GROWTH AND YIELD OF OKRA AS INFLUENCED BYPOTASSIUMAND GIBBERELLIC ACID

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DHAKA-1207

DECEMBER,2015

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REGISTRATION NO. 10-04014

AThesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JULY-DECEMBER, 2015

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD OF OKRA AS INFLUENCED BY POTASSIUM AND GIBBERELLIC ACID"** submitted to the Faculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **Horticulture,** embodies the results of a piece of bonafide research work carried out by **Samia Nur Afrose** Registration. No. **10-04014** under my supervision and guidance. No part of this 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.

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ACKNOWLEDGEMENTS

Each and every glorification is for the immense mercy of Almighty Allah Who has made the author to avail in every moment, in every single case to materialize the research work and thesis successfully for the degree of Master of Science (MS) in Horticulture.

The author is really fortunate to have her supervisor, Md. Hasanuzzaman Akand, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for his scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.

The author expresses her sincere appreciation, profound sense, respect and immense indebtedness to respected co-supervisor, Dr. Jasim Uddain, Associate Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant encouragement, cordial suggestion, and valuable advice to complete the thesis.

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for their valuable teaching and sympathetic co-operations, throughout the course of this study and research work. The author wishes to extend her special thanks to Zannatul Abira, Sharif Imran and Esratunnesa Easha for their help during experimentation. Special thanks to all of her friends for their support and encouragement to complete this study.

The author is deeply indebted to her respected parents and also her only younger sister whose inspiration and moral support opened the gate and paved the way of higher study.

Finally, the author appreciate the assistance rendered by the staff members, of the Department of Horticulture and Horticulture Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka, who have helped her during the period of study.

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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during April to August 2015. BARI Dherosh-1 was used in this experiment. The experiment consisted of two factors viz., Potassium fertilizer as K_0: 0 kg K_2O/ha (control) , K_1: 60 kg K_2O/ha, K_2: 90 kgK_2O/ha and K_3: 120 kg K_2O/ha; and Gibberellic acid (3 levels) as G_0: 0 ppm

GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3 respectively. The experiment was laid out in Randomized Complete Block Design with three replications. All the parameters were significantly influenced by different levels of potassium and gibberellic acid. Due to the effect of potassium, the highest yield (19.04 t/ha) was observed from K_3 and the lowest yield (12.11 t/ha) from K_0. In case of Gibberellic acid, the highest yield (17.08t/ha) was found from G_2 and the lowest yield (16.01 t/ha) from G_0. For combined effect, the highest yield (21.50 t/ha) was found from K_3G_2 and the lowest yield (11.65 t/ha) from K_0G_0. The highest benefit cost ratio (2.91) was noted from K_3G_2 and the lowest (1.30) from K_0G_2. From growth,

yield and economic point of view, it is apparent that the application of 120 kg K_2O/ha with 90 ppm GA_3 was the best for growth and yield of okra.

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CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus L*) is being a member crop of Malvaceae, locally known as "Dherosh" or "Bhindi". It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world. It is used as vegetable in many regions of the world, especially in the developing countries (Tamura and Minamide, (1984). Okra is specially valued for its tender and delicious edible pods which is rich source of vitamins and minerals.Okra possibly originated from East Africa, as it has been grown there for 4000 years. It is commonly cultivated in tropical or Mediterranean climate for its fresh pods. It grows best in hot weather (temperatures above 26°C). The most important okra-producing countries are India, Nigeria, Pakistan, Ghana and Egypt. In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during kharif season and around 70% in the rabi season (Anon., 1993). Therefore, as vegetable okra can get an importance in kharif season as well as summer season in our country context. There are variations of the per capita consumption of vegetables in SAARC countries, where it was in Pakistan (69 g), Srilanka (120 g), and India (135 g) and all are higher than that of Bangladesh (35 g). Although, many dietitians prescribed that the daily requirements of vegetables for an adult person is approximately 285 g (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and per capita vegetable consumption in Bangladesh. As a result, malnutrition is very much evident in our country. Successful okra production may contribute partially in solving vegetable scarcity of summer season for the Bangladeshi people. The low yield of okra in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties in appropriate time, fertilizer management, disease and insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices. Among the different reasons fertilizer management is the important factor that greatly affects the growth, development and yield of this crop.

The application of potassium influences the physical and chemical properties of soil and enhanced the biological activities. Potassium helps to protein production, increase seed size, improve fruit quality of plant. It is essential for production of starch, sugar and oil. Deficiency of soil nutrient is considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). To attain considerable production and quality yield for any crop it is necessary to proper management ensuring the availability of essential nutrient in proper doses. Generally, a large amount of fertilizer is required for the growth and development of okra (Opena *et al.*, 1988). So, the management of fertilizer especially potassium is the important factor that greatly affects the growth, development and yield of okra.. Potassium levels influenced the growth and yield of okra. Potassium is essential macronutrient for plant growth and plays significant roles in activation of several metabolic processes including protein synthesis, photosynthesis, and enzyme activation as well as in resistance to diseases and insects etc. (Rehm and Schmitt, 2002).

Gibberellic acid has significant effect on plant height and pod development

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).

OBJECTIVES

The present study carried with the following objectives:

1. To determine the optimum level of gibberellic acid on growth and yield of okra
2. To optimize different potassium level on growth and yield of okra and
3. To find out the suitable combination of gibberellic acid and potassium for ensuring better growth and higher yield of okra.

CHAPTER II

REVIEW OF LITERATURE

Okra is specially valued for its tender and delicious edible pods and is an important summer vegetable crop in Bangladesh. Management of fertilizer especially potassium and improvement of production technology by plant hormone gibberellic acid is the important factor that greatly affects the growth, development and yield of okra. So it is important to assess the effect of potassium and gibberellic for the best growth and yield of okra. However, limited research reports on the performance of okra in response to potassium and gibberellic acid have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect reviewed under the following headings:

2.1 EFFECT OF POTASSIUM ON GROWTH AND YIELD OF OKRA Ahmed and Tullock-Reild (1968) studied the response of okra to nitrogen, phosphorus, potassium and magnesium fertilization at Trindad on loam soil and best yields were obtained with 112 kg N, 168 kg P, 280 kg K and 112 kg Mg per hectare.

An experiment was conducted by Chauhan and Gupta (1973) to find out the effect of NPK on growth and yield of okra (*Abelmoschus esculentus*).They found that plant height and girth, number of leaves and yield of green pod increased by increasing the application of N (22.5, 45.0 or 67.5 kg/ha).P at 22.5 or 45.0 kg/ha and K at 22.5 kg/ha had no effect on growth and yield. NPK applications, however, generally increased yields. In a 2 year trials with okra the effects were assessed of N (as urea) at 40-120 kg/ha, P_2O_5 (as superphosphate) at 17.44-52.32 kg/ha and K (as murate) at 24.9-74.7 kg/ha (Sharma and Shukla, 1973).The highest yields were obtained with N at 120 P_2O_5 at 34.88 and K at 49.8 kg/ha.

Kumar and Urs (1988) reported that the effect of nitrogen, phosphorus and potassium fertilizers on the incidence of the noctuid *Earias vitella* on okra was studied in the field in Karnataka, India during the rainy seasons of 1983 and 1984. Nitrogen and Potassium were applied in various proportion with a constant level of 75 kg P/ha. The highest yields were recorded in plots treated with nitrogen and potassium at 250 and 30 or 125 and 120 kg/ha, respectively in 1983 and 250 and 60 kg/ha in 1984. The highest infestation were recorded following the treatment with 250 and 30 kg nitrogen and potassium/ha. There was a positive correlation between nitrogen uptake by the plants and infestation by *Earias vitella*, while potassium uptake was negatively correlated with infestation.

Mani and Ramanathan (1990) carried out an experiment to study the effect of nitrogen and potassium on the yield of okra. There were 5 levels of N (0, 20, 40, 60 and 80 kg/ha) and 5 levels of K_2O (0, 15, 30, 45 and 60 kg/ha).Nitrogen fertilizer significantly increased yield. A field experiment was conducted by Rain and Lal (1999) were conducted a field experiment in Bapalta, Andhara Pradesh, India, during 20 March-8 july 1997 studied the growth and development of okra cultivars (parbhanikranti, Arka, Anamika and Pusa Sawani) in response to 4 fertilizer levels (0-0-0,50-25-25,100-50-50 and 150-75-75 kg N,$P_2O_{5,}$ k_2O/ha respectively). Results showed that leaf area, leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects. Among cultivars, Pusa Sawani showed the maximum leaf area, LAI and LAD. However, Arka, Anamika showed significantly superior performance with respect to plant height, number of leaves and number of nodes and yield per plant. The highest fertilizer level result in maximum leaf area, LAI and LAD, which gradually increased up to 60 days after sowing (DAS). Dry matter increased between and was influenced significantly by cultivars, fertilizers levels and their combination. Crop growth (CGR) and relative growth rates were influenced by cultivars and fertilizers. Pusa Sawani supplied with the fertilizer level recorded the maximum CGR 60 DAS.Net assimilation rate (NAR) declined 60 DAS. Harvest index (HI) was also influenced by cultivars, fertilizer levels and their interaction. Arka Anamika with a moderate vegetative growth and high. NAR had the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK/ha.

In trials with okra CV. Pusa Sawani, N and K_2O were each applied at 0-120 kg/ha (Misra and Pandey, 1987). N at 80 kg/ha and K at 40 kg/ha significantly increased the number of fruits/plant, 1000 seed weight and the seed yield. Application of N above 80 kg/ha and K above 40 kg/ha adversely affected seed yield . Interaction effect was significant with 80 kg N, 40 kg K/ha giving the highest seed yield of 15.47 q/ha.

Gowda and Bharme (2001) conducted a field experiment in Bangalore, Karnataka, India during 1999 summer season to determine the response of okra cultivars Arka Anamika, Varshal to NPK fertilizer rates (125:75:60 kg/ha,150:100:75 kg/ha and 175:125:100 kg/ha).The highest dry matter production in leaves (20.40 g),stems (35.17 g).fruits (31.11 g) and whole plants (104.71 g) was recorded with 175:125:100 kg /ha treatments. Varsha recorded significantly higher dry matter production in leaves (17.48 g), stems (31.44 g), roots (17.61 g), fruits (29.98 g) and whole plants (96.51 g) compared with other cultivars. In the interaction effect, the highest total dry matter production (111.48 g/plant) was recorded in Varsha supplemented with 175:125:100 kg NPK/ha, which was at par with Arka Anamika supplemented with 175:125:100 kg NPK/ha. Comparative data on the effect of varying fertilizer rates, cultivars and their interaction on the length, diameter and yield of fruits were tabulated.

Gowda and Bharme (2002) conducted a study in the summer season of 1999 in Bangalore, Karnataka, India to investigate the effects of different fertilizer levels (N:P:K at 125:75: 60,150:100:75 and 175:125:100 kg/ha) on okra cultivars Arka, Anamica, Varsha and Vishal. Dry matter accumulation and nutrient (N, P and K) accumulation increased with increasing fertilizer levels. The highest fertilizer level resulted in the highest nutrient uptake. Varsha showed the highest nutrient uptake the accumulation and accumulation in leaves and fruits at the highest level of fertilizers. Prabu and Pramanik (2002) was conducted an experiment in Parbhani, Maharashtra, India, during the summer season of 2001 to investigate the effects of inorganic fertilizers at 0, 1/3, 2/3 and full rate (N:P:K at 100:50:50 kg/ha) in the presence or absence of farmyard manure (FYM at 10t/ha) and bio fertilizers (uninoculated *Azospirillum* + phosphate solubilizing bacteria and *Azospirillum* + *vesicular arbuscular* mycorrhiza) on the performance of okra cultivar Prabhani Kranti. Result showed that the treatment 2/3 recommended NPK dose + FYM + *Azospirillum* + *vesicular arbuscular* mycorrhiza produced in the highest yield.

Bamel and Singh (2003) conducted a pot experiment to study the effect of different fertilizer sources on *M. incognita* in okra under greenhouse condition. Better plant growth and reduced nematode damage when a combination of N, P, K and Zn fertilizers was applied at recommended dose. Individually, muriate of potash and potassium sulfate at higher dose recorded maximum plant growth. Ammonium sulfate and gypsum reduced nematode reproduction significantly compared to other treatments. All the fertilizers except calcium nitrate, muriate of potash and potassium sulfate showed reduction in nematode damage with a corresponding increase in their dose.

Aslam and Singh (2003) reported that excessive used of nitrogen fertilizers is a factor of nitrate accumulation in vegetable, which cause health problems to the consumers. A study was conducted to assess the effect of NPK fertilizers on NO_3 accumulation in okra (*Abelmoschus esculentus*) and carrot (*Daucus carota*) at Ayub Agricultural Research Institute, Faisalabad, Pakistan. For okra five (0, 100, 150, 175, 200 kg/ha) and two P_2O_5 rates (0, 75 kg/ha) were tested with 60 kg K_2O /ha as basal dose. On carrot, four N (0, 25, 50, 75 kg/ha), three P_2O_5 (0, 50, 75 kg/ha and two K_2O rates (0, 25 kg/ha) were applied. Increasing fertilizer rates increased $N0_3$ concentration over the control in okra and carrot. However, the application of N with P reduced NO_3 concentration in okra. Conversely, the NO_3conentration in carrot increased significantly over the control either with N applied alone or with P, a balanced use of N and P (2:1) fertilizers reduced the NO_3 accumulation.Additionally, the doses of NPK fertilizers applied in this study did not pose health hazards to the consumers.

2.2EFFECT OF GIBBERELLIC ACID ON GROWTH AND YIELD OF OKRA

Nandpuri *et al. (*1969) conducted an experiment with plant growth regulators on germination. Growth, flower formation, fruit set and yield of okra. The effects of GA, PAA and 2, 4-D on okra were compared. Soaking for 8 hours in 1 ppm of any of the chemicals increased germination: GA treatment was significantly superior to the others.GA at 100 and 200 ppm was superior in increasing the height of plants compared with other treatments, followed by IAA at 10 ppm and PAA at 50 and 100 ppm also increased the total growth of plants, whereas 2,4-D at 5 and 10 ppm declined it.GA at 100 ppm was the only treatment that produced a significant increase in flower formation.GA at 200 ppm and PA at 50 ppm proved significantly superior in increasing the length of units and GA at 10 ppm proved significantly superior in increasing the length of units and GA at 10 ppm in increasing the yields at Punjab Agric. Univ, Ludhiana.

Srivastava and Sachan (1971) conducted an experiment with indole acetic acid and gibberellic acid on growth and yield of okra. They treated IAA and GA_3 at 25, 50, 75 and 100 ppm for 24 h before planting. Most treatments resulted in improved germination, growth and yield; GA_3 was more effective than IAA.

Elassar *et al.* (1973) studied on the normal and parthenocapic fruit development. They found B-NOA (napthoxyacetic acid) at rates lower 100 ppm and IAA 10ppm to 100 ppm were effect normal fruit development and were less effective producing parthenocarpic fruit.GA_3(100-1000 ppm) and GA_{4+}7(50 ppm) slowed down the early rate of fruit development during later stages.

Singh *et al*. (1976) analysed the effect of seed treatment with plant growth regulators on yield and economic of okra. Okra seeds cv. Pusa Sawani and Uaishali Vadhu were treated with 10 -30 ppm GA and 25-100 ppm NAA. All treatments improved yield and returns, the best result being obtained with 30 ppm GA.

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Singh and Singh (1977) studied the effect of seed treatment with plant growth substances on germination, vegetative growth and yield of okra. Seeds of okra, cv. Pusa Sawani and Uaishali Vadhu were soaked in 10-30 ppm GA_3 and 25-100 ppm NAA for 24 h before sowing. Germination percentage, plant height, number of branches and spread, number of leaves, leaf area and yield were enhanced by all treatments where, 30 ppm GA_3, gave the best results.

Bhattacharya *et al.* (1978) studied the synergistic effect of gibberellic acid and indole-3-acetic acid on rooting in stem cutting of okra. They found root formation stimulated by separate treatment with IAA at 10 and 25 mg L^{-1}, which was further enhanced considerably when IAA and GA_3 were applied together to okra stem cuttings. Controls placed in water did no root.

Gopalkrishnan and Choudhury (1978) reported that in contrast with TIBA GA in general produced the larger number of male flower; GA at the lower concentration of 10 ppm produced more number of female flowers in first year. In the first year MH 100 ppm to 600 ppm as well as NAA and IAA 50 ppm to 150 ppm induced a reduction in the mean number of female flowers. Treatment with TIBA at 50 ppm 100 ppm and 200 ppm excelled all the other treatment in producing a favorable female to male flowers ratio. TIBA from 50 ppm gave a significant increase in the number of fruit and weight of fruit. Sahai *et al.* (1980) performed a study to observe the action of growth regulators on seed germination, early seedling growth and cotyledon expansion of *Hibiscus esculentus*. Okra seeds were soaked for 12 h in solutions of GA_1,B-Nine (daminozide), Phosfon (chiorphonium) or coumarin at various concentrations (10,100, 500 and 1000 mg L^{-1}),either separately or(for the last 3 compounds) in combination with GA_3 at 10 mg L^{-1}.The germination percentage with GA_3 alone was less than for water soaked control but increased with increasing concentration. With the application of coumarin and phosfon alone or with GA_3, the percentage of germination declined with 500 mg L^{-1} and above, it increased with increased concentrations of B-Nine alone or with GA_3.GA_3 counteracted the retarding effect of coumarin, phosfon and B-Nine on radical and hypocotyls elongation and on cotyledon expansion.

Gosh and Basu (1983) reported that with NAA at 17.5% or 35% mg L^{-1} increased the number of female flowers. Ethel at 25 mg L^{-1} increased female flowers but 100 mg/L decreased it. GA application at 60 mg L^{-1} increased the number of female flowers. All GA application reduced the ratio of male to male flowers.

Abdul *et al*. (1985) studied the influence of some growth regulators on the growth and yield of okra. In 2 years trials with cv. Batraa, IAA, NAA and GA_3 each at 0, 50 and 100 ppm and CCC (chiormequat) and B_9 (daminozide), each at 250, 500, 750 and 1000 ppm were applied on foliage at the 3-4 leaf stage.GA_3 increased plant height, leaf number and shoot dry weight, whereas both chiormequat and daminozide appreciably reduced plant height and shoot dry weight. No significant effect of IAA and NAA was observed. Also, no significant effect of treatment on yield was noted.

Rattan *et al.* (1987) analysed the effect of different levels of plant growth regulators on some agronomic traits in okra. Different combinations of GA_3 and IAA concentrations were compared as seed treatment and/or whole plant spray on the cv. Pusa Sawani. Significant effects were obtained on number of days to flower, number of pods/plant, pod length and green pod yield/plant. Seed treatment with 10 ppm GA_3 +300 ppm GA_3 as a plant spray advanced flowering by 6.33 days, compared with control. Longest pods were obtained with 50 ppm IAA seed treatment+ 100 ppm IAA as a plant spray. Greatest number of pods and maximum green pod yield were obtained by treating the seeds with 30 ppm GA_3+100 ppm GA_3 as a spray.

Vadigeri and Madalageri (1989) reported that seedling of poinsette and Belgum Local at the 4-6 leaf stage were sprayed with Ethrel [ethephon] at 200 ppm or 400 ppm and GA_3 [gibberellic acid] 5 ppm or 10 ppm and subsequently evaluated for sex ratio (male: female flower) and yield. Ethrel at 400 ppm had the greatest effect on both genotypes, significantly increasing controls.

Dhumal *et al.* (1993) stated the effect of seed treatment with gibberellic acid on growth and yield of okra. They treated seeds with GA_3 (0, 25, 50 and 75 then grown with N: P fertilizer rates of 20:20, 24:24, 28:28 and 40:40 kg ha^{-1} to give 50, 60, 70 and 100% of the full recommended rate, respectively. Seed treatment with 25 ppm GA_3 plus application of fertilizer at 70% of the recommended rate , gave a significant increase in fruit yield (203.77 g/plant and 164.82 q ha^{-1}) compared with the full recommended rate of fertilizer alone (151.3 g/plant and 96.42 q ha^{-1}).

Kim (1994) reported that thickness or weight of rind: flesh ratio were recorded maximum with MH 50 mg L^{-1}, while maximum thickness or weight of flesh, dry matter vitamin C and T.S.S contents were observed with cycocel 250 mg L^{-1} GA_3 25 mg L^{-1} resulted in maximum seeds in fruits, while MH 25 mg L^{-1} and ethrel 100 mg L^{-1} caused maximum weight loss of fruits 2 DAS or 4 DAS, Respectively. N 50 kg ha^{-1}+ ethrel 100 mg L^{-1} improved the shape index and seed content of fruit, respectively. Application of auxin transport inhibitors, naptalam (N-1-naphthylphthalamic acid) and TIBA to the ovary or peduncle of cucumber flowers (cultivars khira and pandex and their F_1 hybrid significantly increased the IAA content of the ovary. The ratio of IAA: ABA in pollinated or naptalam or TIBA treated ovaries was also higher than that in pollinated controls. The un-pollinated ovaries of genetically parthenocarpic cv. Pandex showed 92% fruit set. Application of auxins, NAA and 4-CPA, GA_3 cytokinins, BA and CPPU [forchlorfenuron] to the ovary at anthesis, however, induced over 60% parthenocarpic fruit set in khira and the F_1 hybrid.

Chatterjee and Sukul (1995) conducted a trial with plant growth regulators for controlling the root-knot incidence in okra plants. Three plant growth regulators viz. gibberellic acid, a-napthalene acetic acid and boric acid were used as foliar sprays on okra plants against *Meloidogyne incognita* infestations in okra plants, in a pot culture experiment. The growth regulators in general, particularly the NAA, were effective in reducing the disease intensity and inducing higher growth rates in the plants.

Ahmed and Tahir (1996) studied the effect of gibberellic acid as foliar on some characters of okra plant. Okra cv. Pusa Kranti grown in pots, was sprayed with 100 ppm GA_3 once at 3 weeks after germination, twice (3 and 4 weeks after planting),3 times (3,4 and 5 weeks after planting) and 4 times(3, 4 and 6 weeks after planting).Plant height, number of leaves, fresh shoot weight, fresh root weight, number of fruits, and fresh fruit weight were recorded at weekly intervals. The only treatment significantly increased the fruit number weight was 2 applications of GA_3.On the other hand, the shoot growth was greatest with 4 applications of GA_3.

Harrington *et al. (*1996) reported leaf area and stem elongation was 20-30% more with the application of growth hormones applied in okra plant.

Koshioka *et al*. (1996) conducted an experiment with endogenous gibberellins on the immature seeds of okra. Immature seeds of okra were collected from developing fruits two weeks after pollination and the identities and levels of endogenous gibberellins (GA_3) in the seeds were determined. After purifying the acidic, ethyl acetate-soluble fraction by several chromatographic procedures, $GA_{1,}$ GA_3, iso-$GA_{3,}$ $GA_{4,}$ $GA_{8,}$ $GA_{17,}$ $GA_{20,}$ $GA_{29,}$ $GA_{34,}$ GA_{44} and GA_{70} were identified by combined gas-chromatography and mass spectrometry. The major GA was GA_{20}.Based on these results it is suggested that the early C-13-hydroxylation biosynthetic pathway predominate in immature seeds of okra with the early C-13-non-hydroxylation pathway being present as a minor pathway.

Kumar *et al. (*1996) conducted an experiment to observe the beneficial effect of some plant growth regulators on aged seeds of okra under field conditions. Seeds of okra cultivars Pusa Sawani and Parbhani Kranti were allowed to age naturally for 16 months. Soaking them after storage in aqueous solutions of 50 and 100 ppmGA_3 and 100 ppm GA_3, IBA and thio-urea for 24 h at 25^0C sufficiently increased the percentage of germination, plant height, number of leaves per plant, number of fruits, number of seeds per fruit and seed yield per plant compared with control. Seed yield increased from 8.23 to 18%.GA_3 had the greatest effect while IBA the least.

Bhai and Singh (1997) analyzed the effect of different levels of phosphorus, gibberellic acid and picking on seed production of okra. They applied P at the rate of 50, 70 or 90 kg ha^{-1} and seed treatment with 200 and resulted in significantly increased plant height, chlorophyll contents and yield of *Abelmoschus esculentus*, *Hibiscus sabdariffa* and *Solanum gilo* while only combined treatments of 100 mg L^{-1} JAA 10% coconut milk and 100 mg L^{-1} GA_3 +15% coconut milk had such an effect on *A. esculentus* and *S. gilo* but not on *H. sabdariffa*. Moreover, single treatments of 100 mg L^{-1} GA_3 and 15% coconut milk caused significantly higher vitamins A, B_6 and C contents of treated plants whereas the combined treatments produced such an effect on only vitamin C contents of treated plants. Growth regulators treatments of 100 mg L^{-1} GA_3 and 15% coconut milk were consistently the best out of the entire growth regulator treatments tried with alied plants having the greatest plant height, yield, chlorophyll and vitamin C contents.

Sayed *et al*. (1997) conducted an experiment with exogenous growth regulators on growth, flowering and yield of okra. They studied the growth response of okra cv. to exogenous growth regulators; gibberellic acid(GA_3,Planofix (NAA) and Cultar (Paclobutrazol). Each growth regulator was applied to the foliage at the rate of 50,100,150 and 200 ppm. Planofix at 150 ppm reduced the number of days (75) to first picking, whereas Cultar at 200 ppm delayed it (96.75 days).Cultar at 150 ppm and 200 ppm restricted plant height and produced the minimum of 136.22 cm and produced the greatest number of branches (3.65) compared to the tallest plants (253.75 cm). The least number of branches (2.20) was produced by 200 and 150 ppm GA_3 respectively, Planofix (200 ppm) increased inter-nodal length (11.95 cm) whereas Cultar reduced it (7.40 cm).Plants treated with Cultar (150 ppm) had the greatest number of 300 ppm GA_3 for 12 h which had no significant effect on seed yield. However, two harvests had no detrimental effects on seed yield.

Pawar *et al.* (1997) studied the performance of plant growth regulators on germination, growth and yield of okra by treating seeds. Seeds of okra cv. Pusa Sawani were soaked in GA and IAA solutions each at 25_100 ppm. Both growth substances (more by GA) increased seed germination, plant growth and yield, especially at 25-30 ppm.

Gulshan and Lal (1997) carried out an experiment with flowering, fruiting and seed production of okra as influenced by growth regulators and urea. They applied various combinations of gibberllic acid, NAA and urea treatments to okra cv. Pusa Sawani in summer 1988 and 1989 at pantnagar, India. The greatest number of pods $plant^{-1}$ was obtained after seed treatment with NAA at 20 ppm+ foliar spray of 2% urea at 30 days after sowing followed by seed treatment with 150 ppm GA_3 and 20 ppm NAA +foliar spray of 4% urea at 30 days after sowing .Soaking of seeds in 150 ppm GA_3 and 20 ppm NAA gave the highest seed yields (20.4 and 19.4 t ha^{-1}, respectively), which were 7.9 and 6.9 ha higher than the control, respectively.

All treatment combinations reduced the number of days to 50% flowering and the number of days to first fruit set than control.

Kadiri *et al.* (1997) stated the effects of single and combined growth regulator treatments of indole-3-acetic acid (IAA), gibberellic acid (GA_3) and coconut milk on plant height, yield, chlorophyll and vitamin contents of *Abelmoschus esculentus L.* and *Solanum gilo L.* The growth regulator treatments consisted of 50 mg L^{-1},100 mg L^{-1} of IAA and GA_3 and 10%, 15% of coconut milk. In case of combined growth regulator treatments, the treatments were 100 mg L^{-1}IAA+100 mg L^{-1} GA_3, 100 mg L^{-1}. IAA+15% coconut milk and 100 mg L^{-1} GA_3+15% coconut milk. Control vegetable plants were sprayed with water. Single treatments of 100 mg L^{-1},100 mg L^{-1} $GA_{3,}$10% and 15% coconut milk pods plant^{-1} (69.47) and seeds/pod(85.5),whereas these were lowest (44.82 pods) in control plants and those treated with 50 ppm GA_3 (46.60 seeds pod^{-1}).GA_3 increased pod length (10.10cm) and diameter (1.82cm) significantly. Cultar 100 ppm gave the highest yield (14.32 t ha^{-1}) as compared to 11.87 t ha^{-1} with Cultar at 200 ppm and 11.97 t ha^{-1} in the control.

Bhai and Singh (1998) conducted an experiment in India with different levels of phosphorus, GA_3 and pickings on seed production of okra in 1992 and 1993.Phosphorus was applied at 50, 70 and 90 kg ha^{-1}.Seeds are soaked with gibberellic acid at the concentration of 0, 200 and 300 ppm, and investigated the number of harvests (1, 2 and 3) on plant height, number of nodes per plant and the seed yield of okra. However, plant height, number of nodes per plant and seed yield increased significantly with GA_3 treatment up to a concentration of 300 ppm. Two harvests gave the highest values for seed yield and yield components, but plant height and number of nodes per plant showed in consistent trends. Singh *et al.* (1998) worked with gibberellic acid as a pre-sowing seed treatment and different levels of nitrogen on germination, growth, flowering and yield of okra. In a trial at Meercut in 1992 and 1993, okra cv. Pusa Sawani seeds were treated with 0,15,30 and 45 ppm GA_3. Nitrogen fertilizer was applied at 40,60 and 90 kgha^{-1},half before sowing, a quarter 30 days after sowing and a quarter at flowering.GA_3 at 15 ppm increased seed germination by 23.61 and 19.45% at day 9 and 15 after sowing respectively.

Treating seed with 45 ppm GA_3 increased plant height by 8.97%, advanced flowering by 3.33 days and increased pod yield by 30%.The application of 90 kg N ha^{-1} increase plant height by 14.03%, advanced flowering by 4.08 days and increased pod yield by 67.20% compared with control. Singh *et al.* (1999) conducted an experiment with combination of NAA, gibberellic acid and urea were applied to okra, cv. Pusa Sawani, as foliar and seed soaking applications in a field trial in Uttar Pradesh, India, in 1995.Seed germination was greatest (71.6%) with the 20 ppm NAA+150 PPM GA_3 treatment and significantly greater than the control (55.5%).NAA at 20 ppm,20 ppm NAA+20000 ppm urea and 40000 ppm urea as foliar sprays caused significantly earlier flowering, with days taken to 50% flowering being approximately 40.8,compared to 42.0 days in the control. The greatest seed weight per pod (3.2g) and seed yield per hectare (19.4q ha^{-1}) was achieved with 150 ppm GA_3 and was significantly greater than the control (1.8 g and 11.8 q ha^{-1}).Treatments of 150 ppm GA_3 and 20 ppm NAA applied by seed soaking and foliar application of 20000 ppm urea increased seed yield by 64.4, 55.9 and 42.8%, respectively.

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

2.3 COMBINED EFFECT OF DIFFERENT LEVELS OF POTASSIUM AND GIBBERELLIC ACID ON THE GROWTH AND YIELD OF OKRA

Deore *et al. (*1987) performed a trial with growth substance on yield and yield contributing characters of okra. Okra seeds were soaked with 2% NPK starter solution, water alone or were not soaked (control).The plants were sprayed with Ethrel (ethephon) at 500 and 1000 ppm, CCC (chlonnequat) at 500 and 1000 ppm and GA_3 at 50 and 100 ppm at 25 days after sowing. The highest yield 96.84 q ha^{-1}) was obtained after soaking the seeds in starter solution and spraying the plants with 100 ppm GA_3.

Maurya *et al.* (1987) stated the use of gibberellic acid (GA_3) and urea sprays in increasing the yield of okra. They applied P: K at 70:60 kg ha^{-1} as a basal dose plus combines sprays of 0-3% urea and 0-100 ppm GA_3.The sprays were applied twice at 20 and 50 days after sowing. The highest yield of 87.39 q ha^{-1} was obtained with 50 ppm GA_3+2% Urea.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during the period from April to August 2015. 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 $24^{0}09^{/}$ N latitude and $90^{0}26^{/}$E longitudes. The altitude of the location was 8 m from the sea level.

3.2 Climatic condition of the experimental site

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. Details of the meteorological data during the period of the experiment were collected from the Bangladesh Meteorological Department, Agargoan, Dhaka, Appendix I(A).

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 I(B).

3.4 Planting materials

Seed of BARI Dherosh-1 was used as a planting material in this experiment.

3.5 Collection of seeds

The seeds of okra variety were collected from Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute, Gazipur.

3.6 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Potassium fertilizer (4 levels) as

i. K_0: 0 kg K_2O/ha (control)

ii. K_1: 60 kg K_2O/ha

iii. K_2: 90 kg K_2O/ha

iv. K_3: 120 kg K_2O/ha

Factor B: Gibberellic acid (3 levels) as

i. G_0: 0 ppm GA_3 (control)

ii. G_1: 60 ppm GA_3

iii. G_2: 90 ppm GA_3

There were 12 (4 × 3) treatments combination such as K_0G_0, K_0G_1, K_0G_2, K_1G_0, K_1G_1, K_1G_2, K_2G_O, K_2G_1, K_2G_2, K_3G_0, K_3G_1, K_3G_2,

3.7 Land preparation

The plot selected for conducting the experiment was opened in the last week of March, 2015 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for sowing okra seeds. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.8 Application of manure and fertilizers

Urea, TSP and 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 Urea was applied as basal dose at the time of final land preparation dated at 9 April, 2015. Muriate of potash and nitrogen were applied at 25, 40 and 55 days after sowing (DAS).Gibberellic acid was applied at 15, 25, 35 days after sowing.

Table 1. Dose and method of application of fertilizers in okra field (Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, 2012)

Manures and Fertilizers	Dose/ha	Application (%)		
		25 DAS	40 DAS	55 DAS
Cowdung	10 tons (basal)	-	-	-
Nitrogen (as urea)	150 kg	33.33	33.33	33.33
P_2O_5 (as TSP)	100 kg (basal)	-	-	-

K_2O (as MP)	As per treatment

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 of the experimental plot was 175.56 m^2 with length 20.9 m and width 8.4 m. 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 1.8 × 1.2 m. The distance maintained between two blocks and two plots were .75m and 0.5 m, respectively. The spacing was 60 × 40 cm. The layout of the experimental plot is shown in Figure 1.

3.10 Seeds sowing

The okra seeds were sown in the main field at 25 April in 2015. 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 40 cm and 60 cm from plant to plant and row to row, respectively.

3.11 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.

3.11.1 Gap filling

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

3.11.2 Weeding

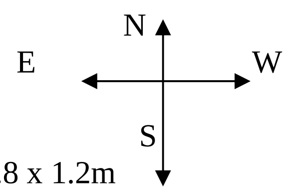
The weeding was done by nirani with roots at (25 , 40 and 55) DAS to keep the plots free from weeds. **3.11.3 Irrigation**

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.

3.11.4 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedlings 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 cutworm. Cut worms were controlled both mechanically and spraying Darsban

K_0G_0		K_1G_1		K_3G_2
K_0G_2		K_2G_2		K_0G_0
K_1G_0		K_3G_2		K_2G_0
K_2G_2		K_2G_1		K_1G_0



Plot size=1.8 x 1.2m
Spacing=60 x 40cm
Plot distance=0.5m
Replication distance=0.75m
Factor A=Potassium(4 levels)as

i. K_0: 0 kg K_2O/ha

K_3G_0	K_0G_1	K_2G_1
K_1G_2	K_0G_0	K_0G_2
K_0G_1	K_1G_2	K_3G_0
K_3G_2	K_1G_0	K_3G_1
K_3G_1	K_3G_0	K_1G_1
K_1G_1	K_2G_0	K_1G_2
K_2G_1	K_3G_1	K_0G_1
K_2G_0	K_0G_2	K_2G_2

(control)

ii. K_1: 60 kg K_2O/ha
iii. K_2: 90 kg K_2O/ha
iv. K_3: 120 kg K_2O/ha

Factor B: Gibberellic acid (3 levels) as
i. G_0: 0 ppm GA_3 (control)
ii. G_1: 60 ppm GA_3
iii. G_2: 90 ppm GA_3

Figure 1. Field layout of the experimental plot

29 EC @ 3%. Some discolored and yellowish diseased leaves were also collected from the plant and removed from the field.

3.12 Harvesting

Fruits were harvested at 5 days interval based on eating quality at soft and green condition. Harvesting was started from 15

June, 2015 and was continued up to July 2015.

3.13 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 following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves, length of petiole, diameter of stem, length of leaf, number of branches per plant, length of internode were collected at 20, 40, 60 and 80 days after sowing (DAS). Fresh weight of leave and dry weight of leave per plant was recorded at 80 DAS at maximum growth stages. All other yield contributing characters and yield parameters such as days to flowering, number of flower buds/plant, number of pods per plant, weight of individual pods, length of pod, diameter of pod, yield per plot was also recorded as per the suitable time of optimum performance of okra plants.

3.13.1 Plant height

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

3.13.2 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 five plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

3.13.3 Length of petiole

Length of petiole was measured from the longest petiole of five 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.

3.13.4 Diameter of stem

Stem diameter was measured from sample plants with a digital calipers-515 (DC-515) from the stem 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.

3.13.5 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 five plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

3.13.6 Length of internode

Length of internode was measured from five 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.

3.13.7 Length of leaves

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. 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 plants.

3.13.8 Days required for flowering

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

3.13.9 Number of flower buds 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.

3.13.10 Number of pods per plant

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

3.13.11 Length of pod

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

3.13.12 Diameter of pod

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

3.13.13 Fresh weight of leaves/plant

At 80 DAS leaves of five okra plants from inner rows selected and pulled out then the plant was taken, clean and weighted by a digital weighing machine and average was calculated for measuring fresh weight of plant.

3.13.14 Dry matter content 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^{0}Cfor 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:

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

3.13.15 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.

3.13.16 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.

3.14 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 potassium and gibberellic acid 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).

3.15 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of potassium and gibberellic acid. 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.

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

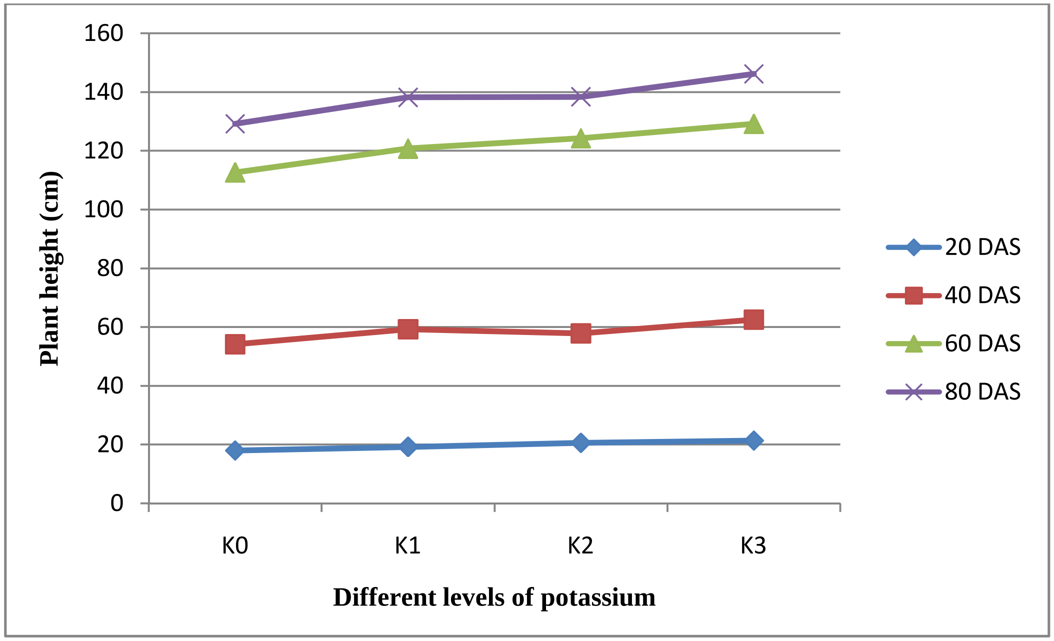
4.1 Plant height

Plant height of okra varied significantly due to application of different levels of potassium at 20, 40, 60 and 80 DAS (Figure

2). Bhai and Singh (1998) stated that K application significantly increased the plant height. At 20, 40, 60 and 80 DAS the tallest plant (21.4, 62.58, 129.2 and 146.2 cm) was recorded from K_3 (120 kg K/ha), whereas the shortest plant (18.04, 54.2, 112.7 and 129.2 cm) was obtained from K_0 (0 kg K/ha i.e. control condition). It was revealed that with the increase of potassium plant height increased upto a certain level. Potassium ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was tallest plant.

