | 0.081** | 0.383** |
| Error | 16 | 0.058 | 10.148 | 3.207 | 0.028 | 0.004 | 0.038 |

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

**Appendix V. Analysis of variance of the data on length of petiole and leaf area at days after sowing (DAS) as influenced by of $GA_3$ and potassium fertilizer**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Length of petiole (cm) at | | | Leaf area ($cm^2$) at | | |
| | | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS |
| Replication | 2 | 0.010 | 0.282 | 0.545 | 0.778 | 4.864 | 5.564 |
| $GA_3$ (A) | 2 | 6.078** | 34.817** | 31.178** | 61.174** | 48.162** | 177.500** |
| Potassium fertilizer (B) | 2 | 15.929** | 55.128** | 63.089** | 70.668** | 272.024** | 249.118** |
| Interaction (A×B) | 4 | 2.526** | 9.004** | 1.284* | 13.997* | 16.955* | 38.939** |
| Error | 16 | 0.404 | 1.320 | 0.629 | 5.205 | 4.317 | 7.702 |

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

**Appendix VI. Analysis of variance of the data on number & length of internode at days after sowing (DAS) and fresh & dry weight per plant as influenced by of $GA_3$ and potassium fertilizer**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of internodes at | | | Length of internodes (cm) at | | | Fresh wt/ plant (g) | Dry wt/ plant (g) |
| | | 20 DAS | 40 DAS | 60 DAS | 20 DAS | 40 DAS | 60 DAS | | |
| Replication | 2 | 0.025 | 0.028 | 0.041 | 0.085 | 0.122 | 0.099 | 2.542 | 0.411 |
| $GA_3$ (A) | 2 | 1.419** | 4.242** | 12.946** | 3.649** | 4.088** | 3.256** | 274.23** | 6.161** |
| Potassium fertilizer (B) | 2 | 4.349** | 18.796** | 16.152** | 1.525** | 4.320** | 2.101** | 823.86** | 15.585** |
| Interaction (A×B) | 4 | 0.918** | 2.875** | 1.320** | 1.637* | 4.032** | 2.081** | 152.94** | 1.188** |
| Error | 16 | 0.106 | 0.381 | 0.291 | 0.110 | 0.183 | 0.318 | 17.499 | 0.301 |

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

**Appendix VII. Analysis of variance of the data on yield contributing characters and yield as influenced by of $GA_3$ and potassium fertilizer**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Days required for blooming | Flower buds/plant (No.) | Pods/plant (No.) | Pod length (No.) | Pod diameter (cm) | Yield ( g $plant^{-1}$) | Yield (kg/plot) | Yield (t/ha) |
| Replication | 2 | 4.593 | 2.414 | 0.614 | 0.173 | 0.018 | 172.76 | 0.015 | 0.455 |
| $GA_3$ (A) | 2 | 38.926** | 158.938** | 220.893** | 15.963** | 0.489** | 7992.67** | 0.612** | 18.874** |
| Potassium fertilizer (B) | 2 | 49.583** | 97.037** | 311.414** | 10.968** | 1.084** | 47345.36** | 3.741** | 115.48** |
| Interaction (A×B) | 4 | 39.380** | 2.949* | 24.628** | 0.511* | 0.073** | 1053.99* | 0.083* | 2.561* |
| Error | 16 | 6.258 | 1.299 | 3.502 | 0.487 | 0.008 | 325.479 | 0.026 | 0.802 |

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance