# EFFECT OF SOWING TIME AND $GA_3$ ON GROWTHAN YIELD OF OKRA

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# *CERTIFICATE*

*This is to certify that thesis entitled, "**EFFECTOF SOWING TIME AND GA3 ON GROWT AND YIELD OF OKRA** 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 bona fide research work carried out by **, SOHERA KHANAM** Registration No. **16-07564** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

**Dated: December, 2017**
**Place: Dhaka, Bangladesh**

……………………………….

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## ABSTRACT

The experiment was conducted at the horticultural research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from April to August 2017 to study the effect of sowing time and $GA_3$ on the growth and yield of okra. Two factors was considered for the present study such as four levels of gibberellic acid ($GA_3$) *viz*. $G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$ and $G_3$ = 100 ppm $GA_3$ and three levels of sowing time *viz*. $S_1$ = 15 April 2017, $S_2$ = 30 April 2017 and $S_3$ = 15 May 2017. The experiment was laid out in Randomized Complete Block Design with three replications. Most of the studied parameters showed significant influence affected by gibberellic acid and time of sowing and their combination. The highest performance was found at the application of $G_2$ and lowest performance was found at the application of $G_0$. In terms of sowing time, highest performance was found at okra seed sown at $S_2$ and lowest performance was found at $S_3$. For combined effect the treatment combination of $G_2S_2$ showed the highest number of branch (5.00), dry weight (13.40%), fruit (11.60 cm), diameter of fruit (8.96 cm), number of flowers (35.50), fruits plant$^{-1}$ (22.60) and fruit yield ha$^{-1}$ (18.90 t). But the highest plant height (123.00 cm), highest number of leaves plant$^{-1}$ (29.10 cm), highest leaf length (50.43 cm), highest leaf breadth (30.00 cm), highest length of petiole (29.88 cm), highest stem diameter (3.50 cm) and highest length of internodes (7.33 cm) was found from $G_3S_1$. In terms of economic analysis, the highest BCR (3.12) was obtained from $G_2S_2$. Application of 80 ppm $GA_3$ and 30 April seed sowing was best for growth and yield of okra.

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**ABBREVIATIONS AND ACRONYMS**

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| cm | = | Centimeter |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan's Multiple Range Test |
| *et al.*, | = | And others |
| e.g. | = | exempli gratia (L), for example |
| etc. | = | Etcetera |
| FAO | = | Food and Agricultural Organization |
| g | = | Gram (s) |
| i.e. | = | id est (L), that is |
| Kg | = | Kilogram (s) |
| LSD | = | Least Significant Difference |
| $m^2$ | = | Meter squares |
| ml | = | MiliLitre |
| M.S. | = | Master of Science |
| No. | = | Number |
| SAU | = | Sher-e-Bangla Agricultural University |
| var. | = | Variety |
| $^oC$ | = | Degree Celceous |
| % | = | Percentage |
| NaOH | = | Sodium hydroxide |
| GM | = | Geometric mean |
| mg | = | Miligram |
| P | = | Phosphorus |
| K | = | Potassium |
| Ca | = | Calcium |
| L | = | Litre |
| µg | = | Microgram |
| USA | = | United States of America |
| WHO | = | World Health Organization |

# CHAPTER I

# INTRODUCTION

Okra [*Abelmoschus esculentus* (L.)Moench] is a popular vegetable belongs to the family Malvaceae and locally known as "Dherosh" or "Bhindi". It is also known as Lady's finger. It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Tahkur and Arora, 1986). It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1990). Okra is specially valued for its tender and delicious edible pods which is rich source of vitamins and minerals. Tender green pods of okra contains approximately 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). The pods have some medicinal value with mucilaginous preparation which may used as plasma replacement or blood volume expander (Savello*et al.,* 1980). In Bangladesh the total production of okra is about 246 thousand tons which was produced from 7287.5 hectares of land in the year 2010 with average yield about 3.38 t/ha which is very low (BBS, 2011) compared to that of other developed countries where the yield is as high as 7.0-12.0 t/ha (Yamaguchi, 1998). In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during kharif season and around 70% in the rabiseason (Yamaguchi, 1998). Therefore, as vegetable okra can get an importance in kharif season as well as summer season in our country context.

Okra is used as fresh, cooked or as chemical addition to the soups, salads and stews. Because of its sensitivity to storage, fresh okras are preserved mostly by freezing or in some countries fruits are dried for later use. Okra provides some amount of vitamins, dietary fiber, energy and minerals (Adom *et al.*, 1997).

Plant growth regulators like auxins, gibberellins and cytokinins are used in the agriculture for better growth and yield responses ultimately affecting crop production (Briant, 1974; Srivastava and Sachan, 1971). Gibberellins (GAs) mediate many responses in plants from seed germination to the senescence

(Davies, 1995). The most widely available compound is a gibberellic acid ($GA_3$) which induces stem and internode elongation, seed germination, enzyme production during germination, and fruit setting and growth (Dijkstra and Kuiper, 1989; Ross *et al*., 1990; Davies, 1995).$GA_3$ is a natural growth hormone and is a part of a type of plant hormones called gibberellins. $GA_3$ promotes cell division and a number of plant development mechanisms and encourages numerous desirable effects such as plant height, uniform flowering, reduced time to flowering and increased flower number and size (Srivastava and Srivastava, 2007). Foliar application of gibberellic acid also modified plant growth and pod characteristics (Asghar *et al*., 1997).

Gibberllic acid ($GA_3$) has potentiality to control growth and flowering process its application also increase petiole length, leaf area (Mehraj *et al*., 2013), delayed petal abscission (Khan, 2006 and Emongor, 2004) and yield also (Islam, 2014) that used in agriculture since long ago (Naeem, 2001). Gibberellin induces cell elongation, development of fruit and flowering. It increase the size and number of fruit and break the dormancy of seed, buds and underground organ like bulb, tuber, corm, etc. It increases the size and number of flower and growth of stem in light, i.e. revival of light inhibited stem growth and increase the size of leaves (Islam, 2014).

Planting date is the most important factor that affects the physiological and morphological properties of plants (Akramghaderi, 2003) and has played an important role in seed production and quality of okra (Yadev and Dhankhar, 2002). Planting date is the most important factor that affects the physiological and morphological properties of plants (Khajehpour, 2000) and has played an important role in seed production and quality of okra (Hossain, 1999; Yadev and Dhankhar, 2002). Okra crop is sensitive to cold and cannot tolerate low temperatures for long periods (Miri, 2006). Monthly mean optimum temperature range for growth, flowering and pod development of this plant is reported between 21-30°C while the minimum and maximum temperature for growth of this plant were 18 and 35°C (Abd El-Kader, 2010). Therefore, the optimal planting time is necessary to attain the optimal yield. Mondal *et al*. (1989) stated that okra planting in April, compared with June, leading to the plant height and fruit yield was higher. Changing the planting date of okra is one of the main reasons for the difference in seedling emergence, survival, and vigor (Gadakh, 1990). Ezeakunne (2004) stated that yield components of okra such as the pod number, pod length, pod size, pod weight and yield is higher partially when the plant is cultivated earlier. In a study on five okra cultivars and three different sowing dates ($18^{th}$ May, $28^{th}$ May and $8^{th}$ June), the largest number of pod harvest and pods per plant, maximum fruit diameter, plant height and yield per hectare were obtained in $28^{th}$ May (Hussain, 2006). In another experiment, the effect of sowing date on yield and yield components of okra in Bangladesh between February and May, the highest seed yield was obtained on 15 April, whereas the highest seed quality belonged to planting date of $15^{th}$ March (Moniruzzaman, 2007). Dilruba *et al.*, (2009) examined the effects of planting dates ($22^{th}$ March, $6^{th}$ April and $21^{th}$ April) on yield and yield components of okra in Bangladesh and reported that the pod number and yield were significantly affected by planting dates, so that the highest yield at planting date of $6^{th}$ April and the lowest value was obtained on $22^{th}$ March.

Under the above circumstances, the present research was undertaken to study the effect of sowing time and $GA_3$ on the growth and yield of okra. Considering the above facts, the present study was under taken with the following objectives:

1. To study the effect of sowing time on growth and yield of okra.
2. To determine the effect of gibberellic acid on growth and yield of okra.
3. To find out the suitable combination of gibberellic acid and sowing time on growth and yield of okra.

# CHAPTER II
# REVIEW OF LITERATURE

In various physiological and biochemical process in plant, the role of gibberellic acid and sowing time are well known. Gibberellic acid is a growth regulator. The plant growth regulators are known to effect right from seed germination to senescence either by enhancing growth or by reducing the plant height, flowering, fruit development, fruit ripening and seed yield. Various production factors like sowing time are also well known to influence growth, yield, and seed quality parameter in okra. Hence, the reviews on these aspects on related and other crops have also been included along with the reviews on okra.

## 2.1 Effect of Gibberellic acid ($GA_3$)

The Gibberellic acid ($GA_3$) is widely used phytohormone in horticulture and food industry. Gibberellins enhance biological activity in stimulating cell division or cell elongation, early flowering, fruit set, fruit growth, and seed germination etc. today 72 forms of gibberellins are known and commercialy available gibberellins are $GA_3$, $GA_4$, $GA_7$ (Taiz, 2010).

Sanodiya *et al*. (2017) conducted an investigation entitled, "Effect of growth regulator on growth, yield and seed quality parameters of okra (*Abelmoschus esculentus* L.) cv. Utkal Gaurav.". Foliar spray two growth regulator like $GA_3$, NAA were spray at different concentration and $20^{th}$, $40^{th}$, $60^{th}$ day after sowing. Result revealed foliar spray is significantly positive impact on growth regulator in growth parameters i.e. $T_4$ (NAA 50 @ ppm at 20days spray) was first flowering (31.47 days), 50 percent flowering (40.40 days), first harvesting (37.02 days), minimum days to fruit maturity (66.02 days), yield parameter $T_5$ (NAA 50 ppm at 40 days spray) maximum fruit weight (16.47 gm.), dry fruit weight (5.61 gm.), fruit length (16.58 cm), fruit girth (6.46 cm), fruit yield per plot (4.83 kg), yield per hectare (96.63 q/ha.), and seed quality parameter $T_6$ (NAA @ 50 ppm spray at 60 DAS) recorded maximum root length (9.40cm), fresh seedling weight (6.43 g), dry seedling weight (26.77mg) and Vigour index type-I and II (2210.29 and 22.58) and as compare to other treatment and $T_9$ (control).

Chormule *et al*. (2017) conducted an investigation entitled "Effect of spacing and plant growth regulators on plant growth parameters, seed yield and its attributes of okra [*Abelmoschus esculentus* (L.) Moench]" with two consecutive seasons (kharif 2015 and kharif 2016). Seeds of okra variety GJO-3 were treated with aqueous solution of growth regulators *viz*., $GA_3$, IBA and NAA, each at 50, 100 and 150 ppm concentrations and without growth regulators (water soaking) and with three plant spacing ($S_1$ : 45 cm × 30 cm, $S_2$ : 60 cm × 30 cm and $S_3$ : 60 cm × 45 cm). All plant growth parameters, seed yield and its attributes studied were significantly influenced by different plant spacing and application of different plant growth regulators. Interactions effects of spacing and seed treatments (S x T) with growth regulators were found significant for field emergence, number of branches per plant, fruit length and fruit thickness during kharif 2015; for fruit length and fruit thickness during kharif 2016; and for field emergence in pooled over years. A combination of wider plant spacing 60 cm x 45 cm and $GA_3$ @ 150 ppm was found best suited combination, as it has good field emergence and produced significantly and/or comparatively the maximum plant height, stem diameter, number of branches per plant, number of fruits per plant, fruit length, fruit thickness, number of seeds per fruit and seed yield per plant.

Singh *et al*. (2017) conducted a field experiment during the kharif season to study the effect of $GA_3$ and NAA on yield and quality of Okra. Yield parameters like number of fingers harvested per plant, average weight of finger, yield per plant, yield per plot and yield per hectare and quality parameters like total number of pickings, thickness of finger and length of finger were analyzed. The experiment consisted of 16 treatments combination involving two growth regulators with four levels each (0, 25, 50 and 75 ppm). $GA_3$ and NAA (75 ppm) was found to be the most effective in increasing more number of fingers harvested per plant (15.10), total number of pickings (9.33) and thickness of finger (1.54 cm). Treatment combinations of ($GA_3$ 75 and NAA 50 ppm) increased average weight of finger (16.28 g) and yield per plant (0.232 g). Maximum length of finger (15.82 cm) was found treatment combinations of ($GA_3$ and NAA 50 ppm each).

Tomar *et al.* (2016) showed that the combinatorial use of $GA_3$, NAA and 2, 4-D at specific concentration ($GA_3$ at 30 ppm, NAA at 30 ppm and 2, 4-D at 5 ppm) considerably increase the weight of fruit and significantly increases total yield up to 523 q/h in tomato.

Chandiniraj *et al.* (2016) reported that maximum plant height (75.60 cm), plant spread in north-south direction (46.53 cm), number of days to flowering (47.56) and maximum fruit diameter (1.24 cm) were recorded in GA3 60 ppm treated plants in chilli.

Krishnaveni *et al.* (2016) revealed maximum yield attributes like number of pods per plant, length of pod and seed yield per plant were recorded with single pinching at 25 DAS and application of GA3 50 ppm in fenugreek.

Thomson *et al.* (2015) examined the effect of plant growth substances on growth, flowering, yield and economics of garden pea, *(Pisum sativum)* L cv. Bonneville. Plants were sprayed with treatments *viz* control, NAA at (25 and 50 ppm), GA3 at (50 and 100 ppm), the results revealed that the plant growth substance GA3 at (100 ppm) showed highest growth parameters. Days to first flowering ranged between 48.97 and 52.75. The minimum days (48.97) to first flowering were taken by the treatment GA3 at (100 ppm) and all other treatments were *statistically at par* for the days taken to first flowering.

Bello (2015) revealed that the okra seeds were pre-soaked GA3 at (100 ppm) for 3-4 hours observed that increase the plant height, number of leaves, leaf Area and dry matter (yield) in okra.

Rathod *et al.* (2015) reported that the maximum plant height (34.53 cm), plant spread (31.46 cm), number of leaves per plant (15.73) and number of branches per plant (7.66) in treatment where GA3 at 200 ppm was applied, while minimum plant height (25.93 cm), plant spread (24.70 cm), number of leaves per plant (11.66) and number of branches per plant (5.20) respectively observed in the treatment in Cycocel 200 ppm, in French bean.

Njogu *et al.* (2015) reported that foliar application of GA3 causes significant increase in subsequent germination, enhances vegetative growth, average number of stems, leaflets number and more yields in potato.

Ravat and Makani (2015) reported that among the different treatments $GA_3$ @ **100** ppm was the best for growth characters *viz*., plant height (cm), number of leaves, number of internodes per plant, days to flower initiation and days to 50 (%) flowering. While the start sprayed with thiourea @ 500 ppm yielded the best for growth characters *viz*. leaf area ($cm^2$), leaf area index and total dry weight of the plant. Ravat and Makani (2015) also reported that among the different treatments $GA_3$ @ 50 ppm was the best for seed quality traits *viz*., average pod weight, 100 seed weight, while the plants sprayed with thiourea @ 500 ppm best for fruit yield traits viz., number of pods per plant, length of pod, number of seeds per pod, seed yield per plant and seed yield per hectare.

Mehraj *et al.* (2015) found that the tallest plant (89.0 cm), longest petiole (29.0 cm), number of leaves (49.0 per plant), leaf area (29.7 $cm^2$), number of branches (5.5 per plant), fresh weight (84.5 g/plant) and dry weight (10.9 g/plant) was from $G_1$ ($GA_3$50 ppm) which was statistically identical with $G_2$ (NAA 50 ppm) while minimum from $G_0$ (control fresh water). The maximum number of pods (33.4/plant), pod length (17.5 cm), pod diameter (1.7 cm) and fruit yield (338.1 g/plant, 2.9 kg/plot and 16.4 t/ha) were also recorded from $G_1$ (50 ppm $GA_3$) which was statistically identical with $G_2$ (50 ppm NAA) while minimum from control. $GA_3$ and NAA have the potentiality to increase the yield of okra but $GA_3$ was found to be most effective in the present study.

Samapika *et al.* (2015) reported that the treatment of $GA_3$ 20 ppm + NAA 100 ppm was significantly superior in terms of growth parameters *i.e.* vine length (cm), number of primary branches per plant and number of leaves per plant as compared to control and other applied treatments in cucumber. Treatment $GA_3$ 20 + NAA 100 ppm was also produced highest fruit yield of cucumber as compared to control.

Prajapati and Varma (2014) reported that application of GA3 at 50 ppm to the maximum number of branches (5.52) and minimum days taken for initiation of flower (48.50 day) in sweet pepper.

Chowdhury *et al.* (2014) reported that the combined use of 100 ppm $GA_3$ and 11.5 t/ha poultry manure produced the tallest plants in okra. Both the growth regulators and organic manures enhanced early flowering. The highest fruit yield (16.67 t/ha) was recorded from 100 ppm $GA_3$ followed by 1000 ppm miraculan (16.49 t/ha). The highest yield (18.03 t/ha) of okra was found from poultry manure, closely followed by vermicompost (17.59 t/h). Considering the treatment combinations, the highest yield was harvested from 100 ppm $GA_3$ + poultry manure (19.62 t/ha) followed by 100 ppm $GA_3$ + vermicompost (19.01 t/h), 1000 ppm miraculan + vermicompost (18.42 t/h) and 1000 ppm + poultry manure (18.30 t/h), respectively.

Mohammadi *et al.* (2014) found that $GA_3$ application increased okra plant height irrespective of cultivar and $GA_3$ concentration (50 and 100 mg per liter), but without increasing flower induction or pod set. He also concluded that the germination was promoted, inhibited or not affected by $GA_3$. It was also found that $GA_3$ had no effect on pod dimensions or more than 100 seed weight. Similarly, $GA_3$ application did not consistently affect seed moisture content, but it did however, increase the number of seeds per pod. Overall, pod and seed characteristics were affected more by harvest time then by $GA_3$ application.

Moniruzzaman *et al.* (2014) reported that the $GA_3$ (Gibberellic acid) and NAA (Naphthalene acetic acid) had no significant effect on plant height and stem diameter at the end of the crop period and days to 100% flowering. NAA 40 ppm produced highest percentage of long and medium styled-flower, leaf photosynthesis and Fv/Fm (efficiency of photosystem II). The variety BARI Begun-5 was earlier to 100% flowering which took 44 days after transplanting which out yielded BARI Begun-10. NAA 40 ppm coupled with BARI Begun-5 gave the maximum Fv/Fm and long-styled flower percent.

Kumar *et al.* (2014) studied that gibberellic acid plants treated with the application of $GA_3$ @ 50 ppm showed an increased plant height, number of leaves, number of fruits, fruit weight, ascorbic acid and total soluble solids in tomato.

Shahid *et al.* (2013) conducted an experiment with different concentrations (0, 50, 100 & 200 ppm) of gibberellic acid ($GA_3$) and naphthalene acetic acid (NAA), alone or in different combinations were sprayed on okra plants at 2-true leaf stage, to ascertain their impact on plant growth, pod production, seed yield and seed quality. All variables regarding vegetative and reproductive growth were significantly influenced by different concentrations of the growth regulators except number of days taken to flowering. Growth regulators were less effective when applied individually as compared to their combined use; however, 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. These results signify the role of $GA_3$ and NAA in okra pod production for fresh consumption as well as for seed yield.

Ayyub *et al.* (2013) revealed that the increase in number of foliar application of $GA_3$ (100 mg/kg) substantially improved the vegetative growth of okra comparing to control plants. It was found that application at different growth stages of okra predominantly boosted the stem elongation and number of leaves per plant, number of pods per plant, number of seeds per pod, seed weight and seed yield. Therefore it can be concluded that foliar application of $GA_3$ may be an effective strategy for maximizing the growth and yield of okra.

Prasad *et al.* (2013) found that there was a linear increase in growth parameters like plant height and number of branches per plant with increasing level of $GA_3$ and NAA. The maximum plant height was recorded as 85.3 cm and 82.3 cm with the application of $GA_3$ @ 80 ppm and NAA @ 100 ppm, respectively after 60 days of transplanting in tomato. The maximum fruit yield (483.6 q/ha and 472.2 q/ha) was obtained with the use of 80 ppm $GA_3$ and 100 ppm NAA, respectively in tomato.

Shahid *et al.* (2013) reported that growth regulators were less effective when applied individually as compared to their combined use however performance of plant treated with individual PGR was the better than untreated plants. The numbers of pods per plant, 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. These results signify the role of $GA_3$ and NAA in okra pod production for fresh consumption as well as for seed yield.

Choudhury *et al. (2013)* observed that maximum plant height at 60 DAT (86.01cm), number of flowers cluster per plant (10.60), number of flowers per plant (39.69), number of fruits per plant (36.54), single fruit weight (74.01 g) and yield (28.40 t/ha ) were found the minimum for all the parameters in tomato were found in control.

Sure *et al.* (2012) observed that the spraying with GA3 at 25 ppm in four leaf stage at trellis method could be a suitable for enhancing growth and yield in medicinal pumpkin.

Singh *et al.* (2012) found that the Application of 160 ppm GA3 resulted in minimum number of days of first flowering (37.13) and days to 50% flowering.

Dhage *et al.* (2011) found that significant effect for plant height (107.74 cm) and intermodal length (3.1 cm) in treatment $GA_3$ at 150 ppm whereas, numbers of branches (3.53) were found maximum in the treatment IAA at 100 ppm. However, significantly minimum numbers of days required for first flowering

(39.67 days) were recorded in treatment $GA_3$ at 150 ppm in okra. Significant effect for minimum number of days required for first harvesting (44.67 days) were also recorded in treatment $GA_3$ at 150 ppm in okra. The significantly maximum parentage of fruit set (74.79) and fruit yield per hectare were observed in same treatment.

Bhagure and Tambe (2011) observed application of GA3 (50 and 100 ppm) at 30 and 45 days after sowing increase the height of plant, number of leaves, number of internodes, induce early flowering, increase number of flowers, fruit set, number of fruits, and high yield per plant in okra.

Hilli *et al.* (2010) reported the spraying of GA3 @ 50 ppm at four leaves stage, flower stage and fruit initiation stage significantly improved the vine length and Maximum vine length and number of branches recorded in ridge gourd.

Unamba *et al.* (2010) reported that the effect of low concentrations (0,1,5,10,20 and 30 ppm) of gibberellic acid on the growth of *Abelmoschus esculentus*(dwarf) and showed that gibberellic acid significantly stimulated internode elongation, plant height, number of leaves and caused a reduction in the petiole length in both treatment methods. Gibberellic acid also stimulated earlier flowering. The foliar spray application was found to have a significant effect on the plant height when compared with the seed soaking application technique. Although GA**3** stimulated internode elongation, it had no effect on the number of internodes in both the treated plants and the control indicating that dwarfism of this variety of Okra may be due to the absence of adequate endogenous gibberellic acid.