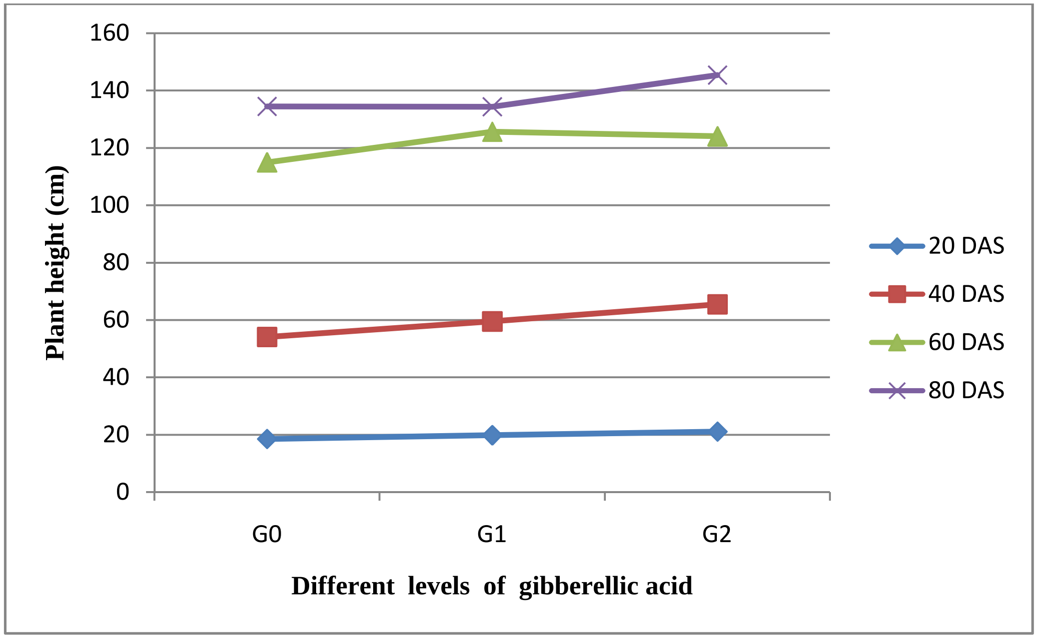
Different levels of gibberellic acid showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Figure 3). Singh *et al*. (1999) reported that GA_3 increased plant height of okra .At 20, 40, 60 and 80 DAS the tallest plant (21.11, 62.02, 65.4 and 145.30 cm) was observed from G_2 (90ppm), and the shortest plant (18.57, 54.05, 114.90 and 134.40 cm) was observed from G_0.

Combined effect of different levels of potassium and gibberellic acid showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Table 2). At 20, 40, 60 and 80 DAS the tallest plant (22.10, 66.73, 137.30 and 164.00 cm) was observed in K_3G_2 (120 kg K/ha and 90 ppm), while the shortest (18.77, 89.90 and 115.80 cm) was obtained from K_0G_0.



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 2: Effect of different levels of potassium on plant height of okra



(G_0:0ppm GA_3, G_1: 60ppm GA_3, G_2:90ppm GA_3)

Figure 3: Effect of different levels of gibberellic acid on plant height of okra

Table 2: Combined effect of different levels of potassium and gibberellic acid on plant height of okra

Plant height (cm)				
Treatments	20 DAS	40DAS	60DAS	80DAS

K_0G_0	18.97b	58.50bc	89.90g	115.80e
K_0G_1	19.97ab	53.43cd	127.90c	131.80cd
K_0G_2	19.20ab	57.00bc	120.40d	139.90bcd
K_1G_0	19.03b	61.73ab	133.90ab	142.50bc
K_1G_1	18.77b	58.53bc	121.10d	134.70bcd
K_2G_2	20.03ab	57.77bc	107.30f	137.30bcd
K_2G_0	20.53ab	49.23d	114.60e	132.90bcd
K_2G_1	20.67ab	61.27ab	127.40c	142.40bcd
K_2G_2	20.77ab	63.23ab	131.00 bc	140.00bcd
K_3G_0	19.73ab	57.73bc	121.10d	146.30b
K_3G_1	20.03ab	59.93bc	125.80cd	128.30d
K_3G_2	22.10a	66.73a	137.30a	164.00a
LSD(0.5)	**2.62**	**5.92**	**5.56**	**12.33**
CV(%)	**6.76**	**15.50**	**9.80**	**6.99**

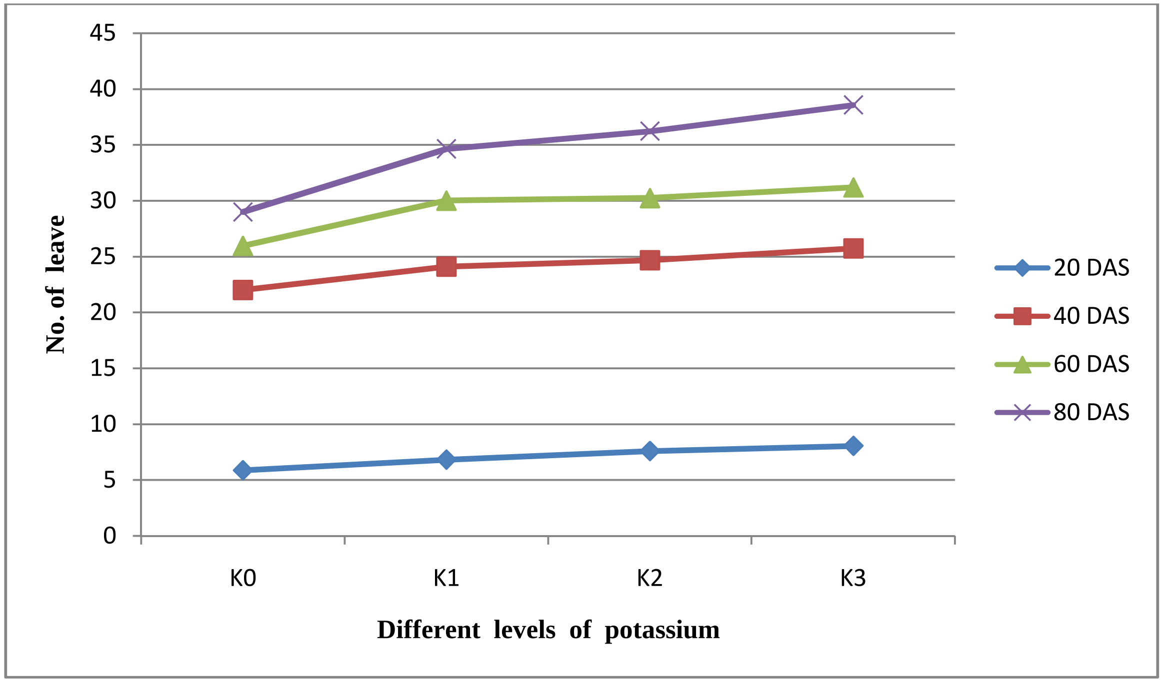
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

4.2 Number of leaves per plant

Significant variation was recorded for number of leaves per plant for different levels of potassium at 20, 40, 60 and 80 DAS of okra under the present trial (Figure 4). Rain and Lal (1999) stated that okra showed superior performance during potassium fertilizer application with respect to number of leaves. At 20, 40, 60 and 80 DAS the maximum number of leaves per plant (8.056, 25.72, 38.56 and 31.18) was recorded from K_3 while whereas the minimum number (5.867.22.01, 28.99 and 25.57) from K_0.

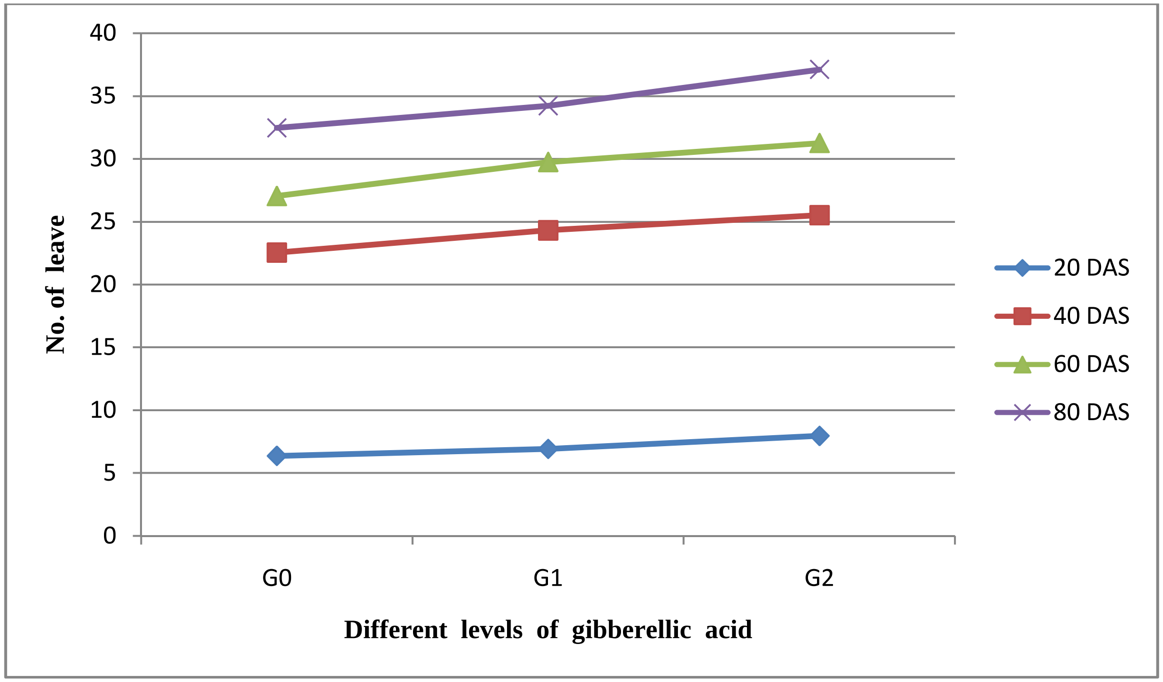
Due to application of different levels of gibberellic acid showed significant differences on number of leaves at 20, 40, 60 and 80 DAS (Figure 5). Abdul *et al* (1985) reported that GA_3 increased leaf number. At 20, 40, 60 and 80 DAS the maximum number of leaves per plant (7.958, 25.51, 31.25 and 37.1) was observed in G_2, while the minimum number of leaves per plant (6.367, 22.55, 27.04 and 32.47) was recorded from G_0 at the same days of observations.

Combined effect of different levels of potassium and gibberellic acid showed significant differences on number of leaves per plant of okra at 20, 40, 60 and 80 DAS (Table 3). At 20, 40, 60 and 80 DAS, the maximum number of leaves per plant (9.80, 30.00, 35.53 and 36.53) was found from K_3G_2 and the minimum number (4.77, 12.90, 24.47 and 25.47) from the treatment combination of K_0G_0.



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 4: Effect of different levels of potassium on number of leave of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure 5: Effect of different levels of gibberellic acid on number of leave of okra

Table 3: Combined effect of different levels of potassium and gibberellic acid on number of leave of okra

	Number of Leaves			
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	4.77d	12.90c	24.47e	25.47e
K_0G_1	6.87bc	22.50b	25.50e	26.50e
K_0G_2	7.30bc	26.00ab	27.93cde	28.93cde

K_1G_0	7.23bc	27.07ab	31.23abc	32.23abc
K_1G_1	6.37c	24.23ab	28.40cde	29.40cde
K_2G_2	6.87bc	20.97b	30.37bcd	31.37bcd
K_2G_0	7.47bc	22.17b	26.03de	27.03de
K_2G_1	7.43bc	28.10ab	33.50ab	34.50ab
K_2G_2	7.87b	23.73ab	31.17abc	32.17abc
K_3G_0	7.33bc	23.43ab	26.43de	27.43de
K_3G_1	7.03bc	22.40b	31.57abc	32.57abc
K_3G_2	9.80a	30.00a	35.53a	36.53a
LSD(0.5)	**1.20**	**6.48**	**3.97**	**4.97**
CV(%)	**9.82**	**10.62**	**7.99**	**10.57**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

4.3 Length of petiole

Different levels of potassium varied significantly on length of petiole at 20, 40, 60 and 80 DAS of okra (Figure 6). At 20, 40, 60 and 80 DAS the longest petiole (6.56, 22.99, 25.28 and 28.71 cm) was obtained from K_3 which was statistically similar to K_2 (6.23, 21.40, 24.23 and 27.53 cm), whereas the shortest petiole (5.12, 17.38, 20.77 and 24.22 cm) was found from K_0.

Different levels of gibberellic acid showed significant variation on length of petiole of okra at 20, 40, 60 and 80 DAS (Figure 7). At 20, 40, 60 and 80 DAS the longest petiole (6.52, 22.45, 25.81 and 27.68 cm) was found from G_2, whereas the shortest petiole (5.80, 19.06, 22.07 and 25.54 cm) was recorded from G_0.

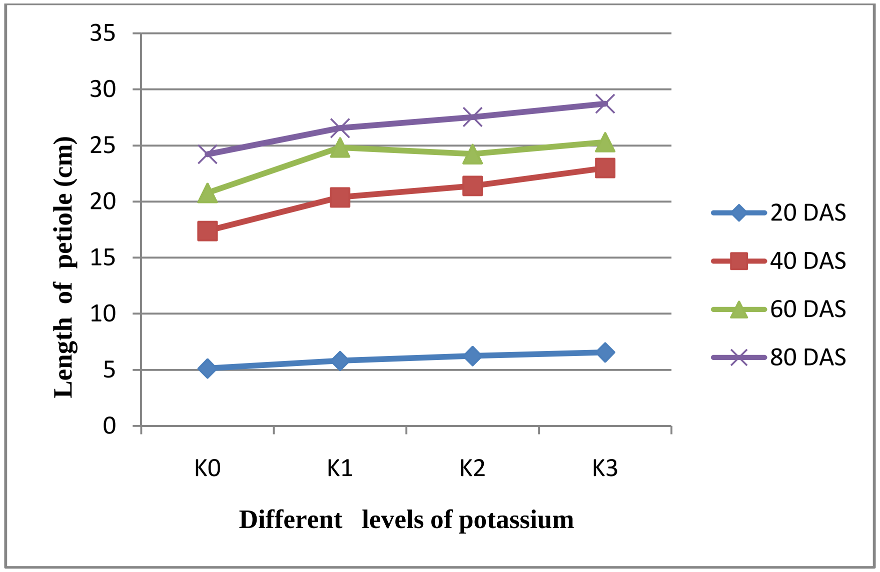
Significant variation was recorded due to combined effect of different levels of potassium and gibberellic acid on petiole length of okra at 20, 40, 60 and 80 DAS (Table 4). At 20, 40, 60 and 80 DAS the longest petiole (8.17, 21.10, 29.90 and 31.60 cm) was obtained from K_3G_2, while the shortest petiole (4.40, 16.63, 15.50 and 19.37 cm) was from K_0G_0.