Patil and Patel (2010) reported that $GA_3$ at 15 mg/l produce the highest percentage of seed germination, stem girth, number of branches, number of leaves per plant and early flowering in okra while $GA_3$ at 45 mg/l found to be beneficial with respect to plant height, number of internodes and intermodal length. $GA_3$ at 15 mg/L recorded maximum fruit girth, fruit length, fruit weight, fruit yield per plant and fruit yield per hectare in okra. However, $GA_3$ at 30 mg/L produced maximum number of fruits per plant. From the economics point of view, NAA 10 mg/L was found to be profitable as compared to rest of treatments.

Fathima and Balasubramanian (2006) reported that the effect of plant growth regulators like gibberelic acid (GA) and naphthalene acetic acid (NAA) on the quality of best fibres in *A. esculentus*. The fibre quality was best in GA100 + NAA 50 micro gram per ml treatment. Fibre macerate studies showed an increase in fibre length and the slenderness ratio was also high. Proximate analysis of retted fibres re-vealed lower moisture and ash content and an increase in wax content. The physico-mechanical properties showed considerable improvement of fibre quality. Considering the above criteria, GA100 + NAA 50 micro gram per mL treatment brought about advantageous changes for improving the quality of fibers.

Surendra *et al.* (2006) revealed that the growth regulators and micronutrients used in this experiment significant increased the plant height. However, among the growth regulators significant increase in plant height was noticed with $GA_3$ (25 and 50 ppm) and among micronutrients $FeSO_4$ (0.5%) has shown significant increase in plant height. Among the growth regulators and micronutrients the foliar application of $GA_3$ (25 and 50 ppm) and $FeSO_4$ (0.5%) at 60 days after sowing (DAS) registered significantly higher fresh fruit yield over other treatments. The increase is due to increase in yield attributing components *viz.*, total number of flowers, fruits per plant, fruit length, number of seeds per fruit, seed weight and harvest index. The benefit: cost ratio was higher with application of $GA_3$ (50 ppm) over all other treatments. It was also indicated that the increase in fruit yield was significantly higher in $GA_3$ (25 and 50 ppm) as compared to other treatments and was found lowest in control.

Sharma (2006) reported in Brinjal cultivar of Pusa Purple Long produced significantly higher yield at 40 ppm NAA than at $GA_3$ at 10 ppm and 30 ppm BAP while, the yields at other treatments were at par.

## 2.2 Effect of sowing time

Sonu *et al*. (2017) conducted an experiment with a view to study the influence of sowing time and plant geometry on plant growth and yield of okra. Four dates of sowing in each season *viz*., 10 June, 24 June, 8 July and 22 July 2009 and 2010 and three plant geometries *viz*., 60 x 30 cm, 60 x 45 cm and 60 x 60 cm and two varieties *viz*., Parbhani Kranti and Pusa A-4 were considered for the experiment. The plant growth and vigour which was evident from greater plant height, pod development, seed size and yield obtained in the crop sown on $10^{th}$ and $24^{th}$ June. Seed yield is correlated with the performance of yield contributing attributes and a perusal of data pertaining to seed yield components *viz*. percent fruit set, number of pods per plant, pod length, pod thickness, number of seeds per pod revealed that the environment was more favourable for okra seed production when the crop was sown on $10^{th}$June and $24^{th}$ June which were found superior in seed yield and its components over rest of the sowing dates.

Bake *et al*. (2017) conducted a field experiment to find out the individual as well as the interaction effects along with the suitable combinations of sowing date and planting distance to evaluate the growth, yield, and quality of okra (*Abelmoschus esculentus* L.) during the year 2015 and 2016. Among the different treatments intermediate spacing (60×60cm) with $D_3$ ($30^{th}$ June sowing) performed better than other treatments for most of the growth, flowering, yield, and quality characteristics, followed by closer spacing (60×45cm) with $D_3$ ($30^{th}$ June sowing).

Atallah (2016) conducted a field experiment to evaluate the response of okra sowing date and variety on growth and yield. Two sowing dates i.e. April 15 and May 15 and five varieties i.e. Balady Assiut, Balady Qena, Emerald, Golden Coast and Pusa Sawani were studied during 2011 and 2012 seasons. From the results it was noticed that the fruit number and fruit yield significantly affected by sowing date and variety. In case of sowing on $15^{th}$ April, the highest fruits yield was (8.577 and 8.146 ton/feddan) in both seasons. However $15^{th}$ May sowing date produced the lowest fruits yield (4.227 and

4.005 ton/feddan). Pusa Sawani cv produced the highest yield of okra in two sowing dates (12.341, 6.632 and 11.904, 6.365 ton/feddan) in both seasons, respectively. Determination of optimum sowing date is considered an important to have optimum yields. Results shown that varities, Golden Coast and Pusa Sawani produced higher fruits yield on 15$^{th}$ May than Balady Qena cv sown on 15$^{th}$ April..

Elhag and Ahmed (2014) conducted this study during two consecutive years (2008/2009) and the effects of three sowing dates, 1$^{st}$ and 20$^{th}$ of July and 10$^{th}$ of August on seed yield of two okra cultivars (Khartoumia and Wad Gammer) were studied. Both vegetative growth (50% flowering) and seed yield (after pod drying) were evaluated. The results showed that late sowing (20$^{th}$ of July and 10$^{th}$ of August) had significant negative effects on both vegetative growth and seed yield of both cultivars in both years. The best vegetative growth and seed yield were obtained at 1$^{st}$ of July. Almost similar negative response of both cultivars to late sowing was noticed. It could be concluded that both okra growth and seed yield were significantly negative affected by late sowing (last week of July or later). Although no significant differences were noticed between the two cultivars in their response to sowing date okra cultivars might differ in their response to sowing date.

Asadipour and Madani (2014) conducted an experiment to evaluate the effects of irrigation intervals and planting dates on fresh pod yield and yield components of okra. Irrigation treatment at three levels (5 days, 7 days and 10 day intervals) and planting dates were applied at five levels (30$^{th}$ April, 7$^{th}$ May, 14$^{th}$ May, 21$^{st}$ May, 28$^{th}$ May). In this experiment, traits of stem length, stem diameter, number of branches per plant, number of leaves per plant, pod length, number of pods per plant and fresh pod yield were measured. The effect of planting date on the means of all traits were significant; so that delayed planting date from 30$^{th}$ April to 14$^{th}$ May, increased all means of above mentioned traits significantly and then to 28$^{th}$ May showed a decreasing trend. The highest fresh pod yields were obtained on 14$^{th}$ May (10235 kg ha$^{-1}$) and 5 days irrigation interval (9993.5 kg ha$^{-1}$).

Ekwu and Nwokwu (2012) conducted a field trial to investigate the effect of plant spacing and planting dates on the growth and yield of okra (*Abelmoschus esculentus*). Three plant spacings (50cm×25cm, 50cm×50cm and 50cm×75cm) and three planting dates (15$^{th}$ May, 15$^{th}$ June and 15$^{th}$ July) were used as treatments. The earliest sowing date (15$^{th}$ May) produced the tallest and most profusely branched plants (13.79), highest number of leaves (31.68), number of pods (22.91) and length of pods (16.09cm). The 15$^{th}$ July sowing gave least values in all the vegetative parameters measured except plant height and number of days to 50% anthesis (flowering).

Chattopadhyay *et al*. (2011) conducted field trials to find out the most suitable sowing time to achieve higher yield, and quality seed of okra over four consecutive years having seven sowing times at fortnight interval(1$^{st}$ February, 16$^{th}$ February, 1$^{st}$ March, 16$^{th}$ March, 1$^{st}$ April, 16$^{th}$ April and 1$^{st}$ May). The seed yield attributing characters differed significantly with different sowing dates. The maximum matured pods per plant (14.57) and the longest matured pod (18.00 cm) was observed from 1$^{st}$ April sowing which was statistically similar with that of number and length recorded between16thFebruary and 1$^{st}$ May sowing dates. However, seeds sown in 16$^{th}$ February significantly produced the highest mean seed yield (6.84 q/ha) followed by 1$^{st}$ March (6.18 q/ha) sowing over the years. Seeds sown in either 16$^{th}$ February or 1$^{st}$ March produced the best quality seed (85.30 and 80.0% germination; 45.0 and 44.0 g test weight 29.75; 11.79 and 11.64 vigour index, respectively). Correlation study clearly revealed that seeds per pod and test weight significantly contributed to the seed yield. The income per rupee investment of okra seed crop was found to be the maximum (2.40) when sown at 2$^{nd}$ fortnight of February.

Joy (2010) carried a research to study the effect of sowing date on productivity of okra (*Abelmoschus esculentus* L. Moench) variety 'V-25' and identify the optimal sowing date. The treatments consisted of three sowing dates (late June, mid-July and early August). The results showed that early flowering and greater pod length, pod diameter, number of pods per plant and pod weight were recorded for the late June sowing. Okra yield was observed to reduce as sowing dates advanced. The yield produced from the late June sowing was significantly ($P< 0.05$) greater by 12.3% and 11.1% respectively, in 2008 and 2009 compared to that obtained from the mid-July sowing and by 22.8% and 25.9% respectively, in 2008 and 2009 compared to that produced from the early August sowing. Actual or potential application of findings: This study showed that to maximize okra yield, the optimal sowing date would be late June for variety 'V-25'.

Dilruba *et al*. (2009) conducted a field experiment to evaluate the response of sowing time and hormones on growth and yield of okra. The experiment consisted of three sowing time i.e. March 22, April 06 and April 21 and four hormones treatments i.e. Control, Alga Gold, Crop care and Ripen-15. From the results it was noticed both the fruit number and fruit yield significantly affected by sowing time and hormones. In case of sowing times, 06 April sowing produced the highest yield (13.88 t $ha^{-1}$) and 22 March sowing produced the lowest yield (10.22 t $ha^{-1}$).

Moniruzzaman *et al*. (2007) conducted a field experiment on okra cv. BARI Dherosh$^{-1}$ comprising four sowing times starting from February to May (15$^{th}$ day of each month) at monthly interval and four spacings (60 × 30, 60 × 40, 60 × 50, and 60 × 60 cm) to find out the most suitable sowing time and optimum plant spacing. The highest seed yield (2.97 t/ha) was recorded from 15 April sowing closely followed by 15 March sowing (2.77 t/ha) whereas the best quality seed was obtained from 16 February (88.7% germination and 29.75 seed vigour index) and 15 March (83.7% germination and 28.80 seed vigour index) sowing. 15 April sowing accompanied with 60 × 30 cm spacing gave the highest seed yield (3.13 t/ha) closely followed by 60 × 30 cm spacing with the same sowing time (3.06 t/ha). The seed yield did not decline in 15 March sowing having similar spacings.

Firoz *et al*. (2007) conducted an experiment to find out the effect of planting time (1$^{st}$ week of June, July, August and September) and plant spacing (60 × 30 cm, 60 × 40 cm and 60 × 50 cm) on the yield and yield components of okra in hill slope condition during rainy season. The highest yield (12.53 t/ha) was obtained by the planting in July which was at par with June (11.69 t/ha). The treatment combination July sowing with 60 × 30 cm plant spacing produced significantly highest yield (12.86 t/ha).

Naz *et al*. (2007) conducted the research under natural field conditions to determine the effect of sowing dates and cultivars on mortality through disease. Different sowing dates *viz*. 20$^{th}$ March, 4$^{th}$ April, 19$^{th}$ April and 4$^{th}$ May and five okra cultivars *viz*. Sabzpari, Irkabinabirka, Sharmely, Anmol and Evergreen, being tested. The interaction was also significant. SabzPari suffered the minimum plant mortality (28.3%) when sown on 19$^{th}$ April. This cultivar registered the greatest yield (5.0 Kg plot$^{-1}$), plant height (110.8 cm), pod length (16.4 cm), fresh shoot weight (313.8 g plant$^{-1}$) and dry shoot weight (194.8 g plant$^{-1}$).

Hussain *et al.* (2006) conducted an experiment in order to study the response of okra cultivars to different sowing times, during summer 2005. The crop was sown in three different sowing dates with 10 days interval i.e. 18$^{th}$ May, 28$^{th}$ May and 8$^{th}$June, 2005. Maximum number of picking (27.80), number of pods per plant (26.22), fruit diameter (1.46cm), plant height (1.48m), yield per hectare (14.57 tons) was recorded when sown on 28 May, 2005. Minimum days to emergence (10.93) and days to first picking (75.60) was observed when different okra cultivars sown on 08 June, 2005.

Sharif *et al.* (2003) conducted an experiment with okra to evaluate the effect of sowing dates on its performance. In both the year of 1999 and 2000 the yield attributed and yield was found to be greatly affected by sowing dates. In both of the cases sowing of okra in mid-April gave the better results.

Sajjan *et al.* (2002) concluded that okra sown on 15 July performed the highest yield attributes of branches per plant, fruits per plant, 100-seed weight, length and girth of fruits, processed seed recovery and processed yield (1139.7 kg ha$^{-1}$) in the kharif season. However, for the 15 November sowing, the highest seed yield of 745.3 kg ha$^{-1}$ was recorded.

Yadav *et al.* (2002) evaluated the effects of sowing date (5 and 15 March; 14 April; 14 and 24 May; 13 June; 3 and 23 July; and 12 August) on the seed yield and quality of okra (cv. Varsha Uphar) were studied in Hisar, Haryana, India, during 1997-98. Crops sown on 13 June gave the highest number of seeds per fruit (48.30), seed yield (17.18 q $ha^{-1}$), test weight (64.86 g), standard germination (90.33%), seedling length (27.6 cm), vigour index (2516), germination percentage after AA test (80.61%), and electrical conductivity of seed leachates (8.50 phos $cm^{-1}$ $seed^{-1}$).

Amjad *et al.* (2001) reported that maximum germination percentage was observed when crop was sown on either 25 April or 5 May. Plant height, number of days to flower and length of green pod were not affected by the sowing dates. Number of leaves per plant, number of pods per plant and green pod yield were higher when crop was sown on 15 April or 5 May. Germination percentage, number of days to flower and length of green pods were not influenced by the interaction between sowing time and fertilizer rate. Maximum plant height, number of leaves per plant, number of pods per plant and green pod yield were recorded when the crop was sown on 5 May and given the highest rate of fertilizers (150 kg N + 80 Kg $P_2O_s$ $ha^{-1}$).

Gulshan *et al.* (2001) studies the perfonnance of three okra cultivars, viz. ParbhaniKaranti, PusaSawni and Punjab-7, under three sowing dates (16 June, 29 June 29 and 12 July) were conducted in Himachal Pradesh, India during the kharif season of 1996-97. PrabhaniKranti obtained the highest green pod yield (85.9 q $ha^{-1}$), followed by PusaSawni (80.4 q $ha^{-1}$) and Punjab-7 (72.5 q $ha^{-1}$). Punjab-7 exhibited the lowest yellow vein mosaic virus infection (0.3%), while PusaSawni showed the highest (41.4%). Sowing of okra on 16 June produced the highest pod yield (92.1 q $ha^{1}$); the green pod yield decreased by 9.95 and 33.37% for 29 June and 12 July sowing dates, respectively. The first sowing date (16 June) was the most favourable in promoting plant growth and green pod yield, while sowing on 12 July was the least. PrabhaniKranti sown on 16 June produced the highest green pod yield (101.8 $qha^{-1}$).

Passam *et a1.* (1998) studied okra cultivars Boyiatiou and Veloudo cultivated for seed. They reported that flowering and production occurred in waves, with optimum quality and satisfactory yield being obtained from sowing in March, although the number and weight of seeds per pod were significantly higher in later sowings.

Raghav (1996) reported the greatest plant height and highest fruit yield when okra crop was sown on 1$^{st}$ March as compared to the crops sown on 21 February, 11 March and 21 March.

Bisen *et al.* (1994) reported that under Jabalpur conditions the best yield of okra fruits and seeds per plant were obtained from plants sown on 20$^{th}$ June as compared to 5$^{th}$July, 20$^{th}$ July or 4$^{th}$ August sowing.

Bhuibhar *et al.* (1989) reported that in cv. PusaSawani higher seed yield and better quality seed was obtained when the crop was sown on 4$^{th}$ July as compared to the sowing of 19$^{th}$ July and 3rd August.

Palanisamy and Ramasamy (1987) reported that the correlation of temperature and day length that prevailed during the vegetative and reproductive phases with the number of flowers and fruits per plant, seed germination and seedling vigour were significant and positive.

# CHAPTER III
# MATERIALS AND METHODS

The experiment was carried out during the period from April to August 2017. The materials and methods that were used for conducting the experiment have been presented in this chapter.

## 3.1 Location of the experimental site

The experiment was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in 24°09′N latitude and 90°26′E longitudes. The altitude of the location was 8 m from the sea level.

## 3.2 Experimental site and climatic condition

Experimental location is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Experimental site and details of the meteorological data during the period of the experiment were collected and presented in Appendix I and II respectively.

## 3.3 Soil characteristics of the experimental site

Selected land of the experimental field was medium high land in nature with adequate irrigation facilities and remained utilized for crop production during the previous season. The soil is belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The soil texture of the experimental soil was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in the Soil Resources Development Institute (SRDI) Dhaka, and result have been presented in Appendix III.

### 3.4 Planting materials

The test crop used in the experiment was BARI Dherosh-1.

### 3.5 Collection of seeds

The seeds of okra variety were collected from BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur, Bangladesh.

### 3.6 Treatment of the experiment

**Factor A: Gibberellic acid ($GA_3$) - 4 levels**

1. $G_0$ = 0 ppm $GA_3$
2. $G_1$ = 60 ppm $GA_3$
3. $G_2$ = 80 ppm $GA_3$
4. $G_3$ = 100 ppm $GA_3$

**Factor B: Sowing time - 3 levels**

1. $S_1$ = 15 April 2017
2. $S_2$ = 30 April 2017
3. $S_3$ = 15 May 2017

**Treatments combinations:** 12 (4×3) treatment combinations
$G_0S_1$, $G_0S_2$, $G_0S_3$, $G_1S_1$, $G_1S_2$, $G_1S_3$, $G_2S_1$, $G_2S_2$, $G_2S_3$, $G_3S_1$, $G_3S_2$, $G_3S_3$.

### 3.7 Land preparation

The plot selected for conducting the experiment was opened before one week of seed sowing in the field with a power tiller, and left exposed to the sun. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for sowing okra seeds. The soil was treated with insecticides (Cinorab3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

### 3.8 Application of manure and fertilizers

Urea, Triple super phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1.

The total amount of cowdung, TSP and MP was applied as basal dose at the time of final land preparation. Urea was applied at 15, 30 and 45 days after sowing (DAS).

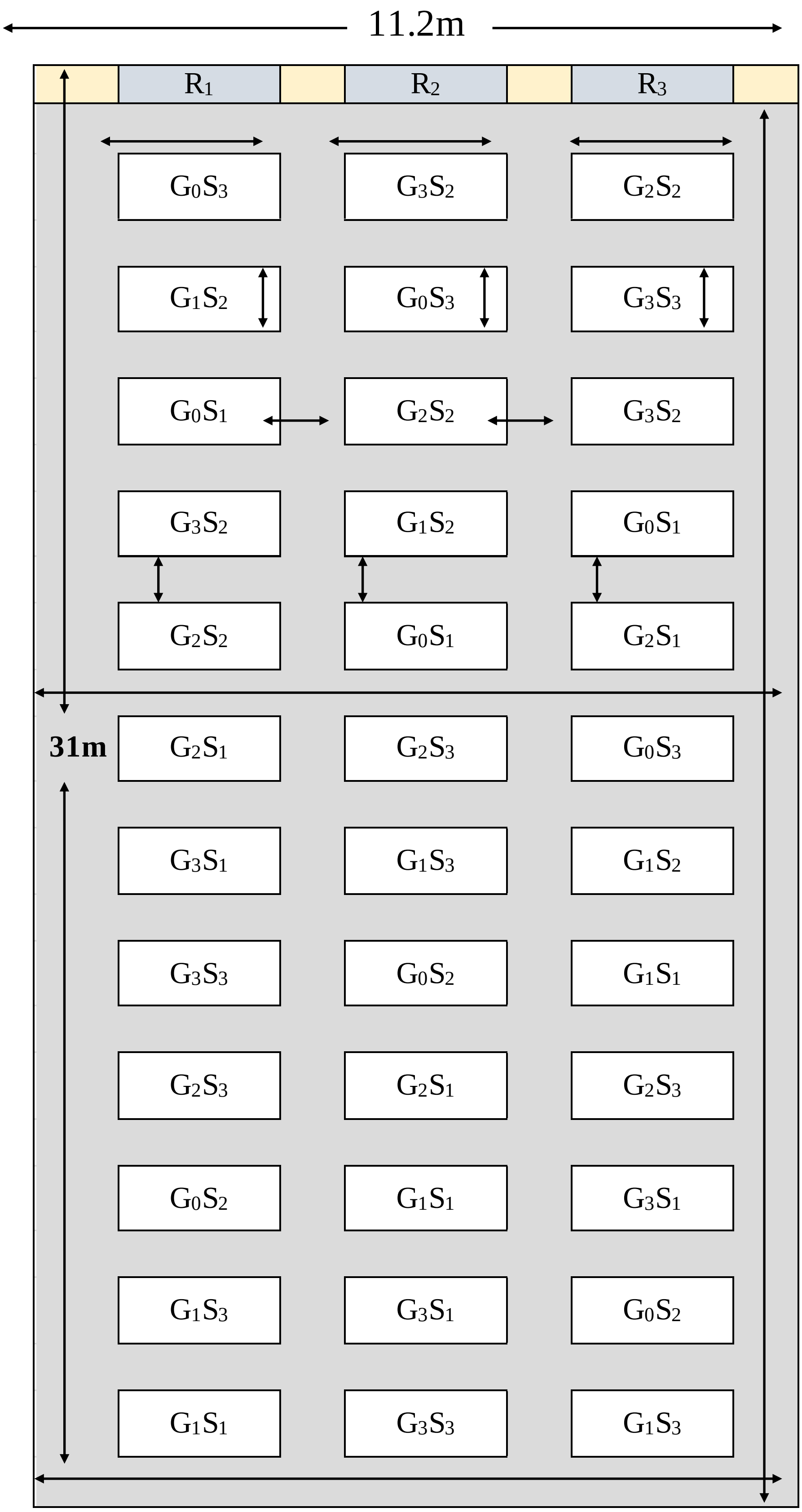
Table 1. Dose and method of application of fertilizers in okra field

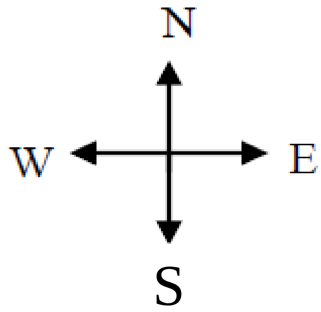
| **Fertilizers** | **Dose/ha** |
|---|---|
| Cowdung | 10 t/ha |
| Urea | 150 kg/ha |
| TSP | 100 kg/ha |
| MOP | 150 kg/ha |

Source: Recommendation Guide, BARC, 2016)

**3.9 Design and layout of the experiment**

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.4 × 1.5 m. The distance maintained between two blocks and two plots were 1.0 and 0.5 m, respectively. The spacing was at 60 × 50 cm. The layout of the experimental plot is shown in Figure 1.