4.4 Diameter of stem

Diameter of stem varied significantly for different levels of potassium at 20, 40, 60 and 80 DAS of okra under the present trial (Figure 8). At 20, 40, 60 and 80 DAS the highest diameter of stem (0.644, 2.211, 2.522 and 2.8 cm) was found from K_3, while the lowest diameter of stem (.4333, 1.711, 2.00 and 1.889 cm) from K_0. Significant variation was recorded due to use different levels of gibberellic acid on diameter of stem at 20, 40, 60 and 80 DAS (Figure 9). At 20, 40, 60 and 80 DAS the highest diameter of stem (0.625, 2.25, 2.458 and 2.675 cm) was obtained from G_2, and the lowest diameter (0.45, 1.75, 2.067 and 2.075 cm) was found from G_0.

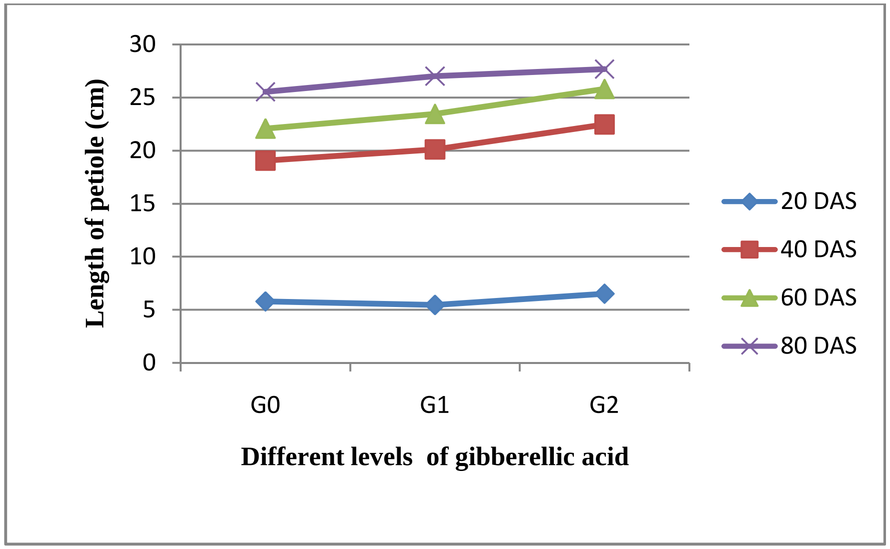
Diameter of stem of okra showed significant differences due to the combined effect of potassium and gibberellic acid on at

20, 40, 60 and 80 DAS (Table 5).



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 6: Effect of different levels of potassium on petiole length of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure 7: Effect of different levels of gibberellic acid on petiole length of okra

Table 4: Combined effect of different levels of potassium and gibberellic acid on petiole length of okra

	petiole length (cm)			
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	4.40c	16.63c	15.50d	19.37c
K_0G_1	5.73bc	17.37bc	22.37c	25.87b

K_0G_2	5.23bc	18.13bc	24.43bc	27.43ab
K_1G_0	6.57ab	20.07bc	27.70ab	28.30ab
K_1G_1	5.00bc	19.80bc	23.30bc	26.70ab
K_2G_2	5.83bc	21.27abc	23.47bc	24.63b
K_2G_0	6.43ab	19.57bc	21.57c	27.00ab
K_2G_1	5.43bc	21.33abc	25.70abc	28.53ab
K_2G_2	6.83ab	23.30ab	25.43 abc	27.07ab
K_3G_0	5.80bc	19.97bc	23.50bc	27.50ab
K_3G_1	5.70bc	21.90abc	22.47c	27.03ab
K_3G_2	8.17a	27.10a	29.90a	31.60a
LSD(0.5)	**1.67**	**5.60**	**4.14**	**4.55**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

At 20, 40, 60 and 80 DAS the highest diameter of stem (0.73, 2.47, 2.67 and 2.87 cm) was observed from K_3G_2 and the lowest diameter of stem (0.37, 1.20, 1.57 and 1.50) was recorded from the treatment combination of K_0G_0.

4.5 Number of branches per plant

Number of branches per plant showed significant variation due to application of different levels of potassium at 20, 40, 60 and 80 DAS of okra under the present trial (Figure 10). At 20, 40, 60 and 80 DAS the maximum number of branches per plant (2.03, 4.88,4.96 and 5.33) was recorded from K_3 which was closely followed (1.37, 4.54, 4.87 and 4.84) by K_2, whereas the minimum number of branches per plant (1.24, 2.81, 3.81 and 4.38) from K_0.

A significant variation was recorded on number of branches per plant of okra at 20, 40, 60 and 80 DAS due to effect of different levels of gibberellic acid (Figure 11). Singh and Singh (1977) stated that maximum number of branches

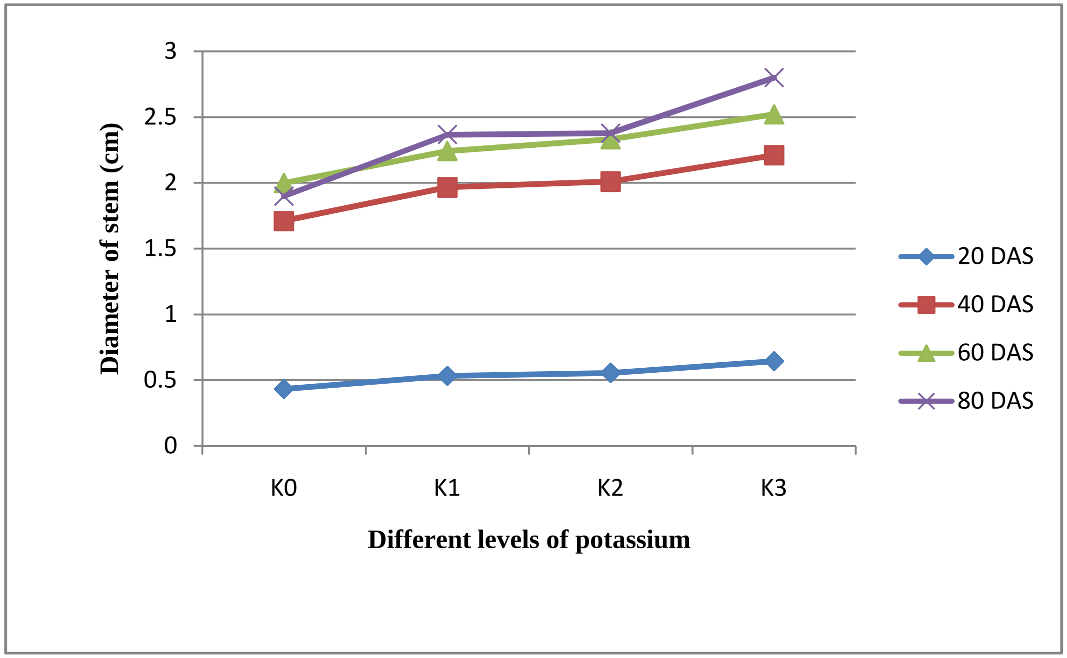
per plant obtained 10-30 ppm GA_3. At 20, 40, 60 and 80 DAS the maximum number of branches per plant (1.67, 4.88, 5.09 and 5.58) was observed in G_2, which was closely followed (1.48, 3.84, 4.15 and 4.45) by G_1 and the minimum number of branches per plant (1.35, 3.84, 4.15 and 4.45) was recorded from G_0.

Number of branches per plant of okra showed significant variations due to interaction effect of different levels of potassium and gibberellic acid at 20, 40, 60 and 80 DAS (Table 6). At 20, 40, 60 and 80 DAS, the maximum number of branches per plant (1.96, 6.20, 5.77 and 7.33) was recorded from K_3G_2 and the minimum number (1.03, 2.20, 3.43 and 3.53) was recorded from K_0G_0.

4.6 Length of internode

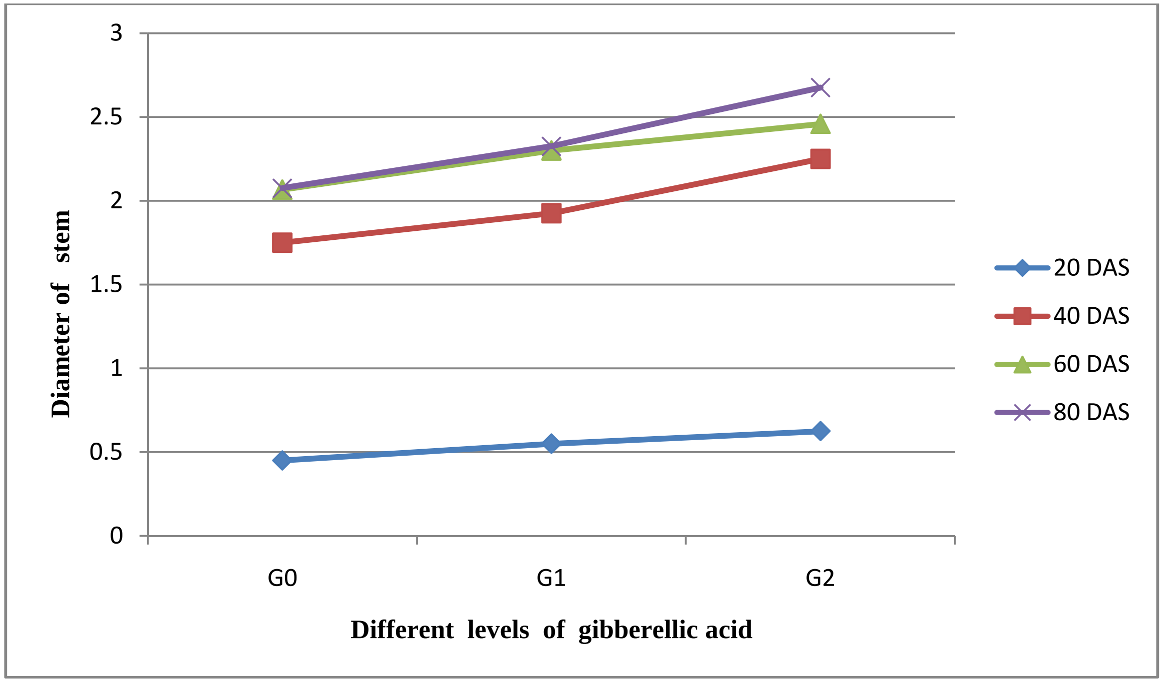
Length of internode differed significantly due to the application of different levels of potassium at 20, 40, 60 and 80 DAS of okra under the present trial (Table 7). The longest internode (3.62cm) was observed from K_2 for 20 DAS

plant and (5.66, 7.4 and 9.91 cm) was observed in K_3, while the shortest internode (4.58, 7.63, 9.756 and 11.34 cm) was measured from K_1 for 40, 60, 80 DAS plant.



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 8: Effect of different levels of potassium on stem diameter (cm) of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2: 90ppm GA_3)

Figure 9: Effect of different levels of gibberellic acid on stem diameter of okra

Table 5:Combined effect of different levels of potassium and gibberellic acid on okra stem diameter

	stem diameter (cm)			
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	0.37c	1.20d	1.57d	1.50d
K_0G_1	0.57b	1.87bc	2.20c	2.03c

K_0G_2	0.50b	2.07abc	2.23c	2.27bc
K_1G_0	0.53b	2.13abc	2.23c	2.47abc
K_1G_1	0.53b	1.93abc	2.27bc	2.27bc
K_2G_2	0.53b	1.83bc	2.23bc	2.37abc
K_2G_0	0.53b	1.67cd	2.23bc	2.10c
K_2G_1	0.57b	2.13ab	2.53ab	2.73ab
K_2G_2	0.57b	2.23ab	2.23bc	2.30bc
K_3G_0	0.50b	2.00abc	2.23bc	2.37abc
K_3G_1	0.53b	1.77bc	2.20c	2.27bc
K_3G_2	0.73b	2.47a	2.67a	2.87a
LSD(0.5)	**0.09**	**0.48**	**0.27**	**0.49**
CV(%)	**9.23**	**14.38**	**6.89**	**12.61**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Statistically significant variation was recorded due to effect different levels of gibberellic acid on length of internode of okra at 20, 40, 60 and 80 DAS (Table 8). Harrington *et al*. (1996) reported that stem elongation was 20-30% more with the application of growth hormones. At 20, 40, 60 and 80 DAS the longest internode (3.358, 5.492, 7.56 and 9.93 cm) was recorded from G_2 whereas the shortest internode (2.399, 4.967, 6.717 and 8.68 cm) was found from G_0.

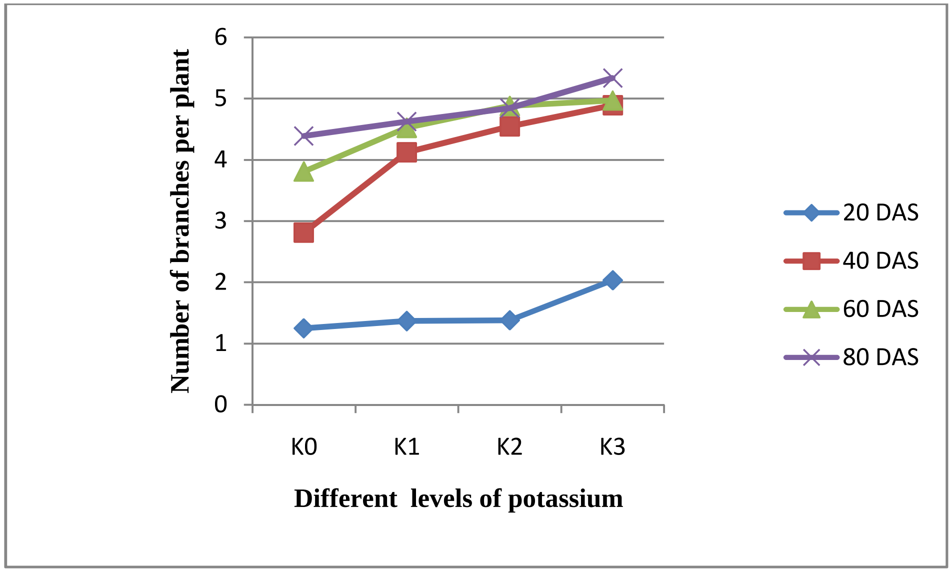
Combined effect of different levels of potassium and gibberellic acid showed significant differences on internode length of okra at 20, 40, 60 and 80 DAS (Table 9). At 20, 40, 60 and 80 DAS the longest internode (4.26 from K_1G_2, 5.97 from K_1G_0, 8.17 from K_0G_2 and 10.77 from K_0G_2)cm was recorded, while the shortest internode (1.13, 4.57, 5.10 and 7.40 cm) was obtained from the treatment combination of K_0G_0.