Plot size= 2.4x1.5cm$^2$
Row to Row = 50 cm
Plant to Plant= 60 cm
**Replication= 3**

**Factor A: Gibberellic acid ($GA_3$) - 4 levels**

1. $G_0$ = 0 ppm $GA_3$
2. $G_1$ = 60 ppm $GA_3$
3. $G_2$ = 80 ppm $GA_3$
4. $G_3$ = 100 ppm $GA_3$

**Factor B: Sowing time - 3 levels**

1. $S_1$ = 15 April 2017
2. $S_2$ = 30 April 2017
3. $S_3$ = 15 May 2017

**No. of Plant/ plot:** 12

Figure 1. Layout of the experiment field

### 3.10 Seeds sowing

The okra seeds were sown in the main field as per treatment. Seeds were treated with Bavistin @ 2ml/L of water before sowing the seeds to control the seed borne diseases. The seeds were sown in rows having a depth of 2-3 cm with maintaining distance from 50 cm and 60 cm from plant to plant and row to row, respectively. So there were 12plants were accommodated in each plot.

### 3.11 Preparation and application of $GA_3$

The $GA_3$ solution of 60, 80 and 100 ppm concentration were prepared by dissolving 60, 80 and 100 mg/litre$GA_3$, respectively. At the time of preparation of $GA_3$ solution 1-2 drops of 0.5-1.0 N NaOH was used to dissolve properly. Distilled water was used as control solution (0 ppm). Gibberellic acid was applied in the field with hand sprayer. Gibberellic acid was obtained from BDH Chemicals Ltd. Poole, England.

### 3.12 Intercultural operation

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

#### 3.12.1 Gap filling

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

#### 3.12.2 Weeding

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

### 3.12.3 Irrigation

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

### 3.12.4 Pest and disease control

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

## 3.13 Harvesting

Fruits were harvested at 5 days interval based on eating quality at soft and green condition. Harvesting was started at eating quality level regarding sowing time.

## 3.14 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except yields of plots, which was recorded plot wise. Data were collected in respect of the growth, yield attributes and yields as affected by different treatments of the experiment.

### 3.14.1 Plant height (cm)

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem of five plants and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

### 3.14.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

### 3.14.3 Leaf length (cm)

Length of leaf was measured from sample plants in centimeter from the one side to another side of leaf of the longest five leaves and mean value was calculated. Plant height was recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days.

### 3.14.4 Leaf breadth (cm)

Leaves of selected plants were detached and leaf breadth was measured in centimeter (cm) by a meter scale at 20, 40, 60 and 80 days after sowing (DAS).

### 3.14.5 Length of petiole (cm)

Length of petiole was measured from the longest petiole of 5 sample plants in centimeter and mean value was calculated. Length of petiole was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of the plants.

### 3.14.6 Stem Diameter (cm)

Stem diameter was measured from sample plants with a digital calipers-515 (DC-515) from the three different parts of five plants and mean value was calculated. Stem diameter was recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

### 3.14.7 Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

### 3.14.8 Length of internode (cm)

Length of internode was measured from 5 sample plants in centimeter and mean value was calculated. Length of internode was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

### 3.14.9 Length of fruit (cm)

The length of fruit was taken when the plant attained at 60 DAS and was measured with a meter scale from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

**3.14.10 Diameter of fruit (cm)**

Diameter of fruit was taken when the plant attained at 60 DAS after picking the fruits and was measured at the middle portion of 10 selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

**3.14.11 Dry weight of leaves (%)**

After taking fresh weight the sample it was sliced into very thin pieces and put into envelop then placed in oven maintained at 70°C for 72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. The final dry content was taken by following formula:

$$\text{Dry matter content of leaves} = \frac{\text{Dry weight of leaves (g)}}{\text{Fresh weight of leaves (g)}} \times 100$$

**3.14.12 Days required for 1st flowering**

Number of days required from sowing to first flower opening was counted and average value was recorded.

**3.14.13 Number of flower per plant**

The number of flower buds per plant was counted from the sample plants and the average numbers of flower buds produced per plant were recorded.

**3.14.14 Number of fruits per plant**

The number of fruits per plant was counted from the sample plants for the whole growing period and the average number of fruits produced per plant was recorded and expressed in fruits per plant.

**3.14.15 Fresh weight of fruits/plant (g)**

The weight of fresh fruits were measured with a digital weighing machine from 5 selected plants from each selected plots and there average was taken and expressed in gram.

### 3.14.16 Dry weight of fruits (%)

After taking fresh weight of 100 g sample it put into envelop then placed in oven maintained at 70°C for 72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. Data was taken with different samples and average dry weight was expressed in percent (%).

### 3.14.17 Yield per plot

Yield of okra per plot was recorded as the whole fruit per plot by a digital weighing machine for the whole growing period and was expressed in kilogram.

### 3.14.18 Yield per hectare

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

### 3.15 Statistical analysis

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

### 3.16 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of nitrogen and phosphorus fertilizer. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of okra was considered for estimating the cost and return.

Analyses were done according to the procedure of Alam*et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

# CHAPTER IV

# RESULTS AND DISCUSSION

The results of the study regarding the effect of sowing time and $GA_3$ on growth and yield of Okra have been presented and possible interpretations have been made in this chapter which is given below:

## 4.1 Growth parameters

### 4.1.1 Plant height

**Effect of gibberellic acid ($GA_3$)**

There was a significant variation on plant height of okra influenced by different levels of Gibberellic acid ($GA_3$) application at different growth stages (Fig. 2 and Appendix IV). It was remarked that the longest plant (14.44, 53.99, 87.60 and 114.80 cm at 20, 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$). The shortest plant (11.60, 40.33, 66.29 and 92.30 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$).Similar resultson plant height was also observed by Chormule *et al*. (2017) and Mehraj *et al.* (2015).

**Effect of sowing time**

Plant height of okra was significantly influenced by different sowing time at different growth stages (Fig. 3 and Appendix IV). Results indicated that the longest plant (13.61, 50.42, 82.17 and 108.19 cm at 20, 40, 60 and 80 DAS, respectively) was achieved by the sowing time $S_1$ (15 April 2017)whereasthe shortest plant (12.62, 45.92, 72.70 and 100.49 cm at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017). At 20 DAS, plant height from sowing time $S_1$ (15 April 2017) was statistically identical with the sowing time $S_2$ (30 April 2017).Similar trend of results was also found by Sonu *et al*. (2017), Shahid*et al*. (2015) and Ekwu and Nwokwu (2012).

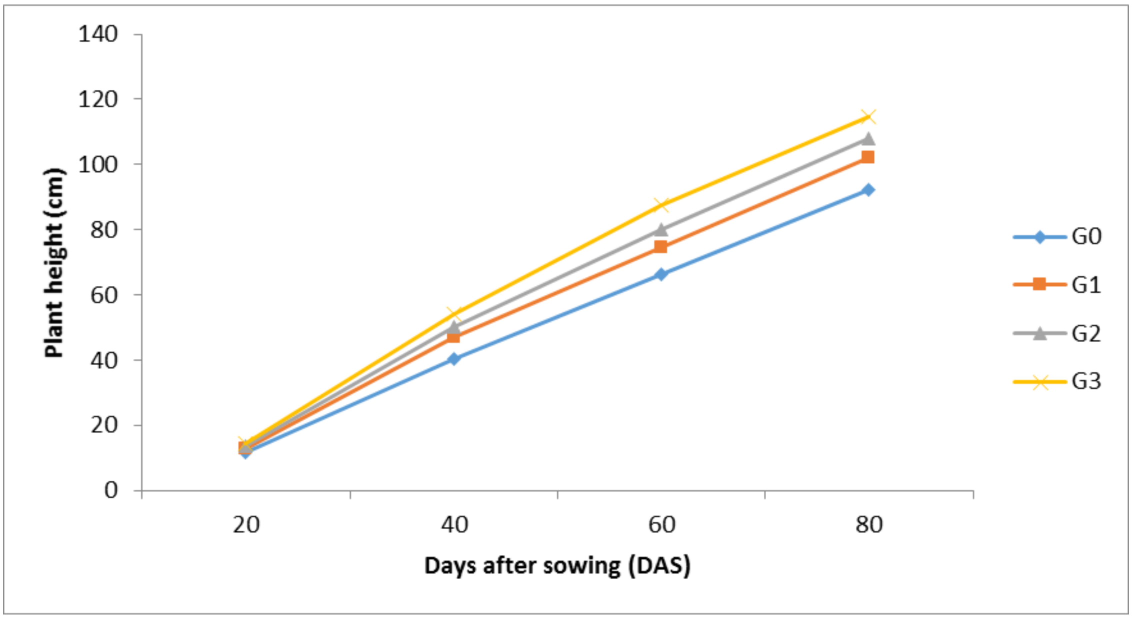



Fig. 2.Effect of gibberellic acid on plant height of okra

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

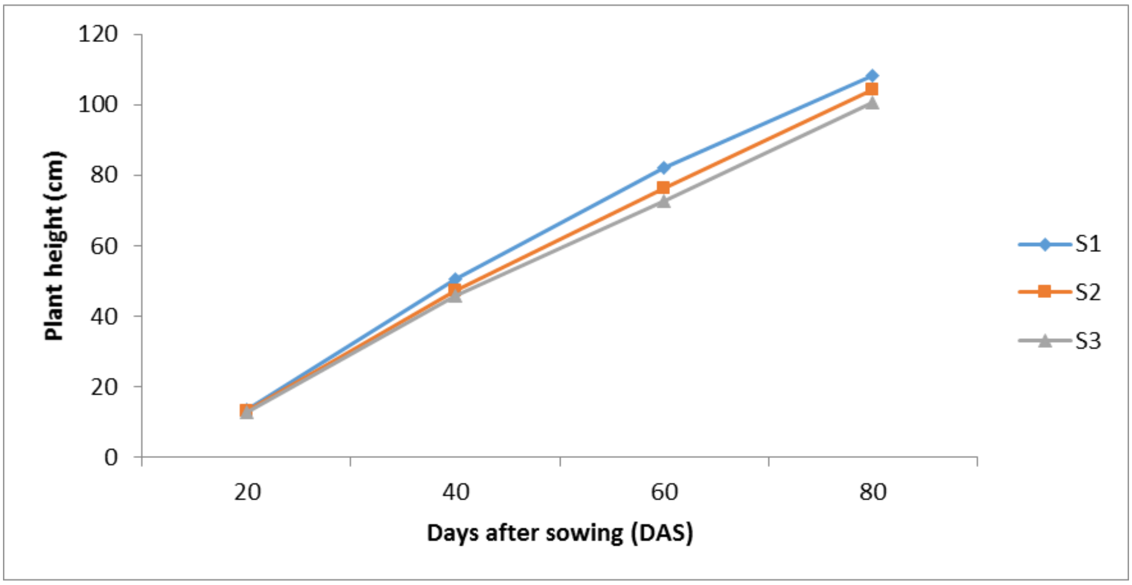



Fig. 3.Effect of sowing time on plant height of okra

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

**Combined effect of $GA_3$ and sowing time**

Significant variation was observed on plant height of okra at different growth stages influenced by combined effect of $GA_3$ and sowing time (Table 2 and Appendix IV). It was observed that plant height among the treatment combinations at 20 DAS was not significant. Results revealed that the highest plant height (14.93, 59.73, 98.80 and 123.0 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$ followed by the treatment combination of $G_3S_2$. Again, the shortest plant (10.53, 38.93, 59.13 and 87.03 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$ followed by $G_0S_1$ and $G_0S_2$.

Table 2.Combined effect of sowing time and $GA_3$ acid on plant height of okra

| Treatment | Plant height (cm) | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| $G_0S_1$ | 12.40 | 42.00 ef | 71.27 f | 95.03 h |
| $G_0S_2$ | 11.87 | 40.05 f | 68.47 g | 94.83 h |
| $G_0S_3$ | 10.53 | 38.93 f | 59.13 h | 87.03 i |
| $G_1S_1$ | 13.10 | 48.53 bc | 76.40 e | 104.9 ef |
| $G_1S_2$ | 12.80 | 46.87 cd | 73.80 f | 102.7 f |
| $G_1S_3$ | 12.47 | 45.13 de | 73.27 f | 98.67 g |
| $G_2S_1$ | 14.00 | 51.40 b | 82.20 bc | 109.8 bc |
| $G_2S_2$ | 13.60 | 50.47 b | 79.33 d | 107.8 cd |
| $G_2S_3$ | 13.47 | 48.80 bc | 78.20 de | 106.6 de |
| $G_3S_1$ | 14.93 | 59.73 a | 98.80 a | 123.0 a |
| $G_3S_2$ | 14.40 | 51.40 b | 83.80 b | 111.7 b |
| $G_3S_3$ | 14.00 | 50.83 b | 80.20 cd | 109.7 bc |
| $LSD_{0.05}$ | NS | 3.234 | 2.550 | 2.643 |
| CV.(%) | 4.183 | 8.319 | 6.224 | 10.523 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

**4.1.2 Number of leaves plant$^{-1}$**

**Effect of gibberellic acid ($GA_3$)**

Number of leaves plant$^{-1}$ was significantly varied due to different levels of gibberellic acid ($GA_3$) application at different growth stages (Fig. 4 and Appendix V). It was found that $GA_3$ application at higher rate showed higher number of leaves plant$^{-1}$. The highest number of leaves plant$^{-1}$(8.28, 22.60, 25.67 and 27.81 cm at 20, 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$) followed by the treatment $G_2$ (80 ppm $GA_3$) where the lowest number of leaves plant$^{-1}$(7.15, 17.18, 21.09 and22.83 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$). The results obtained from the present study was similar with the findings of Ravat and Makani (2015), Samapika *et al.*(2015), Mehraj *et al.*(2015) and Patil and Patel (2010).

**Effect of sowing time**

Remarkable variation was observed on number of leaves plant$^{-1}$ at different growth stages influenced by different sowing time of okra (Fig. 5 and Appendix V). Highest number of leaves plant$^{-1}$(7.87, 20.95, 24.24 and26.61 cm at 20, 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) followed by the sowing time $S_2$ (30 April 2017). The lowest number of leaves plant$^{-1}$(7.65, 18.34, 22.75 and24.38 cm at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017). Asadipour and Madani (2014), Ekwu and Nwokwu (2012) and Amjad *et al.* (2001) also found similar results which supported the present study.

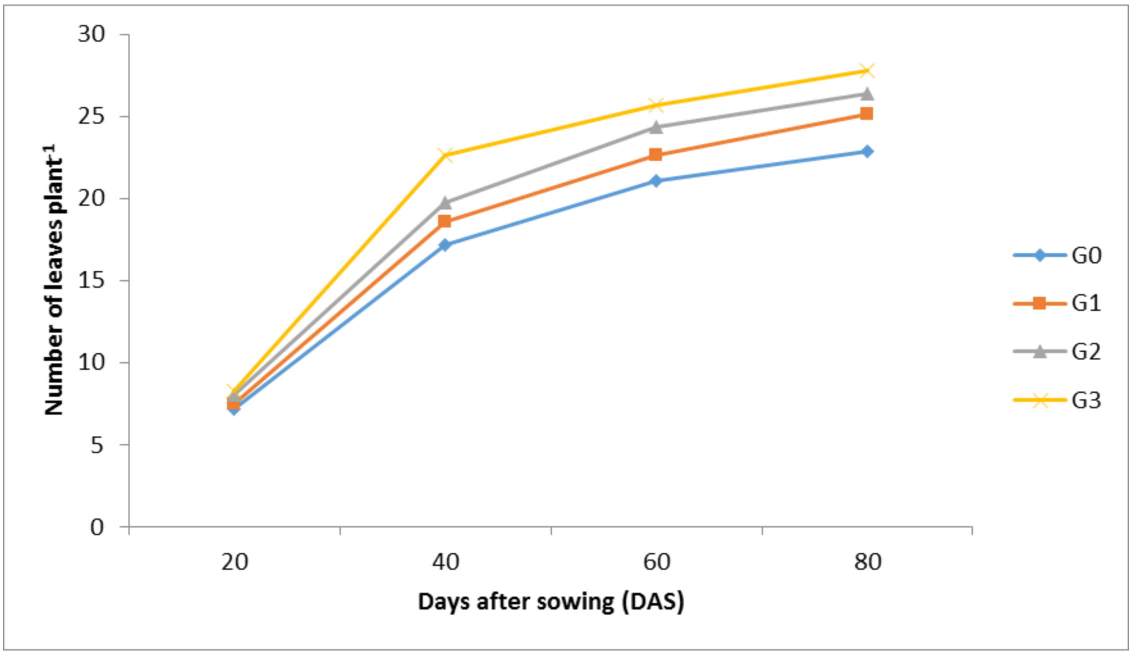


Fig. 4. Effect of giberellic acid on number of leaves plant$^{-1}$ of okra
$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

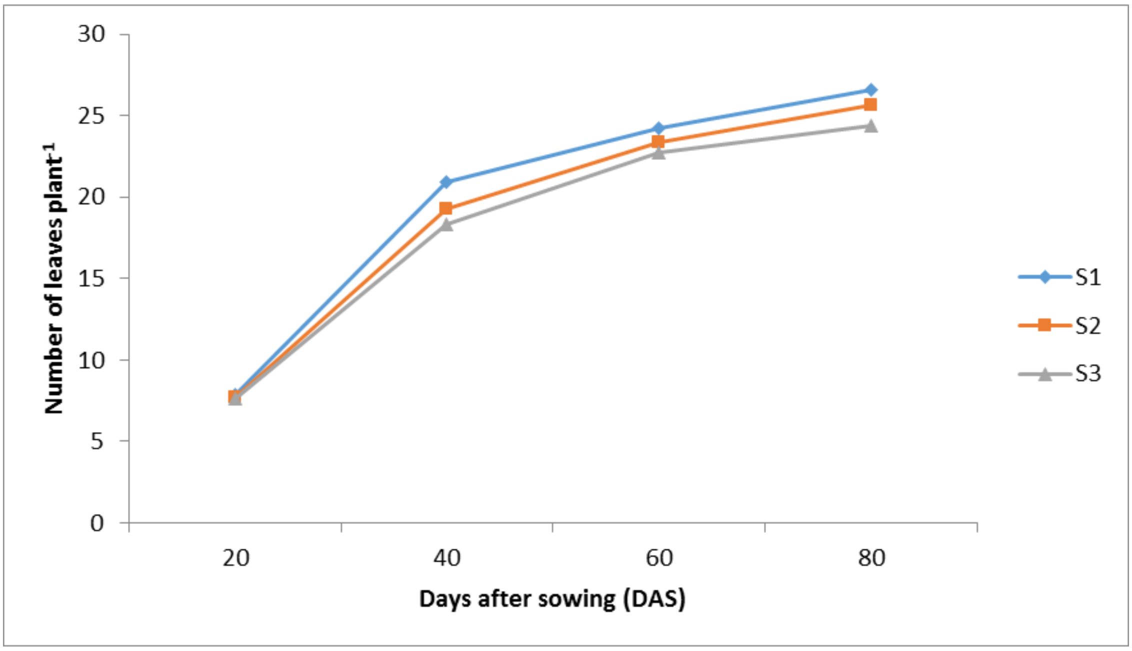


Fig. 5. Effect of sowing time on number of leaves plant$^{-1}$ of okra
$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

**Combined effect of $GA_3$ and sowing time**

Significant influence was noted on number of leaves plant$^{-1}$ at different growth stages affected by combined effect of $GA_3$ and sowing time (Table 3 and Appendix V). It was observed that the highest number of leaves plant$^{-1}$(8.53, 26.60, 26.67 and29.10 cm at 20, 40, 60 and 80 DAS, respectively)at all growth stages was recorded from the treatment combination of $G_3S_1$followed by the treatment combination of $G_3S_2$. The lowest number of leaves plant$^{-1}$(7.130, 15.87, 20.53 and20.00 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$followed by the treatment combination of $G_3S_2$.

Table 3.Combined effect of sowing time and gibberellic acid on number of leaves plant$^{-1}$ of okra

| Treatment | Number of leaves plant$^{-1}$ | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| $G_0S_1$ | 7.20 d | 18.00 fg | 22.00 g | 24.67 e |
| $G_0S_2$ | 7.13d | 17.67 g | 20.73 h | 23.83 f |
| $G_0S_3$ | 7.13 d | 15.87 h | 20.53 h | 20.00 g |
| $G_1S_1$ | 7.60 c | 18.93 d | 23.07 f | 25.33 de |
| $G_1S_2$ | 7.43 cd | 18.60 de | 22.73 f | 25.10 de |
| $G_1S_3$ | 7.40 cd | 18.20 ef | 22.07 g | 25.00 de |
| $G_2S_1$ | 8.13 b | 20.27 c | 25.20 c | 27.33 b |
| $G_2S_2$ | 8.07 b | 19.80 c | 24.07 de | 26.33 c |
| $G_2S_3$ | 7.96 b | 19.07 d | 23.87 e | 25.50 d |
| $G_3S_1$ | 8.53 a | 26.60 a | 26.67 a | 29.10 a |
| $G_3S_2$ | 8.20ab | 21.00 b | 25.80 b | 27.33 b |
| $G_3S_3$ | 8.11 b | 20.20 c | 24.53 d | 27.00 b |
| $LSD_{0.05}$ | 0.359 | 0.454 | 0.525 | 0.615 |
| CV.(%) | 8.319 | 10.114 | 8.245 | 11.533 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.1.3 Leaf length (cm)

**Effect of gibberellic acid ($GA_3$)**

Significant variation was found on leaf length at different growth stages influenced by different levels of Gibberellic acid ($GA_3$) application (Table 4 and Appendix VI). The highest leaf length (20.52, 44.71, 46.79 and48.67 cm at 20, 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$) which was significantly different from others. The lowest leaf length15.08, 37.84, 40.00 and41.34 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$).The results obtained from the present study was conformity with the findings of Mehraj *et al.* (2015), Ravat and Makani (2015) and Bello (2015).

**Effect of sowing time**

Leaf length of okra at different growth stages was found significant by the influence of different sowing time (Table 4 and Appendix VI). Results revealed that the highest leaf length (18.89, 42.52, 45.28 and 46.33 cm at 20, 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) followed by the sowing time of $S_2$ (30 April 2017) whereas the lowest leaf length (16.98, 40.80, 42.52 and 43.63 cm at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017).

**Combined effect of $GA_3$ and sowing time**

Variation on leaf length at different growth stages was noted influenced by combined effect of $GA_3$ and sowing time (Table 4 and Appendix VI). Results indicated that the longest leaf (22.07, 46.53, 48.30 and 50.43 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$which was significantly different from all other treatment combinations. The shortest leaf (14.53, 36.87, 36.60 and39.88 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$.

Table 4. Effect of sowing time and gibberellic acid on leaf length of okra

| Treatment | Leaf length (cm) | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Effect of gibberellic acid | | | | |
| $G_0$ | 15.08 d | 37.84 d | 40.00 d | 41.34 d |
| $G_1$ | 16.84 c | 40.47 c | 43.36 c | 43.47 c |
| $G_2$ | 18.72 b | 43.20 b | 45.55 b | 46.58 b |
| $G_3$ | 20.52 a | 44.71 a | 46.79 a | 48.67 a |
| $LSD_{0.05}$ | 0.527 | 0.573 | 0.614 | 1.011 |
| CV.(%) | 7.214 | 9.358 | 11.627 | 10.385 |
| Effect of sowing time | | | | |
| $S_1$ | 18.89 a | 42.52 a | 45.28 a | 46.33 a |
| $S_2$ | 17.50 b | 41.35 b | 43.98 b | 45.09 b |
| $S_3$ | 16.98 c | 40.80 c | 42.52 c | 43.63 c |
| $LSD_{0.05}$ | 0.511 | 0.627 | 0.572 | 1.115 |
| CV.(%) | 7.214 | 9.358 | 11.627 | 10.385 |
| Combined effect of gibberellic acid and sowing time | | | | |
| $G_0S_1$ | 15.87 f | 38.53 de | 42.60 e | 42.67 f |
| $G_0S_2$ | 14.83 g | 38.13 ef | 40.80 f | 41.47 g |
| $G_0S_3$ | 14.53 g | 36.60 f | 36.87 g | 39.88 h |
| $G_1S_1$ | 17.50 cd | 41.20 c | 44.07 cd | 44.00 de |
| $G_1S_2$ | 16.87 de | 40.40 c | 43.33 de | 43.50 ef |
| $G_1S_3$ | 16.13 ef | 39.80 cd | 42.67 de | 42.87 f |
| $G_2S_1$ | 20.10 b | 43.80 b | 46.13 b | 48.20 b |
| $G_2S_2$ | 18.13 c | 42.93 b | 45.40 bc | 46.67 c |
| $G_2S_3$ | 17.93 c | 42.87 b | 45.13 bc | 44.87 d |
| $G_3S_1$ | 22.07 a | 46.53 a | 48.30 a | 50.43 a |
| $G_3S_2$ | 20.17 b | 43.93 b | 46.40 b | 48.67 b |
| $G_3S_3$ | 19.33 b | 43.67 b | 45.67 b | 46.90 c |
| $LSD_{0.05}$ | 0.9458 | 1.357 | 1.347 | 0.9549 |
| CV.(%) | 7.214 | 9.358 | 11.627 | 10.385 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

#### 4.1.4 Leaf breadth (cm)

**Effect of gibberellic acid ($GA_3$)**

The recorded data on leaf bread that different growth stages was significant with the application of $GA_3$ at different rates (Table 5 and Appendix VII). The highest leaf breadth (14.00, 27.76, 28.80 and 29.19 cm at 20, 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$) followed by the treatment $G_2$ (80 ppm $GA_3$). Again, the lowest leaf breadth (11.55, 24.00, 25.98 and 26.73 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$). It was also found that from the study $GA_3$ application at higher rate resulted higher leaf breadth of okra. The findings obtained by Ravat and Makani (2015), Bello (2015) and Mehraj *et al*. (2015) was similar with the present study.

**Effect of sowing time**

Significant variation was observed on leaf breath different growth stages persuaded by different sowing time of okra (Table 5 and Appendix VII).). The highest leaf breadth (13.38, 26.74, 28.09 and 28.37 cm at 20, 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) which was statistically identical to $S_2$ (30 April 2017) at all growth stages where the lowest leaf breadth (12.58, 25.52, 27.07 and27.57 cm at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017). It was found that early planted plants showed greater leaf breadth than late planted okra.

**Combined effect of $GA_3$ and sowing time**

Remarkable variation was identified on leaf bread that different growth stages due to the combined effect of $GA_3$ and sowing time (Table 5 and Appendix VII).). The highest leaf breadth (15.47, 28.27, 30.00and 32.00 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$which was statistically different from all other treatment combinations at all growth stages. The lowest leaf breadth (11.33, 22.60, 25.33 and 26.00 cm at

20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$followed by $G_0S_1$ and $G_0S_2$.

Table 5. Effect of sowing time and gibberellic acid on leaf breadth of okra

| Treatment | Leaf breadth (cm) | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | | |
| $G_0$ | 11.55 c | 24.00 c | 25.98 c | 26.73 d |
| $G_1$ | 13.33 b | 25.73 b | 27.36 b | 27.47 c |
| $G_2$ | 13.42 b | 27.29 a | 27.89 b | 28.53 b |
| $G_3$ | 14.00 a | 27.76 a | 28.80 a | 29.19 a |
| $LSD_{0.05}$ | 0.214 | 0.365 | 0.417 | 0.522 |
| CV.(%) | 4.522 | 8.314 | 10.173 | 11.645 |
| Effect of sowing time | | | | |
| $S_1$ | 13.38 a | 26.74 a | 28.09 a | 28.37 a |
| $S_2$ | 13.28 a | 26.33 a | 27.78 a | 28.12 a |
| $S_3$ | 12.58 b | 25.52 b | 27.07 b | 27.57 b |
| $LSD_{0.05}$ | 0.236 | 0.414 | 0.529 | 0.514 |
| CV.(%) | 4.522 | 8.314 | 10.173 | 11.645 |
| Combined effect of giberellic acid and sowing time | | | | |
| $G_0S_1$ | 11.63 e | 24.87 e | 26.47 d | 27.10 d |
| $G_0S_2$ | 11.70 e | 24.53 e | 26.13 d | 27.12 d |
| $G_0S_3$ | 11.33 e | 22.60 f | 25.33 e | 26.00 e |
| $G_1S_1$ | 12.73 cd | 26.33 cd | 27.48 bc | 27.67 cd |
| $G_1S_2$ | 13.60 b | 25.87 d | 27.33 c | 27.50 d |
| $G_1S_3$ | 13.67 b | 25.00 e | 27.27 c | 27.20 d |
| $G_2S_1$ | 13.27 bc | 27.47 b | 28.13 b | 28.73 b |
| $G_2S_2$ | 14.87 a | 27.33 b | 27.80 bc | 28.50 b |
| $G_2S_3$ | 12.12 de | 27.07 bc | 27.73 bc | 28.33 bc |
| $G_3S_1$ | 15.47 a | 28.27 a | 30.00 a | 32.00a |
| $G_3S_2$ | 13.33 bc | 27.60 ab | 28.20 b | 28.87 b |
| $G_3S_3$ | 13.20 bc | 27.40 b | 27.90 bc | 28.70 b |
| $LSD_{0.05}$ | 0.7870 | 0.7535 | 0.6426 | 0.6688 |
| CV.(%) | 4.522 | 8.314 | 10.173 | 11.645 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$
$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.1.5 Length of petiole (cm)

**Effect of gibberellic acid ($GA_3$)**

A significant variation was found on length of petiole at different growth stages influenced by different concentrations of Gibberellic acid ($GA_3$) application (Table 6 and Appendix VIII).The highest length of petiole(7.82, 22.28, 25.66 and 29.60 cm at 20, 40, 60 and 80 DAS, respectively) was found from $G_3$ (100 ppm $GA_3$). The lowest length of petiole (4.87, 19.22, 21.40 and 23.11 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$). Similar trend of results on plant height was also observed by Mehraj *et al.* (2015).

**Effect of sowing time**

Significant variation was remarked on length of petiole at different growth stages as influenced by different sowing time of okra (Table 6 and Appendix VIII). The highest length of petiole(6.83, 21.46, 24.70 and 27.83 cm at 20, 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) the lowest length of petiole(5.99, 20.33, 22.75 and 25.73 cm at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017).

**Combined effect of $GA_3$ and sowing time**

The recorded data on length of petiole at different growth stages was significant with the application of combined effect of $GA_3$ and sowing time (Table 6 and Appendix VIII). The highest length of petiole (8.38, 22.50, 27.53 and 29.88 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$. At 80 DAS the treatment combination of $G_3S_2$ showed significantly similar result with the treatment combination of $G_3S_1$. The lowest length of petiole (4.40, 18.00, 19.67 and 21.00 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$followed by the treatment combination of $G_0S_2$.

Table 6. Effect of sowing time and gibberellic acid on length of petiole of okra

| Treatment | Length of petiole (cm) | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | | |
| $G_0$ | 4.87 d | 19.22 d | 21.40 d | 23.11 d |
| $G_1$ | 5.87 c | 20.78 c | 23.29 c | 26.51 c |
| $G_2$ | 7.10 b | 21.66 b | 24.33 b | 28.58 b |
| $G_3$ | 7.82 a | 22.28 a | 25.66 a | 29.60 a |
| $LSD_{0.05}$ | 0.311 | 0.736 | 0.457 | 0.814 |
| CV.(%) | 5.731 | 7.852 | 9.364 | 8.117 |
| Effect of sowing time | | | | |
| $S_1$ | 6.83 a | 21.46 a | 24.70 a | 27.83 a |
| $S_2$ | 6.42 b | 21.16 a | 23.57 b | 27.29 a |
| $S_3$ | 5.99 c | 20.33 c | 22.75 c | 25.73 c |
| $LSD_{0.05}$ | 0.348 | 0.543 | 0.512 | 0.912 |
| CV.(%) | 5.731 | 7.852 | 9.364 | 8.117 |
| Combined effect of giberellic acid and sowing time | | | | |
| $G_0S_1$ | 5.33 fg | 20.30 d | 22.60 f | 25.00 d |
| $G_0S_2$ | 4.87 gh | 19.33 e | 21.93 g | 23.33 e |
| $G_0S_3$ | 4.40 h | 18.00 f | 19.67 h | 21.00 f |
| $G_1S_1$ | 6.20 e | 21.00 c | 23.60 de | 27.13 c |
| $G_1S_2$ | 5.73 ef | 21.00 c | 23.20 ef | 27.07 c |
| $G_1S_3$ | 5.67 f | 20.33 d | 23.07 ef | 25.30 d |
| $G_2S_1$ | 7.40 bc | 22.00 b | 25.07 b | 29.33 b |
| $G_2S_2$ | 7.20 cd | 21.97 b | 24.00 cd | 27.07 c |
| $G_2S_3$ | 6.70 d | 21.00 c | 23.73 cde | 27.30 c |
| $G_3S_1$ | 8.38 a | 22.50 a | 27.53 a | 29.88 a |
| $G_3S_2$ | 7.87 b | 22.33 ab | 25.13 b | 29.67 ab |
| $G_3S_3$ | 7.20 cd | 22.00 b | 24.33 c | 29.25 b |
| $LSD_{0.05}$ | 0.482 | 0.3935 | 0.6688 | 0.4350 |
| CV.(%) | 5.731 | 7.852 | 9.364 | 8.117 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.1.6 Stem diameter

**Effect of gibberellic acid ($GA_3$)**

Significant variation was observed on stem diameterat different growth stages of okra influenced by different levels of Gibberellic acid ($GA_3$) application

(Table 7 and Appendix IX).The highest stem diameter (2.09, 2.19, 2.59 and 3.19 cm at 20, 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$) which was followed by the treatment $G_1$ (60 ppm $GA_3$) and $G_2$ (80 ppm $GA_3$). The lowest stem diameter (0.68, 1.52, 1.87 and 2.51 cm at 20, 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$).Mehraj *et al.* (2015) also found similar results which supported the present study

**Effect of sowing time**

Significant influence was not found on stem diameter at different growth stages affected by different sowing time of okra (Table 7 and Appendix IX). But the highest stem diameter (1.49, 1.92, 2.13 and 2.99 cm at 20, 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) where the lowest stem diameter (0.78, 1.66, 2.01 and 2.71 at 20, 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017). Similar result on plant height was also observed by

**Combined effect of $GA_3$ and sowing time**

Stem diameter at different growth stages was significantly varied due to the combined effect of $GA_3$ and sowing time at different growth stages (Table 7 and Appendix IX). The highest stem diameter (2.56, 2.60, 2.74 and 3.50cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$followed by the treatment combination of $G_3S_2$. The lowest stem diameter (0.66, 1.51, 1.73 and 2.27 cm at 20, 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$which was followed by the treatment combination of $G_0S_1$ and $G_0S_2$.

Table 7. Effect of sowing time and gibberellic acid on stem diameter of okra

| Treatment | Stem diameter (cm) | | | |
|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | | |
| $G_0$ | 0.68 c | 1.52 c | 1.87 b | 2.51 c |
| $G_1$ | 0.78 c | 1.66 b | 2.06 a | 2.76 b |
| $G_2$ | 0.88 b | 1.78 b | 2.15 a | 2.93 b |
| $G_3$ | 2.09 a | 2.19 a | 2.59 a | 3.19 a |
| $LSD_{0.05}$ | 0.127 | 0.128 | 0.133 | 0.157 |
| CV.(%) | 3.26 | 5.17 | 4.523 | 4.26 |

| | | | | |
|---|---|---|---|---|
| Effect of sowing time | | | | |
| $S_1$ | 1.21 | 1.92 | 2.13 | 2.99 |
| $S_2$ | 1.11 | 1.71 | 2.08 | 2.85 |
| $S_3$ | 0.88 | 1.66 | 2.01 | 2.71 |
| $LSD_{0.05}$ | NS | NS | NS | NS |
| CV.(%) | 3.26 | 5.17 | 4.523 | 4.26 |
| Combined effect of giberellic acid and sowing time | | | | |
| $G_0S_1$ | 0.69 d | 1.53 c | 1.97 de | 2.67 d |
| $G_0S_2$ | 0.68 d | 1.54 c | 1.92 e | 2.60 d |
| $G_0S_3$ | 0.66 d | 1.51 c | 1.73 f | 2.27 e |
| $G_1S_1$ | 0.80cd | 1.69 bc | 2.13 bc | 2.83 bcd |
| $G_1S_2$ | 0.76 cd | 1.65 bc | 2.05 cd | 2.73 cd |
| $G_1S_3$ | 0.74 cd | 1.66 bc | 2.01 de | 2.74 cd |
| $G_2S_1$ | 0.91 c | 1.87 b | 2.17 ab | 2.97 bc |
| $G_2S_2$ | 0.88 c | 1.76 bc | 2.15 abc | 2.95 bc |
| $G_2S_3$ | 0.85 c | 1.70 bc | 2.13 bc | 2.87 bcd |
| $G_3S_1$ | 2.56 a | 2.60 a | 2.74 a | 3.50 a |
| $G_3S_2$ | 2.14 b | 1.89 b | 2.19 ab | 3.10 b |
| $G_3S_3$ | 0.88 c | 1.77 bc | 2.15 abc | 2.98 bc |
| $LSD_{0.05}$ | 0.145 | 0.262 | 0.093 | 0.245 |
| CV.(%) | 3.26 | 5.17 | 4.523 | 4.26 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

#### 4.1.7 Number of branch $plant^{-1}$

**Effect of gibberellic acid ($GA_3$)**

Significant variation was remarked on number of branch $plant^{-1}$ at different growth stages as influenced by different levels of Gibberellic acid ($GA_3$) application (Table 8 and Appendix X). It was found that the highest number of branch $plant^{-1}$ (3.20,3.73 and 4.78 at 40, 60 and 80 DAS, respectively) was found from the treatment $G_2$ (80 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$).The lowest number of branch $plant^{-1}$(1.82, 2.81 and 3.78 at 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The results obtained from the present study was conformity with the findings of Chormule *et al*. (2017) and Mehraj *et al.* (2015).

**Effect of sowing time**

The recorded data on number of branch $plant^{-1}$ at different growth stages was significant with different sowing time of okra (Table 8 and Appendix X). Results showed that the highest number of branch $plant^{-1}$(2.93, 3.53 and 4.59 at 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_2$ (30 April 2017). The lowest number of branch $plant^{-1}$(2.31, 3.27 and 4.17at 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_1$ (15 April 2017) which was statistically identical to $S_3$ (15 May 2017). The present study was also supported the findings of Asadipour and Madani (2014), Ekwu and Nwokwu (2012).

**Combined effect of $GA_3$ and sowing time**

There was a significant variation on number of branch $plant^{-1}$ at different growth stages of okra influenced by combined effect of $GA_3$ and sowing time (Table 8 and Appendix X). The highest number of branch $plant^{-1}$(3.60, 3.93 and 5.00 at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_2S_2$followed by the treatment combination of $G_1S_2$, $G_2S_1$, $G_2S_3$ and $G_3S_2$.The lowest number of branch $plant^{-1}$(1.88, 2.67and 3.33at 40, 60 and

80 DAS, respectively) was recorded from the treatment combination of $G_0S_1$followed by the treatment combination of $G_0S_1$ and $G_0S_2$.

Table 8. Effect of sowing time and giberellic acid on number of branch plant$^{-1}$ of okra

| Treatment | Number of branch plant$^{-1}$ | | |
|---|---|---|---|
| | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | |
| $G_0$ | 1.82 c | 2.81 c | 3.78 c |
| $G_1$ | 2.54 b | 3.44 b | 4.44 b |
| $G_2$ | 3.20 a | 3.73 a | 4.78 a |
| $G_3$ | 2.60 b | 3.46 b | 4.45 b |
| $LSD_{0.05}$ | 0.217 | 0.229 | 0.254 |
| CV.(%) | 4.278 | 5.244 | 5.837 |
| Effect of sowing time | | | |
| $S_1$ | 2.31 b | 3.27 b | 4.17 b |
| $S_2$ | 2.93 a | 3.53 a | 4.59 a |
| $S_3$ | 2.38 b | 3.30 b | 4.33 b |
| $LSD_{0.05}$ | 0.114 | 0.136 | 0.183 |
| CV.(%) | 4.278 | 5.244 | 5.837 |
| Combined effect of giberellic acid and sowing time | | | |
| $G_0S_1$ | 1.88 f | 2.67 e | 3.33 d |
| $G_0S_2$ | 2.00 f | 2.93 de | 4.00 d |
| $G_0S_3$ | 2.57 de | 2.83 e | 4.00 e |
| $G_1S_1$ | 2.07 f | 3.20 cd | 4.30 c |
| $G_1S_2$ | 3.12 bc | 3.72 ab | 4.67 b |
| $G_1S_3$ | 2.43 e | 3.47 bc | 4.33 c |
| $G_2S_1$ | 3.17 b | 3.73 ab | 4.72 b |
| $G_2S_2$ | 3.60 a | 3.93 a | 5.00 a |
| $G_2S_3$ | 2.83 cd | 3.52 bc | 4.67 b |
| $G_3S_1$ | 2.13 f | 3.33 c | 4.33 c |
| $G_3S_2$ | 3.00 bc | 3.50 bc | 4.70 b |
| $G_3S_3$ | 2.67 de | 3.54 bc | 4.40 c |
| $LSD_{0.05}$ | 0.278 | 0.308 | 0.207 |
| CV.(%) | 4.278 | 5.244 | 5.837 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.1.8 Length of internodes (cm)

**Effect of gibberellic acid ($GA_3$)**

Application of different levels of gibberellic acid ($GA_3$) showed significant influence on length of internodes at different growth stages of okra (Table 9 and Appendix XI). The highest length of internodes (5.49, 6.18 and 7.17 cm at 40, 60 and 80 DAS, respectively) was found from the treatment $G_3$ (100 ppm $GA_3$) followed by the treatment $G_2$ (80 ppm $GA_3$). Lowest length of internodes (4.05, 4.09 and 5.56 cm at 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$). Dhage *et al.* (2011) also found similar results which supported the present study.

**Effect of sowing time**

Significant variation was observed on length of internodes at different growth stages influenced by different sowing time of okra (Table 9 and Appendix XI). The highest length of internodes (5.11, 5.53 and 6.63 cm at 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_1$ (15 April 2017) where the lowest length of internodes (4.58, 4.64 and 6.08 cm at 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017). The treatment on sowing time of $S_2$ (30 April 2017) showed intermediate result. The results obtained from the present study was conformity with the findings of Dilruba *et al.* (2009).

**Combined effect of $GA_3$ and sowing time**

Length of internodes was significantly influenced by combined effect of $GA_3$ and sowing time at different growth stages (Table 9 and Appendix XI). The highest length of internodes (5.80, 7.30 and 7.33 cm at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_3S_1$which was statistically similar with $G_3S_2$ at 80 DAS. The lowest length of internodes (3.56, 3.77 and 5.00 cm at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$followed by the treatment combination of $G_0S_2$.

Table 9. Effect of sowing time and gibberellic acid on length of internodes of okra

| Treatment | Length of internodes (cm) | | |
|---|---|---|---|
| | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | |
| $G_0$ | 4.05 d | 4.09 d | 5.56 d |
| $G_1$ | 4.76 c | 4.71 c | 6.06 c |
| $G_2$ | 5.09 b | 5.19 b | 6.67 b |
| $G_3$ | 5.49 a | 6.18 a | 7.17 a |
| $LSD_{0.05}$ | 0.247 | 0.312 | 0.338 |
| CV.(%) | 3.244 | 4.126 | 5.052 |
| Effect of sowing time | | | |
| $S_1$ | 5.11 a | 5.53 a | 6.63 a |
| $S_2$ | 4.95 b | 4.87 b | 6.38 b |
| $S_3$ | 4.58 c | 4.64 c | 6.08 c |
| $LSD_{0.05}$ | 0.211 | 0.236 | 0.258 |
| CV.(%) | 3.244 | 4.126 | 5.052 |
| Combined effect of giberellic acid and sowing time | | | |
| $G_0S_1$ | 4.47 e | 4.33 de | 6.00 e |
| $G_0S_2$ | 4.13 f | 4.17 e | 5.67 f |
| $G_0S_3$ | 3.56 g | 3.77 f | 5.00 g |
| $G_1S_1$ | 4.87 d | 4.97 bc | 6.17 de |
| $G_1S_2$ | 4.73 de | 4.70 cd | 6.00 e |
| $G_1S_3$ | 4.67 de | 4.47 de | 6.00 e |
| $G_2S_1$ | 5.47 c | 5.33 b | 7.00 b |
| $G_2S_2$ | 4.93 d | 5.20 b | 6.67 c |
| $G_2S_3$ | 4.87 d | 5.03 bc | 6.33 d |
| $G_3S_1$ | 5.80 a | 7.30 a | 7.33 a |
| $G_3S_2$ | 6.00 b | 5.40 b | 7.17 ab |
| $G_3S_3$ | 5.23 c | 5.27 b | 7.00 b |
| $LSD_{0.05}$ | 0.293 | 0.394 | 0.2454 |
| CV.(%) | 3.244 | 4.126 | 5.052 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.1.9 Dry weight of leaves plant$^{-1}$ (%)

**Effect of gibberellic acid ($GA_3$)**

Dry weight of leaves plant$^{-1}$ was significantly influenced by different levels of Gibberellic acid ($GA_3$) application at different growth stages (Table 10 and Appendix XII). It was observed that the highest dry weight of leaves plant$^{-1}$ (6.86, 9.71 and12.74% at 40, 60 and 80 DAS, respectively) was found from the treatment $G_2$ (80 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$). The lowest dry weight of leaves plant$^{-1}$ (2.05, 4.45 and6.67%at 40, 60 and 80 DAS, respectively) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The result obtained from the present study was similar to the findings ofMehraj*et al.*(2015).