4.7 Length of leaf

Statistically significant variation was observed in terms of length of leaf of okra due to different levels of potassium at 20, 40, 60 and 80 DAS (Table 10). At 20, 40, 60 and 80 DAS the longest leaf (21.31, 40.94, 47.56 and 50.96 cm) was found from K_3 and the shortest leaf length (17.57, 34.37, 39.14 and 47.67 cm) was recorded from K_0.

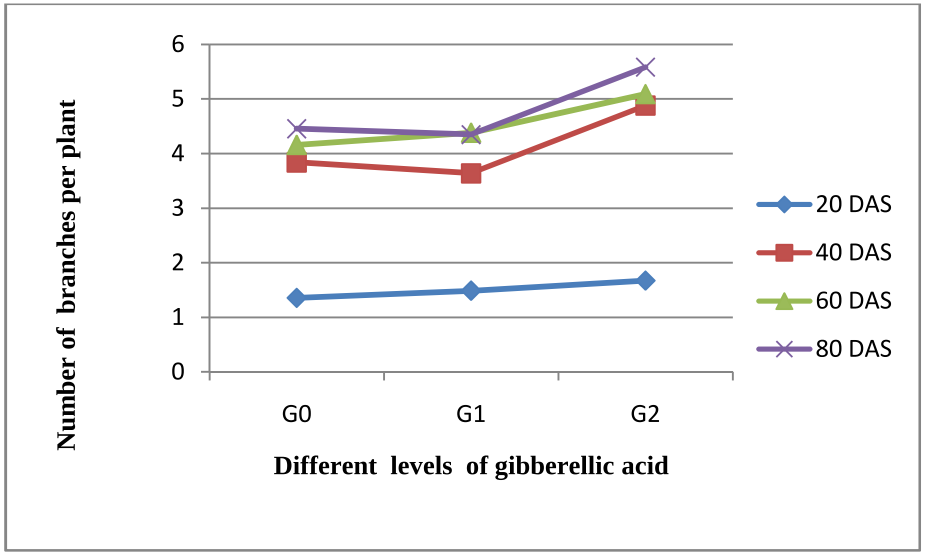
Length of leaf of okra showed significant variation for different levels of gibberellic acid at 20, 40, 60 and 80 DAS (Table 11). At 20, 40, 60 and 80 DAS the longest leaf (20.23, 40.17, 47.92 and 50.26 cm) was observed in G_2, whereas the shortest leaf length (17.71, 36.53, 43.34 and 46.36 cm) was performed by G_0.

Combined effect of different levels of potassium and gibberellic acid showed significant differences on leaf length of okra at 20, 40, 60 and 80 DAS (Table 12). At 20, 40, 60 and 80 DAS the longest leaf (23.60, 45.20, 55.90 and 54.93 cm) was recorded from K_3G_2, while the shortest leaf (14.50, 31.30, 35.54 and 43.37 cm) was from $K_0G_{0.}$



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 10: Effect of different levels of potassium on number of branches per plant of okra



(G_0:0ppm, GA_3, G_1:60ppm GA_3, G_2: 90ppm GA_3)

Figure 11: Effect of different levels of gibberellic acid on number of branches per plant of okra

Table 6: Combined effect of different levels of potassium and gibberellic acid on number of branches per plant of okra

number of branches per plant				
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	1.03b	2.20d	3.43d	3.53c

K_0G_1	1.41ab	2.33d	3.93cd	4.40bc
K_0G_2	1.31b	4.23bc	4.40bc	5.23b
K_1G_0	1.40ab	5.03b	4.47bc	5.07b
K_1G_1	1.45ab	2.97d	4.67bc	4.20bc
K_2G_2	1.25b	4.37bc	4.43bc	4.60bc
K_2G_0	1.43ab	3.97c	4.50bc	4.53bc
K_2G_1	1.52ab	4.97b	5.03ab	4.83bc
K_2G_2	1.18b	4.70bc	5.10ab	5.17b
K_3G_0	1.57ab	4.17bc	4.57bc	4.70bc
K_3G_1	1.58ab	4.30bc	3.90cd	3.97bc
K_3G_2	1.96a	6.20a	5.77a	7.33a
LSD(0.5)	**0.51**	**0.77**	**0.81**	**1.31**
CV(%)	**20.01**	**12.32**	**10.23**	**16.07**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Table 7: Effect of different levels of potassium on length of internode of okra.

Treatments	Length of internode (cm)			
	20DAS	40DAS	60DAS	80DAS
K_0	1.58b	4.63b	6.756a	7.34c
K_1	2.97ab	5.66a	7.32a	8.91a
K_2	3.62a	5.14ab	6.689b	7.98bc
K_3	3.48ab	5.30ab	7.4a	8.31ab
$LSD_{(.05)}$	**1.40**	**0.90**	**0.4006**	**0.7369**
CV(%)	**10.37**	**9.07**	**7.80**	**4.07**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Table 8: Effect of different levels of gibberellic acid on length of internode of okra

Treatments	Length of internode (cm)			
	20 DAS	40 DAS	60 DAS	80DAS
G_0	2.399b	4.967b	6.717b	8.68b

G_1	2.81ab	5.174ab	6.76b	8.81b
G_2	3.358a	5.492a	7.65a	9.93a
$LSD_{(.05)}$	**0.9161**	**0.38**	**0.4006**	**0.4157**
CV(%)	**10.37**	**9.07**	**7.80**	**4.07**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (G_0:0ppm GA_3, G_1:60ppm GA_3, G_2: 90ppm GA_3)

Table 9: Combined effect of different levels of potassium and gibberellic acid on internode length of okra

	Length of internode (cm)			
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	1.13d	4.57d	5.70b	7.40f
K_0G_1	1.47d	4.63d	7.07ab	7.53ef
K_0G_2	2.14cd	4.70d	8.17a	10.77a
K_1G_0	1.74d	5.97a	7.93a	10.67a
K_1G_1	2.92bc	5.30abcd	6.83ab	9.97ab
K_2G_2	4.26a	5.70ab	7.20ab	9.10bcd
K_2G_0	4.11ab	5.20bcd	7.17ab	9.03bcd
K_2G_1	3.41ab	5.47abc	7.03ab	9.40bc
K_2G_2	3.33ab	4.77cd	5.87b	8.50cde

K_3G_0	3.61ab	5.47abc	6.73ab	8.27def
K_3G_1	3.44ab	5.30abcd	6.11b	8.33def
K_3G_2	3.37ab	5.13bcd	6.40b	9.00
LSD(0.5)	**1.06**	**.66**	**1.31**	**.94**
CV(%)	**10.37**	**9.07**	**7.80**	**4.07**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Table 10: Effect of different levels of potassium on length of leaf of okra

Treatments	Length of leaf (cm)			
	20 DAS	40 DAS	60 DAS	80DAS
K_0	17.57c	34.37b	39.14c	47.67b
K_1	18.27b	40.08a	46.18ab	47.89b

K_2	18.44b	39.83a	45.82b	48.80b
K_3	21.31a	40.94a	47.56a	50.97a
$LSD_{(.05)}$	**0.68**	**1.17**	**1.465**	**1.74**
CV(%)	**9.68**	**8.74**	**6.95**	**6.80**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Table 11: Effect of different levels of gibberellic acid on length of leaf of okra

Treatments	Length of leaf (cm)			
	20 DAS	40 DAS	60 DAS	80DAS
G_0	17.71c	29.19b	43.34b	46.36b
G_1	18.76b	29.73ab	43.92ab	49.88a
G_2	20.23a	32.58a	47.92a	50.26a
$LSD_{(.05)}$	**0.85**	**3.37**	**4.32**	**1.35**
CV(%)	**9.68**	**8.74**	**6.95**	**6.80**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3).

4.8 Days required for first flowering

Days required for flowering varied significantly due to response of different levels of potassium (Figure 12). The minimum (36.44) days required for flowering was recorded from K_3, whereas the maximum (37.78) days was from K_1, which was statistically similar (37.67) to K_0.

Application of different levels of gibberellic acid showed significant variation on days required for flowering of okra (Figure 13). Singh *et al* (1998) stated that GA increased advanced flowering by 3.33 days. The minimum (36.67) days for flowering was found from G_2.

On the other hand, the maximum (37.5) days was obtained from G_0, which was statistically identical to (37.5 days) by G_1.

Due to combined effect of different levels of potassium and gibberellic acid showed significant differences on days required for flowering of okra (Table 13). The minimum (35.67) days required for flowering was found from K_3G_2, and the maximum (39.00) days from K_0G_1.

4.9 Number of flower buds per plant

Significant variation was found due to application of different leaves of potassium on number of flower buds per plant (Figure 14). The maximum number of flower buds per plant (46.03) was counted from K_2 which was statistically similar and with K_3 (44.90), whereas the minimum (40.23) was obtained from K_0.

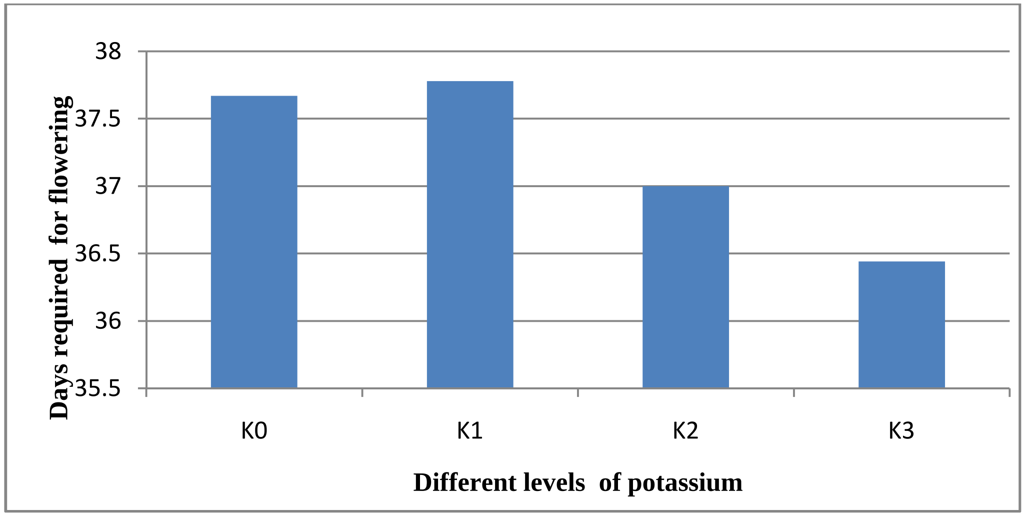
Due to application of different levels of gibberellic acid number of flower buds per plant varied significantly (Figure 15). The maximum number of flower buds per plant (45.38) was observed in G_2, which was statistically similar (44.35) to G_1 and the minimum (40.79) was recorded from G_0.

Table 12:Combined effect of different levels of potassium and gibberellic acid on length of leaf of okra

	Length of leaf (cm)			
Treatments	20 DAS	40DAS	60DAS	80DAS
K_0G_0	14.50d	31.30c	35.54e	43.37c
K_0G_1	17.73c	35.90bc	41.47d	49.53abc
K_0G_2	20.47b	35.90bc	45.07bcd	50.10ab
K_1G_0	18.17bc	37.83b	50.67b	47.87bc
K_1G_1	18.90bc	44.40ab	43.73cd	49.33abc
K_2G_2	17.73c	38.00b	44.13cd	46.47bc
K_2G_0	18.47bc	37.03bc	42.97cd	47.17bc
K_2G_1	17.77c	40.87ab	47.90bc	49.70abc
K_2G_2	19.10bc	41.60ab	46.60bcd	49.53abc
K_3G_0	19.70bc	39.93ab	44.20cd	47.03bc
K_3G_1	20.63b	37.70b	42.57cd	50.93ab

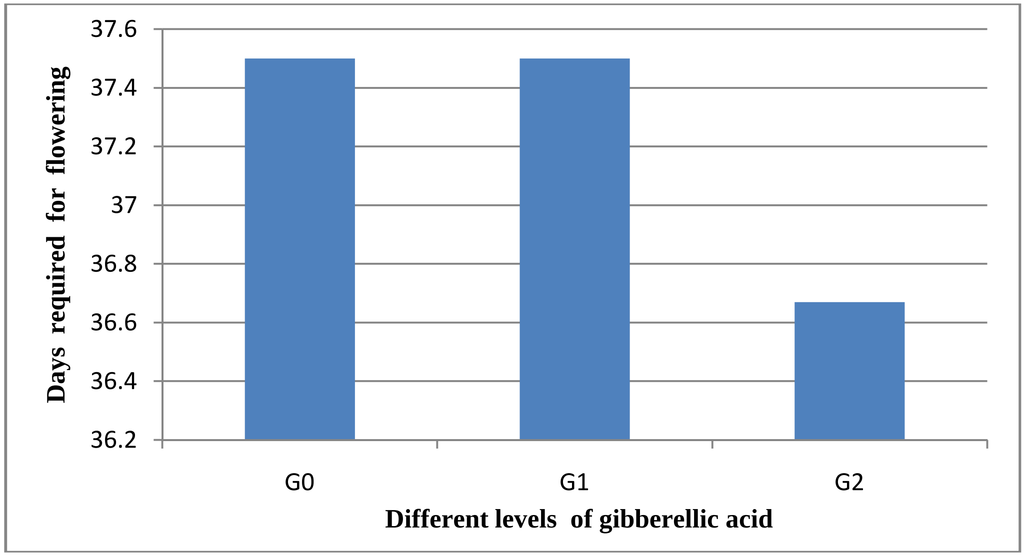
K_3G_2	23.60a	45.20a	55.90a	54.93a
LSD(0.5)	**2.29**	**5.74**	**5.22**	**5.63**
CV(%)	**9.68**	**8.74**	**6.95**	**6.80**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)



(K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 12: Effect of different levels of potassium on days of flowering of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure 13:Effect of different levels of gibberellic acid on days of flowering of okra

Combined effect of potassium and gibberellic acid showed significant variation on number of flower buds per plant (Table 13). The maximum number of flower buds per plant (52.13) was counted from the treatment combination of K_3G_2, while the minimum (35.13) was obtained from K_0G_0.