**Effect of sowing time**

Significant variation was observed on dry weight of leaves plant$^{-1}$ at different growth stages influenced by different sowing time of okra (Table 10 and Appendix XII). Results showed that the highest dry weight of leaves plant$^{-1}$ (5.86, 8.17 and11.38%at 40, 60 and 80 DAS, respectively) was achieved from the sowing time $S_2$ (30 April 2017).The lowest dry weight of leaves plant$^{-1}$ (4.18, 7.06 and9.52%at 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical to the sowing time of $S_1$ (15 April 2017). Hussain *et al.* (2006) also found similar trends of results which supported the present study.

**Combined effect of $GA_3$ and sowing time**

Combined effect of $GA_3$ and sowing time had significant influence on dry weight of leaves plant$^{-1}$ at different growth stages (Table 10 and Appendix XII). Results indicated that the highest dry weight of leaves plant$^{-1}$ (7.64, 10.6 and13.40%at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_2S_2$which was statistically similar to $G_2S_1$.The lowest dry weight of leaves plant$^{1}$ (1.80, 4.30 and 6.40%at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_3$ which was statistically identical to $G_0S_1$ followed by the treatment combination of $G_0S_2$.

Table 10. Effect of sowing time and giberellic acid on percent dry weight of leaves plant$^{-1}$ of okra

| Treatment | Dry weight of leaves (%) | | |
|---|---|---|---|
| | 40 DAS | 60 DAS | 80 DAS |
| Effect of giberellic acid | | | |
| $G_0$ | 2.05 c | 4.45 c | 6.67 c |
| $G_1$ | 4.94 b | 7.72 b | 10.43 b |
| $G_2$ | 6.86 a | 9.71 a | 12.74 a |
| $G_3$ | 5.11 b | 7.97 b | 10.74 b |
| $LSD_{0.05}$ | 0.312 | 0.465 | 0.611 |
| CV.(%) | 5.837 | 4.388 | 4.149 |
| Effect of sowing time | | | |
| $S_1$ | 4.19 b | 7.16 b | 9.53 b |
| $S_2$ | 5.86 a | 8.17 a | 11.38 a |
| $S_3$ | 4.18 b | 7.06 b | 9.52 b |
| $LSD_{0.05}$ | 0.355 | 0.514 | 0.762 |
| CV.(%) | 5.837 | 4.388 | 4.149 |
| Combined effect of giberellic acid and sowing time | | | |
| $G_0S_1$ | 2.24 f | 4.45 h | 6.72 hi |
| $G_0S_2$ | 2.12 f | 4.60 h | 6.88 h |
| $G_0S_3$ | 1.80 f | 4.30 h | 6.40i |
| $G_1S_1$ | 3.50 e | 6.75 g | 8.70 g |
| $G_1S_2$ | 6.90 b | 8.92 c | 12.80 b |
| $G_1S_3$ | 4.42 d | 7.48 f | 9.76 f |
| $G_2S_1$ | 7.20 ab | 10.2 b | 13.10 ab |
| $G_2S_2$ | 7.64 a | 10.6 a | 13.40 a |
| $G_2S_3$ | 5.75 c | 8.36 de | 11.70 d |
| $G_3S_1$ | 3.80 e | 7.20 f | 9.52 f |
| $G_3S_2$ | 6.78 b | 8.60 cd | 12.40 c |
| $G_3S_3$ | 4.75 d | 8.10 e | 10.30 e |
| $LSD_{0.05}$ | 0.5565 | 0.3213 | 0.3935 |
| CV.(%) | 5.837 | 4.388 | 4.149 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$
$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

**4.2 Yield contributing parameters**

**4.2.1 Length of fruit (cm)**

**Effect of gibberellic acid ($GA_3$)**

Length of fruit was significantly influenced by different levels of Gibberellic acid ($GA_3$) application at different growth stages (Table 11 and Appendix XIII).The highest length of fruit(11.05) cm was found from the treatment $G_2$

(80 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$). The lowest diameter of fruit (10.77) was observed from the control treatment $G_0$ (0 ppm $GA_3$). Similar trends of results on plant height was also observed by Chormule *et al*. (2017), Singh *et al*. (2017), Ravat and Makani (2015) and Mehraj *et al*. (2015).

**Effect of sowing time**

Variation on length of fruit was veried significantly due to the different sowing time of okra (Table 11 and Appendix XIII). The highest length of fruit (11.02) cm was achieved from the sowing time $S_2$ (30 April 2017) where the lowest (10.79) cm was obtained from the sowing time $S_3$ (15 May 2017). The results obtained from the present study was similar with the findings of Sonu *et al*. (2017), Shahid *et al*. (2015), Asadipour and Madani (2014) and Ekwu and Nwokwu (2012).

**Combined effect of $GA_3$ and sowing time**

Significant variation was remarked on length of fruit at different growth stages as influenced by combined effect of $GA_3$ and sowing time (Table 11 and Appendix XIII).The highest length of fruit (11.60) cm was recorded from the treatment combination of $G_2S_2$ followed by $G_2S_1$.The lowest length of fruit (10.63) was recorded from the treatment combination of $G_0S_3$

**Table.11: Effect of gibbrellic acid and sowing time on length and diameter of Okra fruit**

| Effect of gibbrellic acid | | |
|---|---|---|
| Treatments | Length of fruit (cm) | Diameter of fruit (cm) |
| $G_0$ | 10.77c | 7.15c |
| $G_1$ | 10.80b | 8.48b |
| $G_2$ | 11.05a | 8.60a |
| $G_3$ | 10.90ab | 8.51ab |
| LSD(0.05) | 0.257 | 0.110 |

| | | |
|---|---|---|
| **Effect of sowing time** | | |
| $S_1$ | 10.79b | 8.34b |
| $S_2$ | 11.02a | 8.66a |
| $S_3$ | 10.95ab | 8.43ab |
| LSD(0.05) | 0.297 | 0.128 |
| **Combined effect of gibbrellic and sowing time** | | |
| $G_0S_1$ | 10.86c | 8.16d |
| $G_0S_2$ | 10.76cd | 7.98de |
| $G_0S_3$ | 10.63d | 7.86e |
| $G_1S_1$ | 10.96bc | 8.21cd |
| $G_1S_2$ | 10.89c | 8.41c |
| $G_1S_3$ | 10.79cd | 8.56bc |
| $G_2S_1$ | 11.42ab | 8.80ab |
| $G_2S_2$ | 11.60a | 8.96a |
| $G_2S_3$ | 11.31b | 8.75b |
| $G_3S_1$ | 11.12bc | 8.53bc |
| $G_3S_2$ | 11.01c | 8.39c |
| $G_3S_3$ | 10.98cd | 8.21cd |
| LSD(0.05) | 0,269 | .221 |
| CV(%) | 7.89 | 6.27 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$
$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 201

**4.2.2 Diameter of fruit (cm)**
**Effect of gibberellic acid ($GA_3$)**

Variation on diameter of fruit was noted influenced by different levels of Gibberellic acid ($GA_3$) application at different growth stages (Table 11 and Appendix XIV). The highest diameter of fruit (8.60) cm was found from the treatment $G_2$ (80 ppm $GA_3$) followed by the treatment $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$) whereas the lowest diameter of fruit (7.15 cm) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The findings obtained by Chormule *et al*. (2017), Singh *et al*. (2017) and Mehraj *et al*. (2015) was similar with the present study.

**Effect of sowing time**

Diameter of fruit was significantly influenced by different sowing time of okra at different growth stages (Table 11 and Appendix XIV). The highest diameter of fruit (8.66 cm) was achieved from the sowing time $S_2$ (30 April 2017) whereas the lowest diameter of fruit (8.34 cm ) was obtained from the sowing time $S_1$ (15 April 2017) which was statistically identical to sowing time $S_3$ (15 April 2017). The results obtained from the present study was conformity with the findings of Sonu *et al*. (2017), Shahid *et al*. (2015), Hussain *et al*. (2006) and Sajjan *et al*. (2002).

**Combined effect of $GA_3$ and sowing time**

Significant variation was found on diameter of fruit influenced by combined effect of $GA_3$ and sowing time at different growth stages (Table 11 and Appendix XIV).It was found that the highest diameter of fruit (8.96 cm) was recorded from the treatment combination of $G_2S_2$which was statistically similar to $G_2S_1$ .The lowest diameter of fruit (7.86) cm was recorded from the treatment combination of $G_0S_3$.

**4.2.3 Days required for 1st flowering**

**Effect of gibberellic acid ($GA_3$)**

Gibberellic acid ($GA_3$) had significant influence on days to 1st flowering of okra (Table 13 and Appendix XV). Results indicated that the lowest days to 1st flowering (34.78 days) was found from the treatment $G_2$ (80 ppm $GA_3$) which was statistically identical to $G_3$ (100 ppm $GA_3$). Again, the highest days to 1st flowering (44.00 days) was observed from the control treatment $G_0$ (0 ppm $GA_3$) followed by $G_1$ (60 ppm $GA_3$) treatment. Sanodiya *et al*. (2017), Chowdhury *et al*. (2014) and Dhage *et al*. (2011) also found similar results which supported the present study.

**Effect of sowing time**

There was a significant variation on days to 1stflowering influenced by sowing time during the crop duration (Table 13 and Appendix XV). It was noted that the lowest days to 1st flowering (36.17 days) was achieved from the sowing time $S_1$ (15 April 2017) followed by $S_2$ (30 April 2017) whereas the highest (40.58 days) was obtained from the sowing time $S_3$ (15 May 2017). Similar findings was also found by Ekwu and Nwokwu (2012), Elhag and Ahmed (2014), Bake *et al*. (2017), Joy (2010) and Amjad *et al*. (2001).

**Combined effect of $GA_3$ and sowing time**

Significantly influence was found for days to 1st flowering affected by the treatment combination of gibberellic acid ($GA_3$) and sowing time (Table 13 and Appendix XV).Results revealed that the lowest days to 1st flowering (32.00 days)was recorded from the treatment combination of $G_2S_1$ which was statistically similar to the treatment combination of $G_2S_2$ and $G_3S_1$. Similarly, the highest days to 1st flowering (45.33 days) was recorded from the treatment combination of $G_0S_3$ which was statistically similar to the treatment combination of $G_0S_2$ followed by $G_0S_1$.

### 4.2.4 Number of flowers plant$^{-1}$

**Effect of gibberellic acid ($GA_3$)**

Significant variation was observed on number of flowers plant$^{-1}$ influenced by different levels of gibberellic acid ($GA_3$) application (Table 13 and Appendix XV). It was observed that the highest number of flowers plant$^{-1}$ (32.50) was found from the treatment $G_2$ (80 ppm $GA_3$) which was significantly different from others where the lowest number of flowers plant$^{-1}$ (22.41) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The treatment, $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$) showed intermediate results. The results obtained from the present study was similar with the findings of Sanodiya *et al*. (2017).

**Effect of sowing time**

Number of flowers plant$^{-1}$ was significantly varied due to different sowing time of okra (Table 13 and Appendix XV). It was continued that the highest number of flowers plant$^{-1}$ (30.23) was achieved from the sowing time $S_2$ (30 April 2017) whereas the lowest number of flowers plant$^{-1}$ (26.37) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical with the sowing time $S_1$ (15 April 2017).

**Combined effect of $GA_3$ and sowing time**

Remarkable variation was observed on number of flowers plant$^{-1}$influenced by combined effect of $GA_3$ and sowing time (Table 13 and Appendix XV). Results revealed that the highest number of flowers plant$^{-1}$ (35.50) was recorded from the treatment combination of $G_2S_2$followed by $G_1S_2$ and $G_2S_1$. Again, the lowest number of flowers plant$^{-1}$ (22.18) was recorded from the treatment combination of $G_0S_3$ which was statistically identical to $G_0S_1$ and $G_0S_2$.

### 4.2.5 Number of fruits plant$^{-1}$

**Effect of gibberellic acid ($GA_3$)**

Significant influence was noted on number of fruits plant$^{-1}$ affected by different levels of gibberellic acid ($GA_3$) application (Table 13 and Appendix XV).Results indicated that the highest number of fruits plant$^{-1}$ (21.80) was found from the treatment $G_2$ (80 ppm $GA_3$) which was statistically different with other treatments. The lowest number of fruits plant$^{-1}$ (16.41) was observed from the control treatment $G_0$ (0 ppm $GA_3$).Similar findings was also found by Sanodiya *et al*. (2017), Chormule *et al*. (2017), Ravat and Makani (2015) and Mehraj *et al*. (2015).

**Effect of sowing time**

Number of fruits plant$^{-1}$ varied significantly due to different sowing time of okra (Table 13 and Appendix XV). It was noted that the highest number of fruits plant$^{-1}$ (20.59) was achieved from the sowing time $S_2$ (30 April 2017) where the lowest number of fruits plant$^{-1}$ (18.92) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical to the sowing time $S_1$ (15 April 2017).Similar trends of results on plant height was also observed by Sonu *et al*. (2017), Shahid *et al*. (2015), Chattopadhyay *et al*. (2011) and Hussain *et al*. (2006).

**Combined effect of $GA_3$ and sowing time**

Significant variation was remarked on number of fruits plant$^{-1}$ of okra as influenced by combined effect of $GA_3$ and sowing time (Table 13 and Appendix XV).Results showed that the highest number of fruits plant$^{-1}$ (22.60) was recorded from the treatment combination of $G_2S_2$which was statistically similar to the treatment combination of $G_2S_1$ and $G_1S_2$. Similarly, the lowest number of fruits plant$^{-1}$ (16.10) was recorded from the treatment combination of $G_0S_3$ which was statistically identical to the treatment combination of $G_0S_1$ and $G_0S_2$.

**4.2.6 Fresh weight of fruits plant$^{-1}$**

**Effect of gibberellic acid ($GA_3$)**

Fresh weight of fruits plant$^{-1}$ was found as significant with the application of different levels of gibberellic acid ($GA_3$) (Table 13 and Appendix XV). Results signified that the highest fresh weight of fruits plant$^{-1}$ (316.92 g) was found from the treatment $G_2$ (80 ppm $GA_3$) which was significantly different from other treatments. The lowest fresh weight of fruits plant$^{-1}$ (196.44 g) was observed from the control treatment $G_0$ (0 ppm $GA_3$) which was also significantly different from others. The results obtained from the present study was conformity with the findings of Sanodiya *et al*. (2017) and Mehraj *et al.* (2015).

**Effect of sowing time**

Variation on fresh weight of fruits plant$^{-1}$ was noted influenced by different sowing time of okra (Table 13 and Appendix XV). It was found that the highest fresh weight of fruits plant$^{-1}$ (290.07 g) was achieved from the sowing time $S_2$ (30 April 2017). Again, the lowest fresh weight of fruits plant$^{-1}$ (255.24 g) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical with the sowing time $S_1$ (15 April 2017). The findings obtained by Shahid *et al*. (2015) and Chattopadhyay *et al*. (2011) was similar to the present study.

**Combined effect of $GA_3$ and sowing time**

Fresh weight of fruits plant$^{-1}$ of okra affected by combined effect of $GA_3$ and sowing time was significant (Table 13 and Appendix XV). Results indicated that the highest fresh weight of fruits plant$^{-1}$ (340.20 g) was recorded from the treatment combination of $G_2S_2$followed by $G_1S_2$ and $G_2S_1$ which were significantly different from all other treatment combinations. Similarly, the lowest fresh weight of fruits plant$^{-1}$ (184.30 g) was recorded from the treatment combination of $G_0S_3$followed by $G_0S_1$.

**4.2.7 Dry weight of fruits**

**Effect of gibberellic acid ($GA_3$)**

The recorded data on dry weight of fruits was significant with the application of Gibberellic acid ($GA_3$) at different levels (Table 13 and Appendix XV). The highest dry weight of fruits (10.17%) was found from the treatment $G_2$ (80 ppm $GA_3$) which was significantly different from other treatments. Again, the lowest dry weight of fruits (7.28%) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The treatments, $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$) showed intermediate results. Sanodiya *et al.* (2017) and Mehraj *et al.* (2015) also found similar results which supported the present study.

**Effect of sowing time**

Considerable influence was observed on dry weight of fruits persuaded by different sowing time of okra (Table 13 and Appendix XV).The highest dry weight of fruits (9.44%) was achieved from the sowing time $S_2$ (30 April 2017). The lowest dry weight of fruits (8.61%) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical with the sowing time of $S_1$ (15 April 2017). The results obtained from the present study was conformity with the findings of Elhagand Ahmed (2014).

**Combined effect of $GA_3$ and sowing time**

Remarkable variation was identified on dry weight of fruits due to the combined effect of $GA_3$ and sowing time (Table 13 and Appendix XV). The highest dry weight of fruits (10.70%) was recorded from the treatment combination of $G_2S_2$which was statistically similar with $G_2S_1$. The lowest dry weight of fruits (7.20%) was recorded from the treatment combination of $G_0S_3$which was statistically identical with the treatment combination of $G_0S_1$ and $G_0S_2$.

Table 12. Effect of sowing time and giberellic acid on yield contributing parameters of okra

| Treatment | Yield contributing parameters | | | | |
|---|---|---|---|---|---|
| | Days required for 1st | Number of flowers plant$^{-1}$ | Number of fruits plant$^{-1}$ | Fresh weight of fruits plant$^{-}$ | Dry weight of fruits (%) |

| | flowering | | | [1] (g) | |
|---|---|---|---|---|---|
| Effect of giberellic acid | | | | | |
| $G_0$ | 44.00 a | 22.41 c | 16.41 c | 196.44 c | 7.28 c |
| $G_1$ | 37.66 b | 28.65 b | 19.91 b | 279.00 b | 9.07 b |
| $G_2$ | 34.78 c | 32.50 a | 21.80 a | 316.92 a | 10.17 a |
| $G_3$ | 35.45 c | 28.51 b | 20.00 b | 278.64 b | 9.17 b |
| $LSD_{0.05}$ | 2.017 | 1.543 | 0.486 | 4.588 | 0.889 |
| CV.(%) | 5.852 | 9.514 | 6.317 | 10.524 | 8.366 |
| Effect of sowing time | | | | | |
| $S_1$ | 36.17 c | 27.46 b | 19.08 b | 257.94 b | 8.71 b |
| $S_2$ | 37.17 b | 30.23 a | 20.59 a | 290.07 a | 9.44 a |
| $S_3$ | 40.58 a | 26.37 b | 18.92 b | 255.24 b | 8.61 b |
| $LSD_{0.05}$ | 0.844 | 2.116 | 0.314 | 5.312 | 0.913 |
| CV.(%) | 5.852 | 9.514 | 6.317 | 10.524 | 8.366 |
| Combined effect of giberellic acid and sowing time | | | | | |
| $G_0S_1$ | 42.67 b | 22.44 f | 16.44 g | 198.7 0 i | 7.30 h |
| $G_0S_2$ | 44.00 ab | 22.60 f | 16.70 g | 206.30 h | 7.33 h |
| $G_0S_3$ | 45.33 a | 22.18 f | 16.10 g | 184.30 j | 7.20 h |
| $G_1S_1$ | 36.33 ef | 25.20 e | 18.50 f | 255.60 f | 8.18 g |
| $G_1S_2$ | 36.33 ef | 32.00 b | 21.74 a-c | 315.00 b | 10.10 bc |
| $G_1S_3$ | 40.33 c | 28.75 d | 19.48 ef | 266.40 f | 8.92 ef |
| $G_2S_1$ | 32.00 h | 32.33 b | 22.00 ab | 319.00 b | 10.30 ab |
| $G_2S_2$ | 33.33 gh | 35.50 a | 22.60 a | 340.20 a | 10.70 a |
| $G_2S_3$ | 39.00 cd | 29.66 d | 20.80 cd | 291.60 d | 9.50 d |
| $G_3S_1$ | 33.67 gh | 25.50 e | 18.75 f | 258.50 g | 8.64 fg |
| $G_3S_2$ | 35.00 fg | 30.80 c | 21.32 bc | 298.80 c | 9.64 cd |
| $G_3S_3$ | 37.67 de | 29.24 d | 19.92 de | 278.60 e | 9.22 de |
| $LSD_{0.05}$ | 1.638 | 1.007 | 0.9903 | 7.071 | 0.4908 |
| CV.(%) | 5.852 | 9.514 | 6.317 | 10.524 | 8.366 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.3 Yield parameters

#### 4.3.1 Fruit yield plot$^{-1}$ (kg)

**Effect of gibberellic acid ($GA_3$)**

Significant variation was observed on fruit yield plot$^{-1}$ influenced by different levels of Gibberellic acid ($GA_3$) application (Fig. 6 and Appendix XVI). Results showed that the highest fruit yield plot$^{-1}$ (7.61 kg) was found from the treatment $G_2$ (80 ppm $GA_3$) followed by the treatments $G_1$ (60 ppm $GA_3$) and

$G_3$ (100 ppm $GA_3$). The lowest fruit yield plot$^{-1}$ (4.71 kg) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The results obtained from the present study was similar with the findings of Sanodiya *et al*. (2017) and Mehraj *et al.* (2015).

**Effect of sowing time**

The recorded data on fruit yield plot$^{-1}$ was significant with different sowing time of okra (Fig. 7 and Appendix XVI). It was found that the highest fruit yield plot$^{-1}$ (6.96 kg) was achieved from the sowing time $S_2$ (30 April 2017) where the lowest fruit yield plot$^{-1}$ (6.13 kg) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical with the sowing time of $S_1$ (15 April 2017).