4.10 Number of pods per plant

Number of pods per plant of okra varied significantly due to response of different levels of potassium (Figure 16). Misra and Pandey (1987) reported that K significantly increasd the number of fruits/plant. The maximum number of pods per plant (29.54) was observed in K_3 and the minimum (20.06) was counted from K_0.

Different levels of gibberellic acid showed significant variation on number of pods per plant of okra (Figure 17).

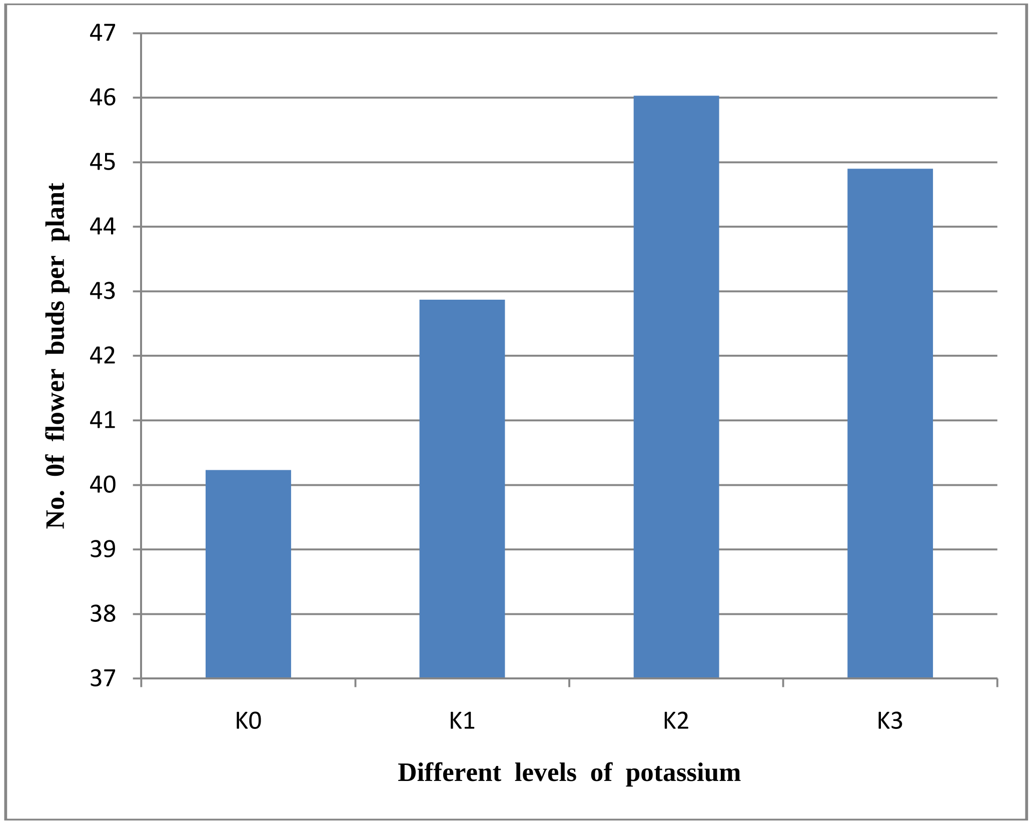
Due to combined effect of different levels potassium and gibberellic acid showed significant differences on number of pods per plant of okra (Table 13). The maximum number of pods per plant (32.90) was found from K_3G_2 and the minimum (15.47) was found from K_0G_0.

4.11 Pod length

Statistically significant variation was observed on pod length of okra due to the application different levels of Potassium (Figure 18). The longest pod (15.11 cm) was observed from K_3 which was statistically similar K_2 and K_1 (12.97 cm and 12.93cm) to, while the shortest pod (11.31 cm) from K_0.

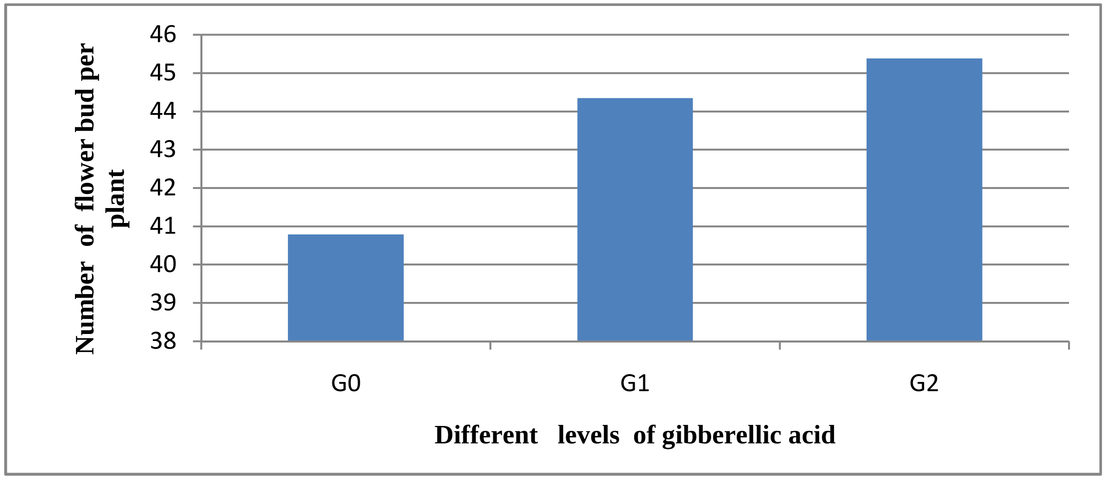
Pod length of okra varied significantly due to response of different levels of gibberellic acid (Figure 19). Kadiri *et al*. (1997) reported that GA_3 increase pod length. The shortest pod (12.57 cm) was found from G_0, whereas the longest pod (13.86 cm) was recorded from G_2.

Combined effect of different levels of potassium and gibberellic acid showed significant differences on pod length of okra (Table 13). The longest pod (17.40 cm) was observed from K_3G_2, again the shortest pod (10.17 cm) was found from K_0G_0.



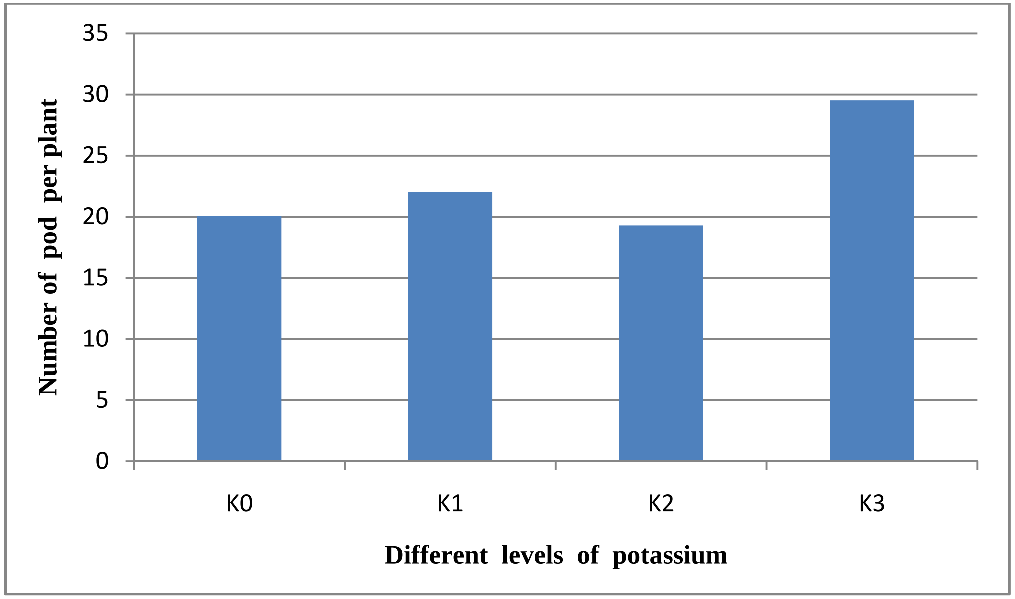
K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 14: Effect of different levels of potassium on number of flower buds per plant of okra



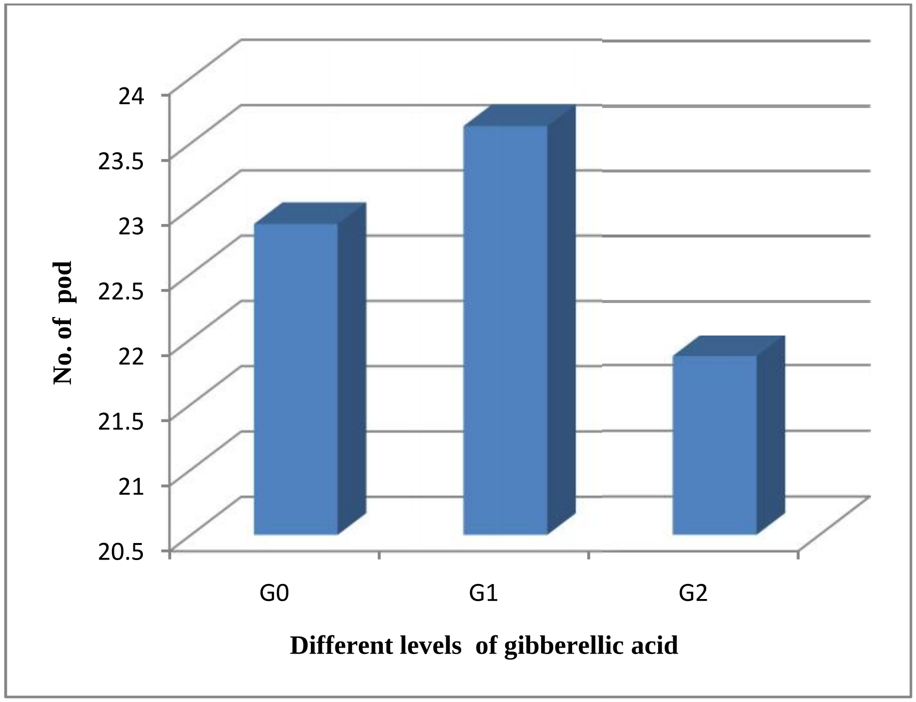
(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure 15: Effect of different levels of gibberellic acid on number of flower buds per plant of okra



(K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure16:Effect of different levels of potassium on number of pod per plant of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure 17:Effect of different levels of gibberellic acid on number of pod per plant of okra

4.12 Pod diameter

Application of different levels of potassium varied significantly on pod diameter under the present trial (Table 14). The highest diameter of pod (1.878 cm) was recorded from K_3 whereas the lowest diameter of pod (1.333cm) from K_0.

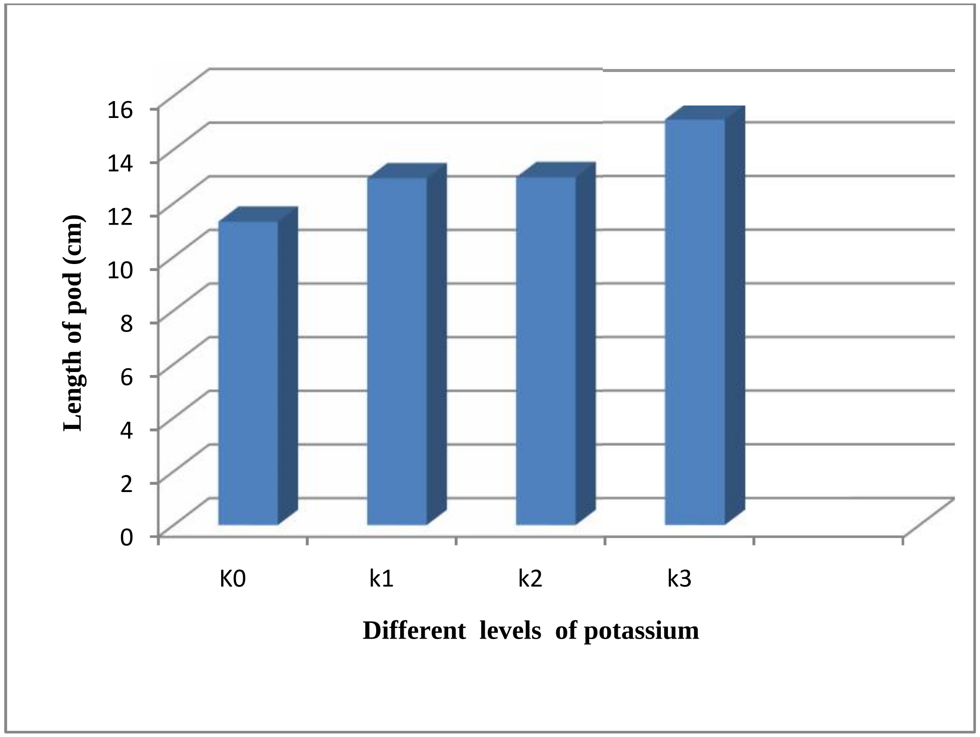
Different levels of gibberellic acid showed significant variation on pod diameter of okra (Table 15). Kadiri *et al.*(1997) stated that gibberellic acid increases pod diameter significantly.The highest diameter of pod (1.63 cm) was observed from G_2, which was statistically identical (1.43 cm) to G_1 whereas the lowest diameter of pod (1.33 cm) was recorded from G_0.