**Combined effect of $GA_3$ and sowing time**

Remarkable variation was observed on fruit yield plot$^{-1}$ influenced by combined effect of $GA_3$ and sowing time (Table 14 and Appendix XVI). Results revealed that the highest fruit yield plot$^{-1}$ (8.16 kg) was recorded from the treatment combination of $G_2S_2$which was statistically similar with the treatment combination of $G_1S_2$, $G_2S_1$ and $G_3S_2$. Again, the lowest fruit yield plot$^{-1}$ (4.42 kg) was recorded from the treatment combination of $G_0S_3$ which was statistically identical with the treatment combination of $G_0S_1$ and $G_0S_2$.

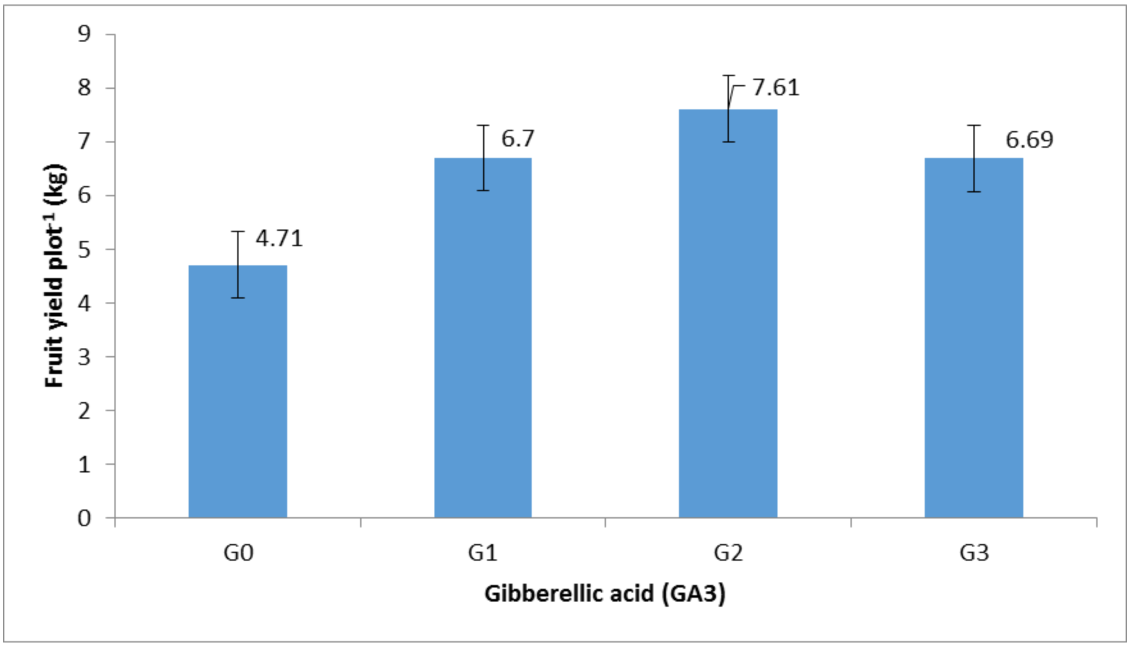


Fig. 6.Effect of gibberellic acid on fruit yield plot$^{-1}$ of okra

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

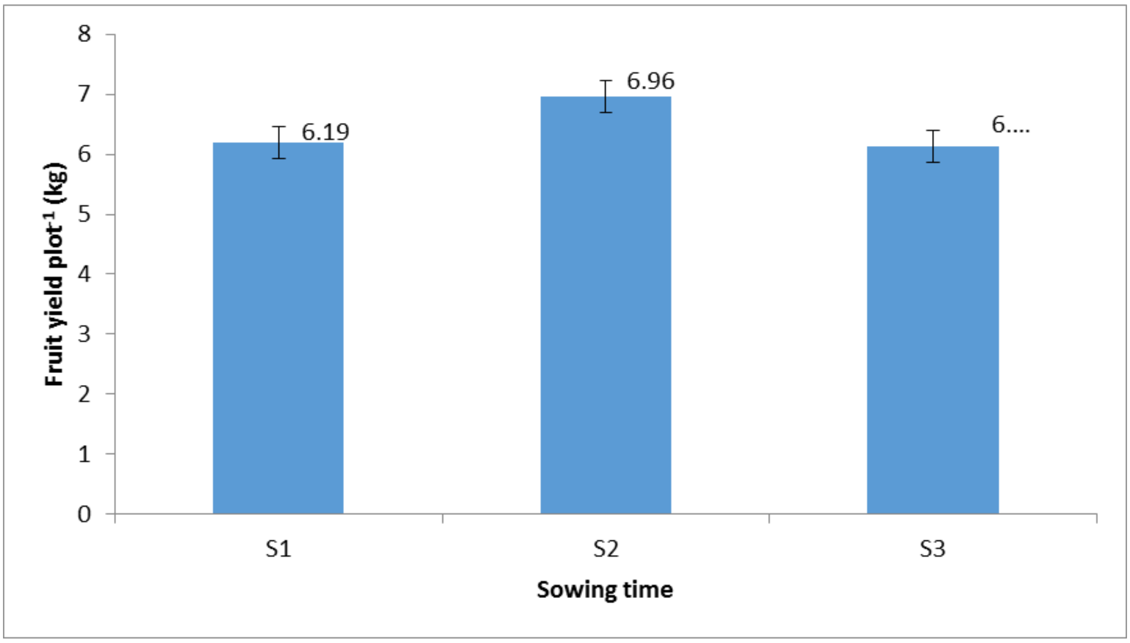



Fig. 7.Effect of sowing time on fruit yield plot$^{-1}$ of okra

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.3.2 Fruit yield $ha^{-1}$ (t)

**Effect of gibberellic acid ($GA_3$)**

Variation on fruit yield $ha^{-1}$ was noted influenced by different levels of Gibberellic acid ($GA_3$) application (Fig. 8 and Appendix XVI). Results denoted that the highest fruit yield $ha^{-1}$ (17.61 t) was found from the treatment $G_2$ (80 ppm $GA_3$) followed by the treatments $G_1$ (60 ppm $GA_3$) and $G_3$ (100 ppm $GA_3$) where the lowest fruit yield $ha^{-1}$ (10.91 t) was observed from the control treatment $G_0$ (0 ppm $GA_3$). The results obtained from the present study was conformity with the findings of Sanodiya *et al.* (2017). Ravat and Makani (2015).Mehraj *et al.* (2015) and Chowdhury *et al.* (2014).

**Effect of sowing time**

Remarkable variation was identified on fruit yield $ha^{-1}$ due to the effect of different sowing time of okra (Fig. 9 and Appendix XVI).The highest fruit yield $ha^{-1}$ (16.12 t) was achieved from the sowing time $S_2$ (30 April 2017) where the lowest fruit yield $ha^{-1}$ (14.18 t) was obtained from the sowing time $S_3$ (15 May 2017) which was statistically identical with the sowing time of $S_1$ (15 April 2017). Sonu *et al.* (2017), Shahid *et al.* (2015), Asadipour and Madani (2014), Moniruzzaman *et al.* (2007) and Firoz *et al.* (2007) also found similar results which supported the present study.

**Combined effect of $GA_3$ and sowing time**

Considerable influence was observed on fruit yield $ha^{-1}$ resulted by combined effect of $GA_3$ and sowing time (Table 14 and Appendix XVI). Results revealed that the highest fruit yield $ha^{-1}$ (18.90 t) was recorded from the treatment combination of $G_2S_2$which was statistically similar with $G_1S_2$ and $G_2S_1$. On the other hand, the lowest fruit yield $ha^{-1}$ (10.24 t) was recorded from the treatment combination of $G_0S_3$which was statistically identical with $G_0S_1$ and $G_0S_2$.

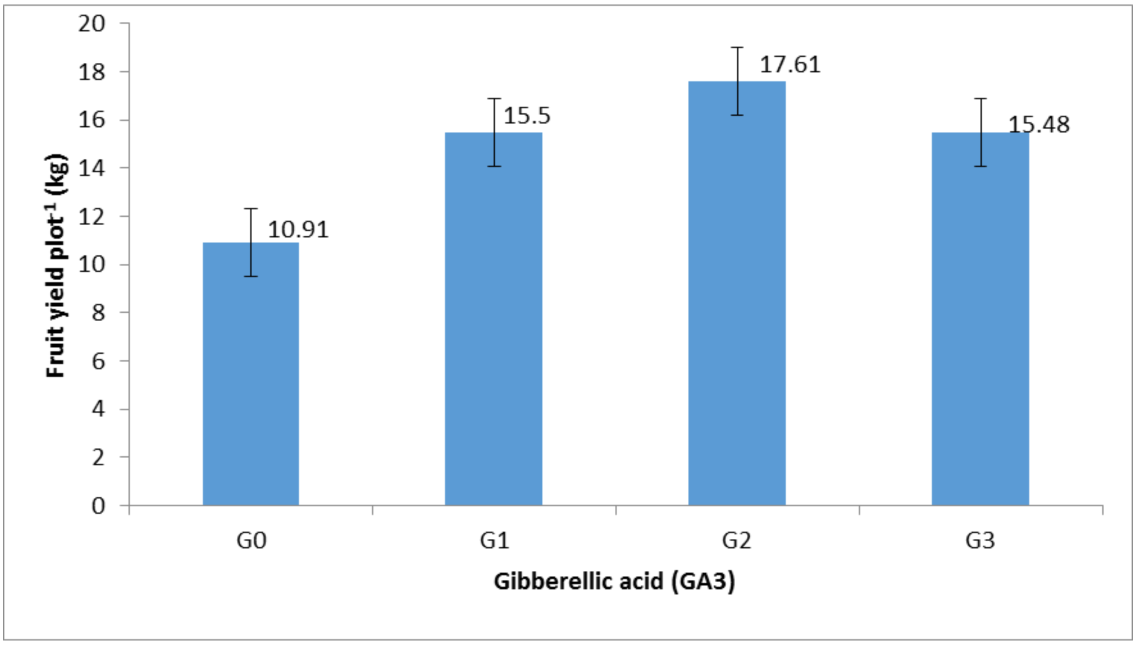


Fig. 8.Effect of gibberellic acid on fruit yield ha$^{-1}$ of okra

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

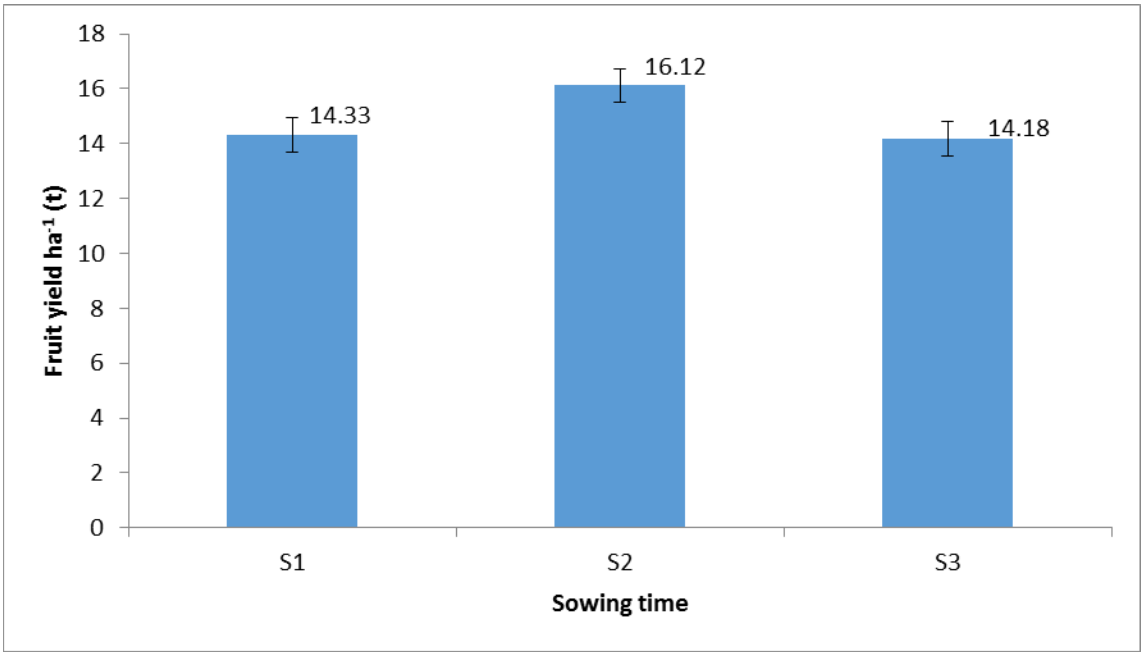


Fig. 9.Effect of sowing time on fruit yield ha$^{-1}$ of okra

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

Table 13.Combined effect of sowing time and gibberellic acid on yield parameters of okra

| Treatment | Yield parameters | |
|---|---|---|
| | Fruit yield plot$^{-1}$ (kg) | Fruit yield ha$^{-1}$ (t) |
| $G_0S_1$ | 4.77 d | 11.04 e |
| $G_0S_2$ | 4.95 d | 11.46 e |
| $G_0S_3$ | 4.42 d | 10.24 e |
| $G_1S_1$ | 6.13 c | 14.20 d |

| | | |
|---|---|---|
| $G_1S_2$ | 7.56 ab | 17.50 ab |
| $G_1S_3$ | 6.39 c | 14.80 cd |
| $G_2S_1$ | 7.66 ab | 17.72 ab |
| $G_2S_2$ | 8.16 a | 18.90 a |
| $G_2S_3$ | 7.00 bc | 16.20 bc |
| $G_3S_1$ | 6.20 c | 14.36 d |
| $G_3S_2$ | 7.17 abc | 16.60 b |
| $G_3S_3$ | 6.69 bc | 14.48 d |
| $LSD_{0.05}$ | 0.9367 | 1.472 |
| CV.(%) | 5.219 | 6.311 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$
$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

### 4.4 Economic analysis

All the material and non-material input cost like land preparation, okra seed cost organic manure, fertilizers, irrigation and manpower required for all the operation, interest on fixed capital of land (Leased land by ban loan basis) and miscellaneous cost were considered for calculating the total cost of production from planting seed to harvesting of okra fruit were recorded for unit plot and converted into cost per hectare (Table 15 and Appendix XVII). Price of okra fruit was considered at market rate of Kawran Bazar, Dhaka. The economic analysis is presented under the following headlines:

#### 4.4.1 Gross income

The combination of different $GA_3$ levels and sowing time showed different gross return (Table 15). Gross income was calculated on the basis of sale of pods. The highest gross return (Tk283500) obtained from $G_2S_2$ (80 ppm $GA_3$with sowing time at 30 April 2017) treatment combination and lowest gross return (Tk153600) obtained from the treatment combination of $G_0S_3$ (0 ppm $GA_3$ with sowing time at 15 May 2017).

#### 4.4.2 Net return

Treatment combinations of different $GA_3$ levels and sowing time showed net returns variation (Table 15). The highest net return (Tk. 192760) obtained from the treatment combination of $G_2S_2$ (80 ppm $GA_3$ with sowing time at 30 April 2017) and lowest net return (Tk. 65481) obtained from the treatment combination of $G_0S_3$ (0 ppm $GA_3$ with sowing time at 15 May 2017).

### 4.4.3 Benefit cost ratio (BCR)

Among different treatment combinations of $GA_3$ levels and sowing time, variation on BCR was observed among the treatment combinations (Table 15). The highest Benefit cost ratio (BCR); 3.12 was obtained from the treatment combination of $G_2S_2$ (80 ppm $GA_3$ with sowing time at 30 April 2017) and lowest BCR (1.74) was obtained from $G_0S_3$ (0 ppm $GA_3$ with sowing time at 15 May 2017) treatment combination. From economic point of view, it was noticeable from the above results, the treatment combination of $G_2S_2$ (80 ppm $GA_3$ with sowing time at 30 April 2017) was more profitable than rest of the treatment combinations.

Table 14. Cost and return analysis of okra considering sowing time and giberellic acid

| Treatment | Okra yield (t $ha^{-1}$) | Gross return (Tk. $ha^{-1}$) | Total cost of production (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
|---|---|---|---|---|---|
| $G_0S_1$ | 11.04 | 165600 | 88119 | 77481 | 1.88 |
| $G_0S_2$ | 11.46 | 171900 | 88119 | 83781 | 1.95 |
| $G_0S_3$ | 10.24 | 153600 | 88119 | 65481 | 1.74 |
| $G_1S_1$ | 14.20 | 213000 | 90085 | 122915 | 2.36 |
| $G_1S_2$ | 17.50 | 262500 | 90085 | 172415 | 2.91 |
| $G_1S_3$ | 14.80 | 222000 | 90085 | 131915 | 2.46 |
| $G_2S_1$ | 17.72 | 265800 | 90740 | 175060 | 2.93 |
| $G_2S_2$ | 18.90 | 283500 | 90740 | 192760 | 3.12 |
| $G_2S_3$ | 16.20 | 243000 | 90740 | 152260 | 2.68 |
| $G_3S_1$ | 14.36 | 215400 | 91395 | 124005 | 2.36 |
| $G_3S_2$ | 16.60 | 249000 | 91395 | 157605 | 2.72 |
| $G_3S_3$ | 14.48 | 217200 | 91395 | 125805 | 2.38 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was carried out at the horticultural research field of Sher –e-Bangla Agricultural University, Dhaka, during the period from April to August 2017 to study the effect of sowing time and gibberellic acid on the growth and yield of okra. The experiment consists of 2 factors such as (a) 4 levels of Gibberellic acid ($GA_3$) *viz*. $G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$and $G_3$ = 100 ppm $GA_3$ and (b) 3 levels of sowing time *viz*. $S_1$ = 15 April 2017, $S_2$ = 30 April 2017 and $S_3$ = 15 May 2017. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was 2.4 m × 1.5 m. The distance maintained between two plots was 0.5 m and between blocks was 1 m. different parameters were recorded on growth, yield and yield contributing parameters.

Gibberellic acid ($GA_3$) application, showed significant effect on growth, yield contributing parameters and yield of okra. Regarding growth parameters, it was found that the highest plant height (14.44, 53.99, 87.60 and 114.80 cm at 20, 40, 60 and 80 DAS, respectively), highest number of leaves plant$^{-1}$ (8.28, 22.60, 25.67 and 27.81 cm at 20, 40, 60 and 80 DAS, respectively), highest leaf length (20.52, 44.71, 46.79 and 48.67 cm at 20, 40, 60 and 80 DAS, respectively),highest leaf breadth (14.00, 27.76, 28.80 and 29.19 cm at 20, 40, 60 and 80 DAS, respectively), highest length of petiole (7.82, 22.28, 25.66 and 29.60 cm at 20, 40, 60 and 80 DAS, respectively),highest stem diameter (2.09, 2.19, 2.59 and 3.19 cm at 20, 40, 60 and 80 DAS, respectively) and highest length of internodes (5.49, 6.18, and 7.17 cm at 40, 60 and 80 DAS, respectively) were found from the treatment $G_3$ (100 ppm $GA_3$). Similarly, the highest number of branch plant$^{-1}$ (3.20, 3.73 and 4.78 at 40, 60 and 80 DAS, respectively),highest dry weight of leaves plant$^{-1}$ (6.86, 9.71 and 12.74% at 40, 60 and 80 DAS, respectively),highest length of fruit (11.05 cm ) and highest diameter of fruit(8.60 cm) were found from the treatment $G_2$ (80 ppm $GA_3$). Considering yield contributing parameters and yield of okra, the highest number of flowers plant$^{-1}$ (32.50), highest number of fruits plant$^{-1}$ (21.80),highest fresh weight of fruits plant$^{-1}$ (316.92 g),highest dry weight of fruits (10.17%),highest fruit yield plot$^{-1}$ (7.61 kg)and highest fruit yield ha$^{-1}$ (17.61 t) was found from the treatment $G_2$ (80 ppm $GA_3$). The lowest days to 1$^{st}$ flowering (34.78 days) was also found from the treatment $G_2$ (80 ppm $GA_3$).

Again, the lowest plant height (11.60, 40.33, 66.29 and 92.30 cm at 20, 40, 60 and 80 DAS, respectively),lowest number of leaves plant$^{-1}$ (7.15, 17.18, 21.09 and 22.83 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf length 15.08, 37.84, 40.00 and 41.34 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf breadth (11.55, 24.00, 25.98 and 26.73 cm at 20, 40, 60 and 80 DAS, respectively),lowest length of petiole (4.87, 19.22, 21.40 and 23.11 cm at 20, 40, 60 and 80 DAS, respectively),lowest stem diameter (0.68, 1.52, 1.87 and 2.51 cm at 20, 40, 60 and 80 DAS, respectively),lowest number of branch plant$^{-1}$ (1.82, 2.81 and 3.78 at 40, 60 and 80 DAS, respectively),lowest length of internode (4.05, 4.09 and 5.56 cm at 40, 60 and 80 DAS, respectively) and lowest dry weight of leaves plant$^{-1}$ (2.05, 4.45 and 6.67% at 40, 60 and 80 DAS, respectively) were observed from the control treatment $G_0$ (0 ppm $GA_3$). Likewise in terms of yield contributing parameters and yield of okra the lowest length of fruit (10.77cm) and lowest diameter of fruit (7.15 cm) were observed from the control treatment $G_0$ (0 ppm $GA_3$). The lowest number of flowers plant$^{-1}$ (22.41),lowest number of fruits plant$^{-1}$ (16.41),lowest fresh weight of fruits plant$^{-1}$ (196.44 g),lowest dry weight of fruits (7.28%),lowest fruit yield plot$^{-1}$ (4.71 kg)and lowest fruit yield ha$^{-1}$ (10.91 t)were also observed from the control treatment $G_0$ (0 ppm $GA_3$).The highest days to 1$^{st}$ flowering (44.00 days) was also obtained from the control treatment $G_0$ (0 ppm $GA_3$)

Different sowing time of okra showed significant influence for most of the studied parameters. Considering growth parameters, the highest plant height (13.61, 50.42, 82.17 and 108.19 cm at 20, 40, 60 and 80 DAS, respectively),highest number of leaves plant$^{-1}$ (7.87, 20.95, 24.24 and 26.61 cm at 20, 40, 60 and 80 DAS, respectively), highest leaf length (18.89, 42.52, 45.28 and 46.33 cm at 20, 40, 60 and 80 DAS, respectively),highest leaf breadth (13.38, 26.74, 28.09 and 28.37 cm at 20, 40, 60 and 80 DAS, respectively),highest length of petiole (6.83, 21.46, 24.70 and 27.83 cm at 20, 40, 60 and 80 DAS, respectively),highest stem diameter (1.49, 1.92, 2.13 and 2.99 cm at 20, 40, 60 and 80 DAS, respectively) and highest length of internode (5.11, 5.53 and 6.63 cm at 40, 60 and 80 DAS, respectively) were achieved from the sowing time $S_1$ (15 April 2017). The lowest days to 1$^{st}$ flowering (36.17 days) was also achieved from the sowing time $S_1$ (15 April 2017). Again, the highest number of branch plant$^{-1}$ (2.93, 3.53 and 4.59 at 40, 60 and 80 DAS, respectively) and highest dry weight of leaves plant$^{-1}$ (5.86, 8.17 and 11.38% at 40, 60 and 80 DAS, respectively) were achieved from the sowing time $S_2$ (30 April 2017). Regarding yield contributing parameters and yield of okra, the highest length of fruit (11.02 cm) and highest diameter of fruit (8.66 cm) were achieved from the sowing time $S_2$ (30 April 2017). Similarly, the highest number of flowers plant$^{-1}$ (30.23),highest number of fruits plant$^{-1}$ (20.59),highest fresh weight of fruits plant$^{-1}$ (290.07 g),highest dry weight of fruits (9.44%),highest fruit yield plot$^{-1}$ (6.96 kg)and highest fruit yield ha$^{-1}$ (16.12 t) was also gained from the sowing time $S_2$ (30 April 2017).

Conversely, the lowest number of branch plant$^{-1}$ (2.31, 3.27 and 4.17 at 40, 60 and 80 DAS, respectively) was obtained from the sowing time $S_1$ (15 April 2017) but the lowest plant height (12.62, 45.92, 72.70 and 100.49 cm at 20, 40, 60 and 80 DAS, respectively),lowest number of leaves plant$^{-1}$ (7.65, 18.34, 22.75 and 24.38 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf length (16.98, 40.80, 42.52 and 43.63 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf breadth (12.58, 25.52, 27.07 and 27.57 cm at 20, 40, 60 and 80 DAS, respectively),lowest length of petiole (5.99, 20.33, 22.75 and 25.73 cm at 20, 40, 60 and 80 DAS, respectively),lowest stem diameter (0.78, 1.66, 2.01 and 2.71 at 20, 40, 60 and 80 DAS, respectively),lowest length of internode (4.58, 4.64 and 6.08 cm at 40, 60 and 80 DAS, respectively),lowest dry weight of leaves plant$^{-1}$ (4.18, 7.06 and 9.52% at 40, 60 and 80 DAS, respectively) were obtained from the sowing time $S_3$ (15 May 2017).Evaluating, yield contributing parameters and yield of okra, the lowest length of fruit(10.79 cm) and lowest diameter of fruit(8.34 cm) were also obtained from the sowing time $S_3$ (15 May 2017). Again, the sowing time $S_3$ (15 May 2017) also showed lowest number of flowers plant$^{-1}$ (26.37), lowest number of fruits plant$^{-1}$ (18.92),lowest fresh weight of fruits plant$^{-1}$ (255.24 g),lowest dry weight of fruits (8.61%),lowest fruit yield plot$^{-1}$ (6.13 kg)and lowest fruit yield ha$^{-1}$ (14.18 t).The highest days to 1$^{st}$ flowering (40.58 days) was also obtained from the sowing time $S_3$ (15 May 2017).

All the studied parameters were significantly influenced by combined effect of $GA_3$ and sowing time. In case of growth parameters, the highest plant height (14.93, 59.73, 98.80 and 123.0 cm at 20, 40, 60 and 80 DAS, respectively),highest number of leaves plant$^{-1}$ (8.53, 26.60, 26.67 and 29.10 cm at 20, 40, 60 and 80 DAS, respectively),highest leaf length (22.07, 46.53, 48.30 and 50.43 cm at 20, 40, 60 and 80 DAS, respectively),highest leaf breadth (15.47, 28.27, 30.00 and 32.00 cm at 20, 40, 60 and 80 DAS, respectively),highest length of petiole (8.38, 22.50, 27.53 and 29.88 cm at 20, 40, 60 and 80 DAS, respectively),highest stem diameter (2.56, 2.60, 2.24 and 3.50 at 20, 40, 60 and 80 DAS, respectively) and highest length of internodes (5.80, 7.30 and 7.33 cm at 40, 60 and 80 DAS, respectively) were recorded from the treatment combination of $G_3S_1$. But the highest number of branch plant$^{-1}$ (3.60, 3.93 and 5.00 at 40, 60 and 80 DAS, respectively) and highest dry weight of leaves plant$^{-1}$ (7.64, 10.6 and13.40% at 40, 60 and 80 DAS, respectively) were obtained from the treatment combination of $G_2S_2$.Considering yield contributing parameters and yield of okra, the highest length of fruit(11.60 cm) and highest diameter of fruit (8.96 cm) were also recorded from the treatment combination of $G_2S_2$.The highest number of flowers plant$^{-1}$ (35.50),highest number of fruits plant$^{-1}$ (22.60),highest fresh weight of fruits plant$^{-1}$ (340.20 g),highest dry weight of fruits (10.70%),highest fruit yield plot$^{-1}$ (8.16 kg)and highest fruit yield ha$^{-1}$ (18.90 t)were also obtained from the treatment combination of $G_2S_2$.The lowest days to 1st flowering (32.00 days) was recorded from the treatment combination of $G_2S_1$.

Regarding growth parameters influenced by combined effect of $GA_3$ and sowing time, the lowest plant height (10.53, 38.93, 59.13 and 87.03 cm at 20, 40, 60 and 80 DAS, respectively),lowest number of leaves plant$^{-1}$ (7.130, 15.87, 20.53 and 20.00 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf length (14.53, 36.60, 36.87 and39.88 cm at 20, 40, 60 and 80 DAS, respectively),lowest leaf breadth (11.33, 22.60, 25.33 and 26.00 cm at 20, 40, 60 and 80 DAS, respectively),lowest length of petiole (4.40, 18.00, 19.67 and 21.00 cm at 20, 40, 60 and 80 DAS, respectively),lowest stem diameter (0.66, 1.51, 1.73 and 2.27 cm at 20, 40, 60 and 80 DAS, respectively), lowest length of internode (3.56, 3.77 and 5.00 cm at 40, 60 and 80 DAS, respectively) and and lowest dry weight of leaves plant$^{-1}$ (1.80, 4.30 and 6.40% at 40, 60 and 80 DAS, respectively) were recorded from the treatment combination of $G_0S_3$ but the lowest number of branch plant$^{-1}$ (1.88, 2.67 and 3.33 at 40, 60 and 80 DAS, respectively) was recorded from the treatment combination of $G_0S_1$.Evaluating, yield contributing parameters and yield of okra, lowest length of fruit(10.63 cm) and lowest diameter of fruit(7.86 cm) were achieved from the treatment combination of $G_0S_3$.This treatment combination ($G_0S_3$) also showed the highest days to 1st flowering (45.33 days), lowest number of flowers plant$^{-1}$ (22.18), lowest number of fruits plant$^{-1}$ (16.10), lowest fresh weight of fruits plant$^{-1}$ (184.30 g), lowest dry weight of fruits (7.20%), lowest fruit yield plot$^{-1}$ (4.42 kg)and lowest fruit yield ha$^{-1}$ (10.24 t).

In terms of economic analysis, it was found that the highest gross return (Tk283500) and the highest net return (Tk192760) were obtained from the treatment combination $G_2S_2$ (80 ppm $GA_3$ with the sowing time of 30 April 2017). The highest BCR (3.12) was also obtained from $G_2S_2$ (80 ppm $GA_3$ with the sowing time of 30 April 2017) treatment combination.

Again, the lowest gross return (Tk153600), lowest net return (Tk65481) and lowest BCR (1.74) were obtained from the treatment combination of $G_0S_3$ (0 ppm $GA_3$ with the sowing time of 15 May 2017).

Based on the experimental results, it may be concluded that

1. The effect of gibberellic acid ($GA_3$) and different sowing time of okra had positive effect on growth characters, yield and yield attributes in okra.
2. The treatment combination of $G_2S_2$ (80 ppm $GA_3$ with the sowing time of 30 April 2017) seemed to be more suitable for getting higher yield in okra.
3. From economic point of view the treatment combination of $G_2S_2$ (80 ppm $GA_3$ with the sowing time of 30 April 2017) was more suitable under the present study.

**Recommendations**

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

1. Such study may be conducted in different agro-ecological zones (AEZ) and seasons of Bangladesh for exploitation of regional adaptability and other performances
2. Some other levels of gibberellic acid ($GA_3$) and sowing time of okra may be included in future program for more confirmation of the results.

## REFERENCES


Abd El-Kader, A.A., Shaaban, S.M. and Abd El-Fattah, M.S. (2010). Effect of irrigation levels and organic compost on okra plants *(Abelmoschus esculentus* L.) grown in sandy calcareous soil. *Agric.Biol J. North Americ.*,**1**: 225-231.

Adom, K.K., Dzogbefia, V.P., Ellis, W.O. (1997).Combined effect of drying time slice thickness on the solar drying of okra. *J. Sci. Food Agric.*,**73**:315-320.

Akramghaderi, F., Latifi, N. and Rezaei, J. (2003).Effects of planting date on the phenology and morphology of three cotton cultivars in Gorgan. *Adv. Plant Sci.,***7** (2) : 244-250.

Alam, M.S., Iqbal, T.M.T., Amin, M. and Gaffar, M.A. (1989).Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T.M.,Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Amjad, M., Anjum, M.A. and Hussain, S. (2001). Effect of different sowing dates and various doses of fertilizers on juvenility and productivity of okra. *Pakistan J. Agric. Sci.*,**38**(1-2): 29-32.

Asadipour, A.and Madani, H. (2014). The effects of irrigation and sowing date on the quantitative traits of okra (*Abelmoschus esculentus* L.). *Intl J. Farm Alli Sci. Vol.*, **3** (5): 497-501.

Asghar, S., Hussain, S.A., Ali, N. (1997). Effect Of Xogenous Growth Regulators on growth, flowering and yield of okra (*Abelmoschus esculentus* L.). *Sarhad J. Agric*. **13**(5):449-453.

Atallah, S.Y. (2016). Performance of Five Okra Cultivars Sown on Different Dates under Assiut Environmental Conditions. *Assiut J. Agric. Sci*. **47**(6-1): 217-224.

Ayyub, C.M., Manan, A., Pervez, M.A., Ashraf, M.I., Afzal, M., Ahmed, S., Shoab- ur-Rehman, Jahangir, M. M., Anwar, N. and Shaheen, M.R.( 2013). Foliar feeding with gibberellic acid ($GA_3$): A strategy for enhanced growth and yield of okra ***(Abelmoschus esculentus*** (L.) Moench.).***African J. Agri ,Res,***8(25): 3299-3302.

Bake, I.D., Singh, B.K., Singh, A.K.,Moharana, D.P. and Maurya, A.K. (2017). Effect of sowing dates and planting distances on quantitative attributes of Okra [*Abelmoschus esculentus* (L.)Moench] cv. Kashi Pragati. Th*e Pharma Innovation J*. **6**(12): 142-148.

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

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

Bhagure YL and Tambe TB.(2011). Effect of seed soaking and foliar sprays of plant growth regulators on germination, growth and yield of okra *[Abelmoschu sesculentus* (L.)Moench] var. Parbhani Kranti.*The Asian J. Horticulture*.8(2): 399-402.

Bhuibhar, B.R., Mahakal, K.G., Kole, P.B. and Wankbade, S.G. (1989).Effect of time of sowing and number of pickings of green fruits on growth and seed yield of okra [*Abelmoschus esculentus* (L.) Moench].*PKV Res. J*.**13** (1): 39-43 .

Bisen, R.K.; Surender Jogdand and Bisen, C.S. (1994).Effect of sowing dates and spacings on the yield of okra seed [*Abelmoschus esculentus* (L.) *Moench]. Advances as Plant Sci.,***7** (2) : 244-250.

Briant, R.E. (1974).An analysis of the effects of Gibberellic acid on tomato leaf growth. *J. Exp. Bot.,***25**:764-771.

Chandiniraj, A., Holebasappa, K., Hore, J.K. and Chattopadyay, N. (2016). Growth and yield of chilli *(Capsicum annuum* L.) as influenced by different growth regulators, *The BIOSCAN, J. Int. Quarterly J. life Sci,* **11**(1): 385-388.

Chattopadhyay, A., Dutta, S. and Chatterjee, S. (2011).Seed yield and quality of okra as influenced by sowing dates.*African J. Biotechnology*.**10**(28): 5461-5467.

Chormule, S. R. and Patel, J. B. (2017).Effect of Spacing and Plant Growth Regulators on Plant Growth Parameters, Seed Yield and Its Attributes in Okra [*Abelmoschus esculentus* (L.).*Int. J. Pure App. Biosci*.**5** (5): 366-379.

Choudhury, S., Islam, N., Sarkar, M.D. and Ali, M.A. (2013). Growth and yield of summer tomato as influenced by plant growth regulators, *Int.J. Sustainable Agri*,**5**(1): 25-28.

Chowdhury, M.S., Hasan, Z., Kabir, K., Jahan, M.S. and Kabir, M.H. (2014).Response of okra (***Abelmoschus esculentus*** L.) to growth regulators and organic manures. ***A Scientific J. Krishi Foundation,***12(2): 56-63.

Davies, P.J. (1995). Plant Hormones, Physiology, Biochemistry, and Molecular Biology. *Universal J. Appl. Sci*. **2**(3): 64-67.

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

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

Dilruba, S., Hasanuzzaman, M, Karim, R. and Nahar, K. (2009). Yield response of okra to different sowing time and application of growth hormones. *J Hortic.Sci. Ornamental Plants* **1**: 10-14.

Ekwu, L.G.andNwokwu, G. N. (2012). Effect of plant spacing and planting date on the growth and yield of okra (*Abelmoschus esculentus* L.) in abakaliki.*Int. J. Agric. and Rural Dev*. **15** (2): 1041-1048.

Elhag, A.Z. and Ahmed, A.A. (2014). Effect of Cultivar and Sowing Date on Okra (*Abelmoschus esculentus* L. Moench.) Seed Yield. *Universal J. Appl. Sci*. **2**(3): 64-67.

Ezeakunne, C.O. (2004). Large scale fruit and vegetable production in Nigeria. Extension Bulletin, Ahmadu Bello University, Zaria, 8pp.

Fathima, M. and Balasubramanian, A. (2006).Effect of plant growth regulators on the quality of bastfibres in ***Abelmoschus esculentus*** (Linn.).Moench. ***Acta Botanica Croatica,***65(1): 101-112.

Fertilizer Recommendation Guide.(2016). Bangladesh Agriculture Research Council (BARC), Farmgate, Dhaka.

Firoz, Z. A., Islam, M. A.,Mohiuddin, M. and Rahman, M. M. (2007). Yield and yield attributes of okra as influenced by planting time and plant spacing in hill slope condition. *Progress. Agric*.,**18**(2) : 67-73.

Gadakh, S.R., Lawande, K.E. and Kale, P.N. (1990).Effect of different seasons and pacing on yield and quality of Bhindi. *Haryana J.Hort.Sci*.,**19**: 329-332

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

Gulshan, L., Singh, D.K., Jain, S.K. and Lai, G. (2001).Response of Okra *[Abelmoschus esculentus* (L.)] Moench) cultivars to varying sowing dates under Tarai foot hills of Himalayas. *Adv. Hort. For*.8: 129-137.

Hilli, J.S., Vyakarnahal, B.S., Biradar, D.P. and Hunje, R.(2010). Effect of growth regulators and stages of spray on growth, fruit set and seed yield of Ridge gourd *(Luffaacutangula L. Roxb),* Karnataka *J. Agri. Sciences*,**23**(2): 239242.

Hossain, M.D., Salam, M.A., Islam, M.S. and Masud, M.A.T. (1999). Yield and quality of Okra (BARI Dherosh-1) seed as influenced by time of sowing and plant spacing. *Bangladesh J. Seed Sci Tech***3** (1-2): 83-87.

Hussain, S., Muhammad, S., Noor-ul-Amin, Alam, S. and Iqbal, Z. (2006). Response of okra (*Abelmoschus esculentus*) cultivars to different sowing times.*J. Agril. Biol. Sci*.**1** (1): 55-59.

HussainSh, Sajid, M., Amin, N., Alam, S.H. and Iqbal, Z. (2006).Response of okra *(Abelmoschus esculentus)* cultivars to different sowing times.*J. Agric. Biol. Sci*.**1**(1): 54-59.

Islam, S., Chakrabortty, S., Uddin, M.J., Mehraj, H.and Jamal Uddin, A.F.M. (2014).Growth and Yield of Wheat as Influenced by $GA_3$ Concentrations. *Int. J. Business Social and Sci Res*, **2**(1): 74-78.

Joy, M. (2010). Productivity of okra (*Abelmoschus esculentus* L. Moench) at varying sowing dates in Makurdi, Nigeria. *J. Appl. Biosci*. **32**: 2015 – 2019.

Khajehpour, M. (2000).Principles and basis of agronomy. Publishing center of Isfahan University, Isfahan.

Khan, A.S. and Chaudhry, N.Y. (2006). $GA_3$ improves flower yield in some cucurbits treated with lead and mercury. *African J. Biotechnology*, **5**: 149-153.

Krishnaveni, V., Padmalatha, T., Padma, S.S.V. and Prasad, A.L.N. (2016). Influence of pinching and plant growth regulators on flowering, yield and economic of fenugreek *(Trigonellafoenum-graecum* L.), *J. Spices and Aromatic Crops*,**25** (1): 41-48.

Kumar, A., Biswas, T.K., Singh, N. and Lal, E.P. (2014). Effect of Gibberellic Acid on Growth, Quality and Yield of Tomato *(Lycopersicon esculentum* Mill) *J. Agri and Veterinary Science*,**7**(7):28-30.

Mehraj, H., Taufique, T., Ali, M.R., Sikder, R.K. and Jamal Uddin, A.F.M. (2015).Impact of $GA_3$ and NAA on horticultural traits of ***Abelmoschus esculentus*.*World Applied Sciences J.,*** 33(11): 1712-1717.

Mehraj, H., Taufique,T., Ona, A.F., Roni, M.Z.K. and Jamal Uddin, A.F.M. (2013). Effect of spraying frequency of gibberellic acid on growth and flowering in gerbera.*J. Experimental Biosciences*, **4**(2): 7-10.

Midmore, D.J. and Jansen, H.G.(2003). Supplying vegetables to Asian cities: is there a case forperi-urban production? *Food Policy*, **28**(1), pp.13-27.

MiriKh. (2006).Effects of sowing date and density on yield and yield components of okra *Abelmoschus esculentus* L. Moench in Iranshahr. *Seed and plant* **22**(3): 369-379.

Mohammadi, G., Khan, E.M., Petropoulos, S.A., Chachalis, D.B., Akbari, F. and Yarsi, G. (2014).Effect of gibberellic acid and harvesting time on the seed quality of four okra cultivars. ***J. Agricultural Science,***6(7): 200-211.

Mondal, G., Malik, S.C. and Maity, T.K. (1989).Effect of sowing date and spacing on the growth and yield of okra. *Crop Research Hisar*,**2** (2): 230-231.

Moniruzzaman, M., Khatoon, R., Hossain, M.F.B., Jamil, M.K. and Islam, M.N. (2014).Effect of $GA_3$ and NAA on physio-morphological characters, yield and yield components of brinjal ***(Solanum melongena*** L.).***Bangladesh J. Agricultural Research,*** 39(3): 397-405.

Moniruzzaman, M., Uddin, M. Z. and Choudhury, A. K. (2007).Response of okra seed crop to sowing time and plant spacing in south eastern hilly region of Bangladesh. *Bangladesh J. Agril. Res*.,**32**(3): 393-402.

Moniruzzaman, M., Uddin, M.Z. and Choudhury, A.K. (2007).Response of okra seed crop to sowing time and plant spacing in South Eastern hilly region of Bangladesh. *Bangladesh J. of Agric Research,***32**(3): 393 – 402.

Naeem, N., Ishtiaq, M., Khan, P. and Mohammad, N. (2001).Effect of gibberellic acid on growth and yield of tomato cv. Roma. *J. Biological Sciences*, **1**(6): 448-460.

Naz, I., Khan, H., Ali, A., Ahmad, M.,Hussain, A. and Tahir, M. (2007).Effect of various sowing dates and cultivars on the management of okra root rot under natural field conditions. *Sarhad J. Agric*. **25**(2): 251-260.

Njogu, M.K., Gathungu, G.K. and Daniel, P.M. (2015). Comparative effects of foliar application of gibberellic acid and benzyl aminopurine on seed potato tuber sprouting and yield of resultant plants, *American J.*

*Agriculture and Forestry*,**3**(5): 192-201.

Palanisamy, V. and Ramasamy, K.R. (1987). Influence of environmental factors on production and quality of seeds in bhindi [*Abelmoschus esculentus* (L.) Moench].*South Indian Hort*. **33** (I) : 58-59.

Passam, H.C., Akouminakis, K. and Sarigiannidi, A. (1998).The effect of time of sowing on the production of okra (*Hibiscus esculentus* L.) seed in the Mediterranean region.*Pl. Var. and Seed*.**11** (3) : 145-150.

Patil, D.R. and Patel, M.N. (2010).Effect of seed treatment with $GA_3$ and NAA on growth and yield of okra ***(Abmelmoschus esculentus*** L. Moench.) cv. GO-2.*The Asian J. Horticulture,**5**(2): 269-272.*

Prajapati, V.P. and Varma, L.R.(2014). Effect of spray treatment of plant growth substances at different stages on growth and yield of sweet pepper *(Capsicum annum* L.) cv. Indra under green house, *International J. Life Sciences Research***2**(4): 235-240.

Prasad, R.N., Singh, S.K., Yadava, R.B. and Chaurasia, S.N.S. (2013).Effect of $GA_3$and NAA on growth and yield of tomato. ***Vegetable Science,***40(2): 195-197.

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

Raghav, M. (1996). Influence of dates of sowing and plant spacing on growth and yield of okra. *Recent Hort*. **3** (1): 99-101.

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

Rathod, R.R., Gore, R.V. and Bothikar, P.A. (2015).Effect of growth regulators on growth and yield of French bean *(Phaseolus vulgaris* L.) Var. Arkakomal, *J. Agriculture and Veterinary Science,* **8**(5): 36-39.

Ravat, A.K. and Makani, N. (2015). Influence of plant growth regulators on growth, seed yield and seed quality in okra ***(Abelmoschus esculentus***

(L.) Moench.) cv. GAO-5 under middle Gujarat condition. ***International J. Agricultural Sciences,***11(1): 151-157.

Ross, J.J., James, B.R., Noel, W.D., Ian, C.M. (1990). Murfet. I.C.: Internode length in Lathyrusodoratus: The involvement of gibberellins. *Physiol. Plant*. **79**: 448-452.

.Shahid, M.R., Amjad, M. and Ziaf, K. (2013).Growth, yield and seed production of okra as influenced by different growth regulators.*Pak. J. Agri. Sci*. **50**(3), 387-392

Sajjan, A.S., Shekhargouda, M. and Badanur, V.P. (2002). Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. *Karnataka J. Agric. Sci.***15**(2): 267-274.

Samapika, D., Singh. M.K., Singh, K.V., Kumar, M., Malik, S. and Kumar, V. (2015). Effect of foliar application of $GA_3$ and NAA on growth, flowering yield and yield attributes of cucumber. ***Annals Horti***, 8(2): 181-194.

Sanodiya, K., Pandey, D., Kacholli, P. and Dubey, A.K. (2017).Effect of Growth Regulator on Growth, Yield and Seed Quality Parameters of Okra (*Abelmoschus esculentus* L.).*Int. J. Current Microbiol. Appl. Sci*. **6**(10): 3551-3556.

Sanodiya, K.A.N. (2015). *Effect of growth regulator on Growth, yield and seed quality parameters of okra (Abelmoschus esculentus L.): cv. Utkal Gaurav* (Doctoral dissertation).

Savello, P.A., Mortin, F.W. and Hill, J.M. (1980).Nutritional composition of okra seed meal. *Agril food Chem*., **28**: 1163-1166.

Sharif Hossain, A.B.M., Wahab, A. and Onguso, J.M. (2003).Comparative studies on the effect of sowing dates and spacing on the growth and yield of okra in different years.*J. Biol. Sci*.**3**(12): 1173-1180.

Sharma, M.D.,(2006). Effect of plant growth regulators on growth and yield of brinjal at khajura, banke, *J. The Institute of Agriculture and Animal Science*, **27**(1): 153-156.

Singh, D.,Vadodaria, J.R. and Morwal, B.R. (2017).Effect of $GA_3$ and NAA on Yield and Quality of Okra (*Abelmoschus esculentus* L.).*KrishiVigyan*.,**6**(1): 65-67.

Singh, J., Singh, B.K., Singh, A.K., Panwar, M. and Singh, B. (2012).Effect of foliar spray of $GA_3$and IBA on plant characters and yield of okra *[Abelmoschus esculentus* (L.) Moench], *Environment & Ecology*, **30**(4): 1351-1353.

Sonu, S.J.P., Nathiram, R. and, Himanshu, K. (2013).Effect of sowing dates and plant geometry on growth and yield of okra cv. Parbhani Krantiand Pusaa-4.*Asian J. Hort.*, **8**(2) : 772-774.

Srivastava, N.K., Srivastava, A.K. (2007). Influence of gibberellic acid on 14CO2 metabolism, growth, and production of alkaloids in Catharanthusroseus. *Photosynthetica* **45**:156-60.

Srivastava, V.K., Sachan, S.C.P. (1971). Effect of IAA and GA on growth and yield in okra .*Indian J. Hort.***28**:237-239.

Sure, S., Arooie, H. and Azizi, M. (2012). Influence of plant growth regulators (PGRs) and planting method on growth and yield in pumpkin *(Cucurbitapepo* var. *Styriaca), Notulae Scientia Biologicae*,**4**(2): 101-107.

Surendra, P., Nawalagatti, C.M., Chetti, M.B. and Hiremath, S.M. (2006).Effect of plant growth regulators and micronutrients on yield and yield components in okra. ***Karnataka J. Agriculture Science,*** 19(2): 264-267.

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

Taiz, L. and Zeiger, E. (2010). Gibberellins: Regulators of plant height and seed germination. *Plant Physiology, Sinauer Associates, Sunderland*, pp.583-619.

Thomson, T., Patel, G.S., Pandya, K.S., Dabhi, J.S. and Pawar, Y. (2015). Effect of plant growth substances and antioxidants on growth, flowering, yield and economics of garden pea, *Pisumsativum* L cv.

Bonneville, *International J.Farm Sciences,***5**(1): 8-13.

Tomar, S., Dubey, A.K., Singh, S.K. and Ujjwal, V. (2016).Effect of different levels of NAA, $GA_3$ and 2, 4-D on growth and yield of tomato ***(Lycopersicon esculentum*** Mill).***Annals Horti,***9(1): 97-100.

Unanamba, C.I.N., Ezeibekwe, I.O. and Mbagwu, F.M. (2010).Comparative effect of foliar spray and seed soaking application method of gibberellic acid on growth of ***Abelmoschus esculentus*** (Okra dwarf).***J. American Science,***5(4): 133-140.

UNDP.(1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212, 577.

Yadav, S.K., Dhankhar, B.S., Deswal, D.P. and Tomer, R.P.S. (2002).Effect of sowing date and plant geometry on seed production and quality of okra *(Abelmoschus esculentus* L. Moench) cv. Varsha Uphar. *Seed Res.* **29**(2): 149-152.

Yadev, S.K., Dhankhar, B.S. (2002). Performance of Varsha Uphar cultivar of okra as *affected* by the sowing dates and plant geometry. *Vegetable Sci*. **27**: 70 - 74.

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

# APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

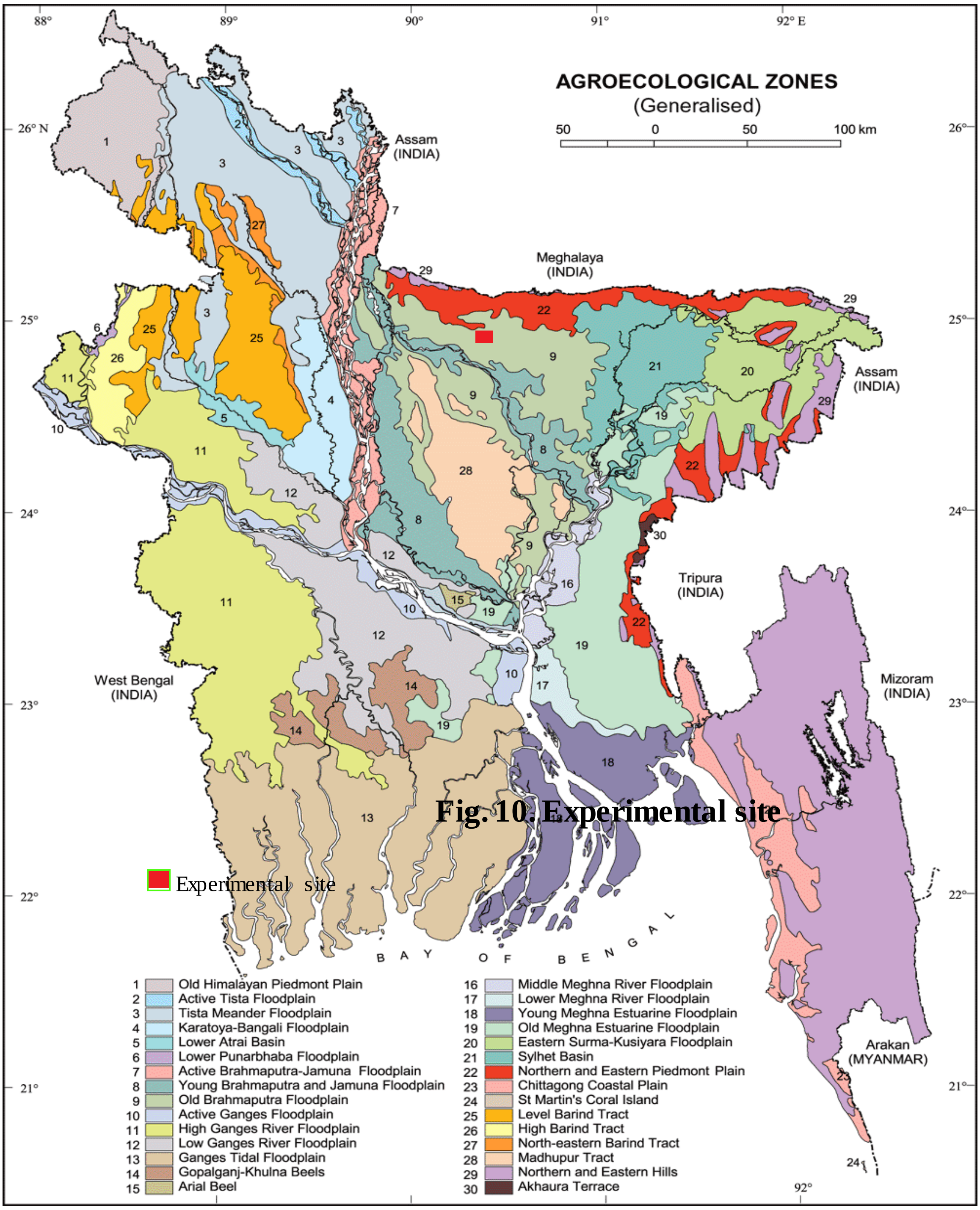



**Fig. 10. Experimental site**

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from April 2017 to August, 2017

| Month and year | RH (%) | Air temperature (C) | | | Rainfall (mm) | Sunshine (Hours) |
|---|---|---|---|---|---|---|
| | | *Max.* | *Min.* | *Mean* | | |
| April, 2017 | 71.6 | 34.6 | 29.2 | 31.9 | 3.0 | 210.5 |
| May, 2017 | 66.5 | 33.6 | 24.6 | 29.1 | 3.0 | 218.1 |
| June, 2017 | 74.0 | 33.5 | 26.6 | 30.1 | 3.5 | 221.5 |
| July, 2017 | 63.4 | 34.8 | 28.6 | 31.2 | 3.5 | 221.2 |
| August, 2017 | 65.8 | 33.6 | 29.5 | 31.6 | 2.8 | 222.4 |

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

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Agronomy Farm, SAU, Dhaka |
| *AEZ* | Modhupur 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 |
| Cropping pattern | Not Applicable |

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam (ISSS) |
| Ph | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI

Appendix IV. Effect of sowing time and gibberellic acid on plant height of okra at different days after sowing

| Source of variance | Degree of freedom | Mean Square Plant height (cm) at | | | |
|---|---|---|---|---|---|
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.132 | 0.467 | 1.104 | 1.311 |
| GibberellicAcid(A) | 2 | 8.325* | 14.78* | 17.87* | 22.524* |
| Sowing time(B) | 3 | 13.11* | 21.68* | 38.48* | 42.362* |
| Interaction (A×B) | 6 | 9.74NS | 18.79* | 14.69* | 14.855* |
| Error | 22 | 1.014 | 1.314 | 2.514 | 2.514 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix V. Effect of sowing time and gibberellic acid on number of leaves plant$^{-1}$ of okra

| Source of variance | Degree of freedom | Mean Square Number of leaves plant$^{-1}$ at | | | |
|---|---|---|---|---|---|
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.762 | 2.715 | 2.777 | 4.121 |
| Gibberellic Acid (A) | 2 | 9.852* | 8.993* | 9.112* | 14.215* |
| Sowing time(B) | 3 | 12.721* | 4.182** | 22.161** | 32.802* |
| Interaction (A×B) | 6 | 8.269** | 7.565** | 6.825* | 11.771* |
| Error | 22 | 2.469 | 3.089 | 3.892 | 3.765 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix VI. Effect of sowing time and gibberellic acid on leaf length of okra

| Source of variance | Degree of freedom | Mean Square Leaf length (cm) at | | | |
|---|---|---|---|---|---|
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.789 | 2.173 | 1.995 | 3.701 |

| | | | | | |
|---|---|---|---|---|---|
| Gibberellic Acid (A) | 2 | 9.101* | 11.805* | 15.127* | 14.293* |
| Sowing time(B) | 3 | 14.125* | 23.276* | 31.814* | 39.089* |
| Interaction (A×B) | 6 | 7.521* | 9.444 | 13.136** | 10.104** |
| Error | 22 | 1.809 | 3.369 | 3.376 | 3.267 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix VII. Effect of sowing time and gibberellic acid on leaf breadth of okra

| Source of variance | Degree of freedom | Mean Square | | | |
|---|---|---|---|---|---|
| | | Leaf breath (cm) at | | | |
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.307 | 0.916 | 1.016 | 0.998 |
| Gibberellic Acid (A) | 2 | 6.109* | 9.199* | 10.101* | 8.898* |
| Sowing time(B) | 3 | 10.113** | 23.619* | 25.295* | 28.312* |
| Interaction (A×B) | 6 | 8.216* | 12.192* | 9.123* | 8.916* |
| Error | 22 | 0.739 | 2.222 | 2.889 | 2.088 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix VIII. Effect of sowing time and gibberellic acid on length of petiole of okra

| Source of variance | Degree of freedom | Mean Square | | | |
|---|---|---|---|---|---|
| | | Length of petiole | | | |
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.888 | 1.998 | 1.837 | 0.985 |
| Gibberellic Acid (A) | 2 | 5.757* | 10.103* | 14. 144* | 12.693* |
| Sowing time(B) | 3 | 9.192* | 21.219* | 24.482** | 23.275* |
| Interaction | 6 | 4.214* | 7.192* | 9.591** | 15.559** |

| | | | | | |
|---|---|---|---|---|---|
| (A×B) | | | | | |
| Error | 22 | 0.855 | 2.863 | 3.339 | 3.472 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix IX. Effect of sowing time and gibberellic acid on stem diameter of okra

| Source of variance | Degree of freedom | Mean Square | | | |
|---|---|---|---|---|---|
| | | Stem diameter (cm) at | | | |
| | | 20 DAS | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.891 | 0.078 | 0.445 | 0.189 |
| Gibberellic Acid (A) | 2 | 3.453* | 5.527* | 6.672* | 6.997* |
| Sowing time(B) | 3 | 1.089 NS | 3.773 NS | 1.516 NS | 2.001 NS |
| Interaction (A×B) | 6 | 1.652* | 2.275* | 2.828 | 2.895* |
| Error | 22 | 0.0918 | 1.101 | 0.175 | 0.813 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix X. Effect of sowing time and giberellic acid on number of branch plant$^{-1}$ of okra

| Source of variation | Degrees of freedom | Mean Square | | |
|---|---|---|---|---|
| | | Number of branch plant$^{-1}$ | | |
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.016 | 0.341 | 0.631 |
| Gibberellic Acid (A) | 2 | 2.022 * | 6.487** | 8.3446* |
| Sowing time(B) | 3 | 8.718** | 8.026* | 13.083* |
| Interaction (A×B) | 6 | 4.365* | 4.951** | 6.249* |
| Error | 22 | 0.140 | 0.316 | 0.528 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XI. Effect of sowing time and gibberellic acid on length of internodes of okra

| Source of variation | Degrees of freedom | Mean Square | | |
|---|---|---|---|---|
| | | Length of internodes (cm) | | |
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.766 | 0.0677 | 0.929 |
| Gibberellic Acid (A) | 2 | 2.275* | 8.226** | 9.982* |
| Sowing time(B) | 3 | 5.282* | 9.953* | 14.167* |
| Interaction (A×B) | 6 | 2.134* | 5.565** | 8.229** |
| Error | 22 | 0.717 | 0.884 | 1.616 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XII. Effect of sowing time and gibberellic acid on percent dry weight of leaves $plant^{-1}$ of okra

| Source of variation | Degrees of freedom | Mean Square | | |
|---|---|---|---|---|
| | | Dry weight of leaves $plant^{-1}$ (%) | | |
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.766 | 0.867 | 2.278 |
| Gibberellic Acid (A) | 2 | 6.732* | 8.885* | 10.100* |
| Sowing time(B) | 3 | 8.695* | 12.192* | 15.536* |
| Interaction (A×B) | 6 | 5.625* | 9.909* | 8.186* |
| Error | 22 | 0.683 | 1.0982 | 2.789 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XIII. Effect of sowing time and gibberellic acid on length of fruit of okra

| Source of variation | Degrees of freedom | Mean Square | | |
|---|---|---|---|---|
| | | Length of fruit (cm) | | |
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.086 | 0.122 | 0.242 |
| Gibberellic Acid (A) | 2 | 7.316* | 6.014** | 6.262* |

| | | | | |
|---|---|---|---|---|
| Sowing time(B) | 3 | 12.42* | 15.167* | 17.28* |
| Interaction (A×B) | 6 | 5.506** | 7.135** | 10.55* |
| Error | 22 | 0.324 | 0.304 | 0.436 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XIV. Effect of sowing time and gibberellic acid on diameter of fruit of okra

| Source of variation | Degrees of freedom | Mean Square | | |
|---|---|---|---|---|
| | | Diameter of fruit (cm) | | |
| | | 40 DAS | 60 DAS | 80 DAS |
| Replication | 2 | 0.064 | 0.076 | 0.103 |
| Gibberellic Acid (A) | 2 | 2.326* | 4.115* | 5.567* |
| Sowing time(B) | 3 | 6.227** | 9.882* | 8.382* |
| Interaction (A×B) | 6 | 1.538* | 3.521* | 2.765* |
| Error | 22 | 0.047 | 0.138 | 0.171 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XV. Effect of sowing time and gibberellic acid on yield contributing parametersof okra

| Source of variation | Degrees of freedom | Mean Square | | | | |
|---|---|---|---|---|---|---|
| | | Yield and yield contributing parameters | | | | |
| | | Days required for 1st flowering | Number of flowers plant$^{-1}$ | Number of fruits plant$^{-1}$ | Fresh weight of fruits plant$^{-1}$ (g) | Dry weight of fruits (%) |
| Replication | 2 | 1.533 | 1.314 | 0.831 | 2.426 | 0.154 |
| Gibberellic Acid (A) | 2 | 14.232* | 17.518* | 11.358* | 28.601* | 5.207** |
| Sowing time(B) | 3 | 26.215* | 32.652* | 23.456** | 117.417* | 13.134* |
| Interaction | 6 | 12.568* | 14.131 | 12.291* | 36.525* | 6.249* |

| | | | | | | |
|---|---|---|---|---|---|---|
| (A×B) | | | * | | * | * |
| Error | 22 | 0.695 | 1.749 | 1.052 | 3.024 | 0.214 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XVI. Effect of sowing time and gibberellic acid on yield parametersof okra

| Source of variation | Degrees of freedom | Mean Square | |
|---|---|---|---|
| | | Yield and yield contributing parameters | |
| | | Fruit yield $plot^{-1}$ (kg) | Fruit yield $ha^{-1}$ (t) |
| Replication | 2 | 0.174 | 0.513 |
| Gibberellic Acid (A) | 2 | 3.38** | 8.958* |
| Sowing time(B) | 3 | 8.74* | 13.129* |
| Interaction (A×B) | 6 | 5.48** | 6.038* |
| Error | 22 | 0.412 | 1.91 |

**: Significant at 1% level of probability; *: Significant at 5% level of probability

Appendix XVII: Cost of production of okra per hectare

A. Input cost (Tk. $ha^{-1}$)

| Treatments | Cultivation with Labor | Seed cost | Pesticides | Irrigation | Cowdung | Fertilizer | | | | Seed sowing cost | $GA_3$ cost | Subtotal (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Urea | TSP | MP | Gypsum | | | |
| $G_0S_1$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 0 | 42600 |
| $G_0S_2$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 0 | 42600 |
| $G_0S_3$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 0 | 42600 |
| $G_1S_1$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 1800 | 44400 |
| $G_1S_2$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 1800 | 44400 |
| $G_1S_3$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 1800 | 44400 |
| $G_2S_1$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 2400 | 45000 |
| $G_2S_2$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 2400 | 45000 |
| $G_2S_3$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 2400 | 45000 |
| $G_3S_1$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 3000 | 45600 |
| $G_3S_2$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 3000 | 45600 |
| $G_3S_3$ | 14000 | 1000 | 3000 | 2500 | 6000 | 2000 | 2500 | 2400 | 1200 | 8000 | 3000 | 45600 |

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$

$S_1$ = 15 April 2017, $S_2$ = 30 April 2017, $S_3$ = 15 May 2017

B. Overhead cost (Tk. $ha^{-1}$), Cost of production (Tk. $ha^{-1}$), Gross return (Tk. $ha^{-}$

| Treatments | Overhead cost (Tk. $ha^{-1}$) | | | | Subtotal (A) | Total cost of production ( A+B) | Yield $ha^{-1}$ (ton) | Gross return (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cost of leased land for 6 months (8% of value of land Tk. | Miscellaneous cost ( Tk. 5% of the input cost) | Interest on running capital for 6 month (8% | Subtotal (B) | | | | | | |
| $G_0S_1$ | 40000 | 2130 | 3389 | 45519.2 | 42600 | 88119 | 11.04 | 165600 | 77481 | 1.88 |
| $G_0S_2$ | 40000 | 2130 | 3389 | 45519.2 | 42600 | 88119 | 11.46 | 171900 | 83781 | 1.95 |
| $G_0S_3$ | 40000 | 2130 | 3389 | 45519.2 | 42600 | 88119 | 10.24 | 153600 | 65481 | 1.74 |
| $G_1S_1$ | 40000 | 2220 | 3465 | 45684.8 | 44400 | 90085 | 14.20 | 213000 | 122915 | 2.36 |
| $G_1S_2$ | 40000 | 2220 | 3465 | 45684.8 | 44400 | 90085 | 17.50 | 262500 | 172415 | 2.91 |
| $G_1S_3$ | 40000 | 2220 | 3465 | 45684.8 | 44400 | 90085 | 14.80 | 222000 | 131915 | 2.46 |
| $G_2S_1$ | 40000 | 2250 | 3490 | 45740 | 45000 | 90740 | 17.72 | 265800 | 175060 | 2.93 |
| $G_2S_2$ | 40000 | 2250 | 3490 | 45740 | 45000 | 90740 | 18.90 | 283500 | 192760 | 3.12 |
| $G_2S_3$ | 40000 | 2250 | 3490 | 45740 | 45000 | 90740 | 16.20 | 243000 | 152260 | 2.68 |
| $G_3S_1$ | 40000 | 2280 | 3515 | 45795.2 | 45600 | 91395 | 14.36 | 215400 | 124005 | 2.36 |
| $G_3S_2$ | 40000 | 2280 | 3515 | 45795.2 | 45600 | 91395 | 16.60 | 249000 | 157605 | 2.72 |
| $G_3S_3$ | 40000 | 2280 | 3515 | 45795.2 | 45600 | 91395 | 14.48 | 217200 | 125805 | 2.38 |

$^{1}$), Net return (Tk. $ha^{-1}$) and BCR

** Cost of okra = 15 Tk $kg^{-1}$

$G_0$ = 0 ppm $GA_3$, $G_1$ = 60 ppm $GA_3$, $G_2$ = 80 ppm $GA_3$, $G_3$ = 100 ppm $GA_3$