Significant variation was recorded due to the combined effect of different levels of potassium and gibberellic acid on diameter of pod of okra (Table 16).

The highest diameter of pod (2.10) was found from K_3G_2 and the lowest diameter of pod (1.20 cm) was recorded from K_0G_0.

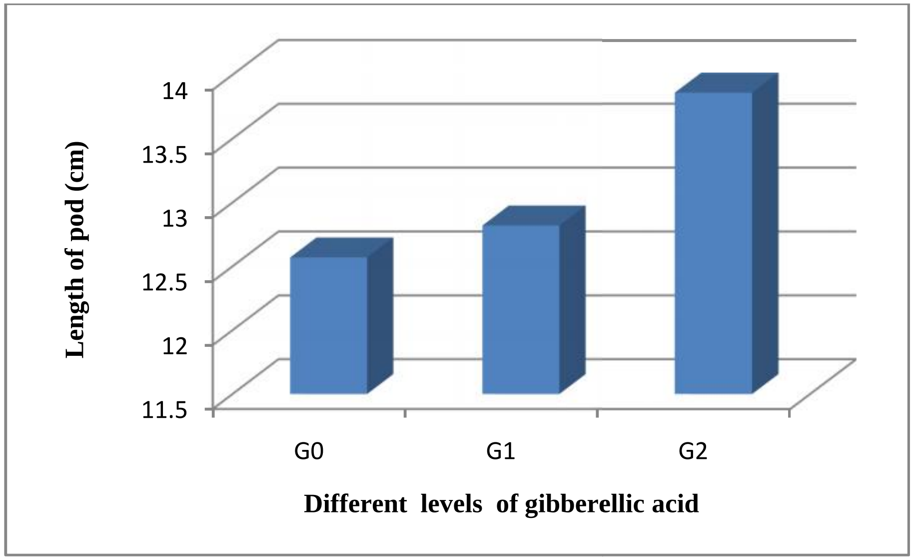
4.13 Fresh weight of leaves per plant

Statistically significant variation was recorded on fresh weight of leaves per plant of okra due to different levels of potassium under the present trial (Table 14). The highest fresh weight of plant (281.30 g) was recorded from K_3 whereas the lowest weight (241.00 g) was obtained from K_0.



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure18:Effect of different levels of potassium on length of pod of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3)

Figure19:Effect of different levels of gibberellic acid on length of pod of okra

Table 13:Combined effect of different levels of potassium and gibberellic acid on days of flowering, no. of flower bud, no. of pod per plant, length of pod of okra.

Treatments	Days of flowering	No. of flower bud /plant	no. of pod/ plant	Length of pod (cm)
K_0G_0	39.00a	35.13e	15.47e	10.17c
K_0G_1	37.33abc	43.37bcd	25.90b	11.33bc

K_0G_2	36.67bc	42.20bcd	18.80de	12.43bc
K_1G_0	38.33ab	45.63bcd	24.03bc	12.87bc
K_1G_1	37.33abc	43.67bcd	21.57bcd	13.10bc
K_2G_2	37.67abc	39.30de	20.47cd	12.83bc
K_2G_0	36.33bc	41.90cd	15.93e	13.17bc
K_2G_1	38.00ab	48.30ab	22.63bcd	12.97bc
K_2G_2	36.67bc	47.90abc	19.33de	12.77bc
K_3G_0	36.33bc	40.50de	31.30ab	14.07b
K_3G_1	37.33abc	42.07bcd	24.43bc	13.87b
K_3G_2	35.67c	52.13a	32.90a	17.40a
LSD(0.5)	**1.82**	**5.55**	**4.08**	**2.91**
CV(%)	**2.88**	**7.87**	**10.80**	**12.52**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Fresh weight of leaves per plant of okra showed significant variation due to application different levels of gibberellic acid (Table 15). The highest fresh weight of leaves per plant (256.80 g) was observed in G_2, which was statistically identical (248.70 g) to G_1 whereas the lowest weight (236.90 g) was recorded from G_0.

Combined effect of different levels of potassium and gibberellic acid showed significant differences on fresh weight of leaves per plant of okra (Table 16). The highest fresh weight of plant (287.60.61 g) was recorded from the treatment combination of K_3G_2, while the lowest weight (207.30 g) was found from K_0G_0.

4.14 Dry matter content of leaves

Percent dry matter content of leaves of okra significantly differed due to different levels of potassium under the present trial (Table 14). The highest dry matter of plant (10.4%) was found from K_1, while the lowest dry matter (8.352%) was obtained from K_0.

Statistically significant variation was recorded on dry matter percent 0f leaves of okra due to different levels of gibberellic acid (Table 15). The highest dry matter (10.41%) was found from G_2, and the lowest dry matter (8.493%) was recorded from G_0.

Due to combined effect of potassium and gibberellic acid showed significant differences on dry matter percent of leaves of okra (Table 16). The highest dry matter of leaves (12.37%) was observed from K_3G_2, and the lowest dry matter (7.53%) was obtained from the treatment combined of K_0G_0.

Table 14:Effect of different levels of potassium on Diameter of pod, fresh wt. of leave/plant (gm), dry matter content of leave/plant (%) of okra

Treatments	Dia. of pod (cm)	fresh wt. of leave/plant (gm)	Dry matter content of leave/plant (%)
K_0	1.333b	241.00b	8.352d
K_1	1.378b	228.70c	10.4a
K_2	1.433b	238.70bc	5.91ab
K_3	1.878a	281.30a	6.62a
$LSD_{(.05)}$	**0.2324**	**11.84**	**0.94**
CV(%)	**8.80**	**2.73**	**8.79**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Table 15:Effect of different levels of gibberellic acid on Dia. of pod, fresh wt. of leave/plant, dry matter content of leave/plant of okra

Treatments(Levels	Dia. of	fresh wt. of	Dry matter content

of gibberellic acid)	pod(cm)	leave/plant(gm)	of leave/plant (%)
G_0	1.33b	236.90b	8.49c
G_1	1.43ab	248.70ab	9.80b
G_2	1.63a	256.80a	10.41a
$LSD_{(.05)}$	**0.22**	**13.95**	**0.31**
CV(%)	**8.80**	**2.73**	**8.79**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (G_0:0ppm GA_3,G_1:60ppm GA_3,G_2:90ppm GA_3).

Table 16: Combined effect of different levels of potassium and gibberellic acid on dia. of pod, fresh wt. of leave/plant, dry matter content of leave/plant of okra

Treatments	dia. of pod(cm)	fresh wt. of leave/plant (gm)	Dry matter content of leave/plant (%)
K_0G_0	1.20d	207.30f	7.53d
K_0G_1	1.43bc	255.80c	9.94bc
K_0G_2	1.53b	260.00c	9.25c

K_1G_0	1.37bcd	216.80ef	9.23c
K_1G_1	1.37bcd	211.00ef	10.97ab
K_2G_2	1.40bcd	258.40c	11.00b
K_2G_0	1.30cd	241.00d	9.98bc
K_2G_1	1.50bc	253.90c	9.42c
K_2G_2	1.50bc	221.10e	9.04c
K_3G_0	1.43bc	282.50ab	8.89cd
K_3G_1	1.43bc	274.00b	8.91cd
K_3G_2	2.10a	287.60a	12.37a
LSD(0.5)	**2.24**	**11.46**	**1.36**
CV(%)	**8.80**	**2.73**	**8.79**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

4.15 Yield per plot

Yield per plot of okra varied significantly for different levels of potassium (Figure 20). Bhai and Singh (1998) reported that K application significantly increased yield of okra.The highest yield per plot (4.22 kg) was found from the K_3 and lowest yield per plot (2.47 kg) from K_0.

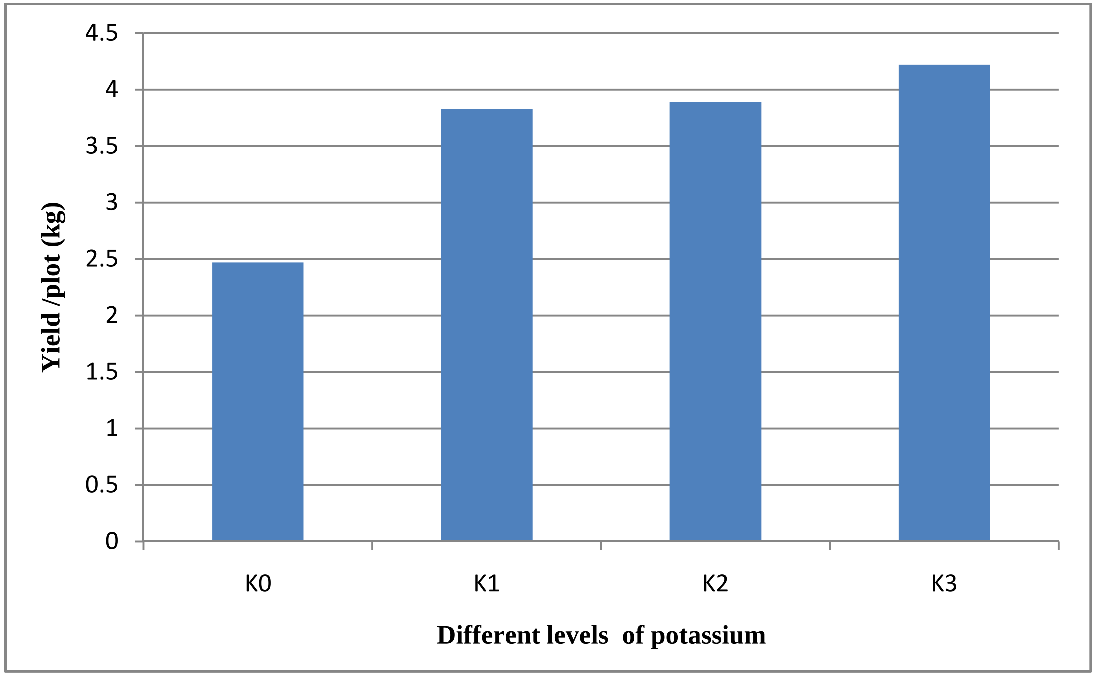
Application of different levels of gibberellic acid showed significant variation on yield per plot of okra (Figure 21). Singh and Singh (1977) reported that yield were enhanced by GA_3 treatment. The highest yield per plot (3.76 kg) was recorded from G_2, which was closely followed (3.58 kg) by G_2. On the contrary, the lowest yield per plot (3.47 kg) was observed from $G_{0.}$

Combined effect of different levels of potassium and gibberellic acid showed significant differences on yield per plot of okra under the present trial (Table 17). Maurya *et al.* (1987) stated that combination of gibberellic acid and fertilizer give the highest yield. The highest yield per plot (4.93 kg) was observed from K_3G_2, while the lowest yield per plot (2.24 kg) was found from K_0G_0.

4.16 Yield per hectare

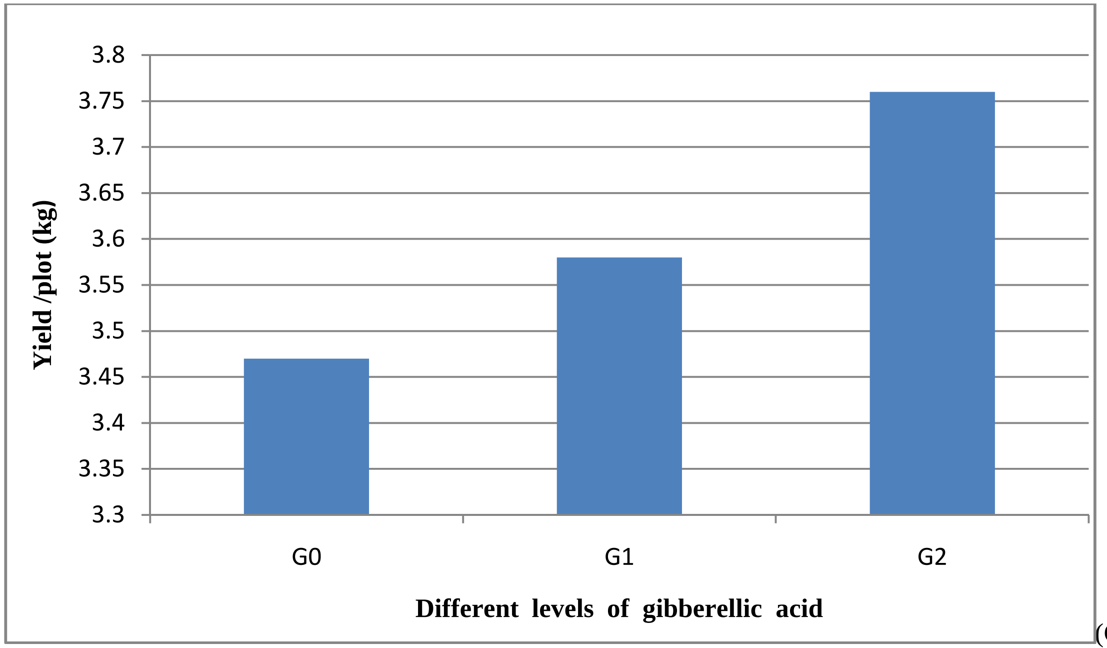
Statistically significant variation was recorded on yield/hectare(ton) of okra due to the application of different levels of potassium under the present trial (Figure 22). The highest yield per hectare (19.04) was recorded from K_3, while the lowest yield per hectare (12.11) from K_0.

Different levels of gibberellic acid showed significant variation on yield per hectare of okra (Figure 23). The highest yield per hectare (17.08) was observed in G_2. On the other hand, the lowest yield per hectare (16.01) was found from G_0.



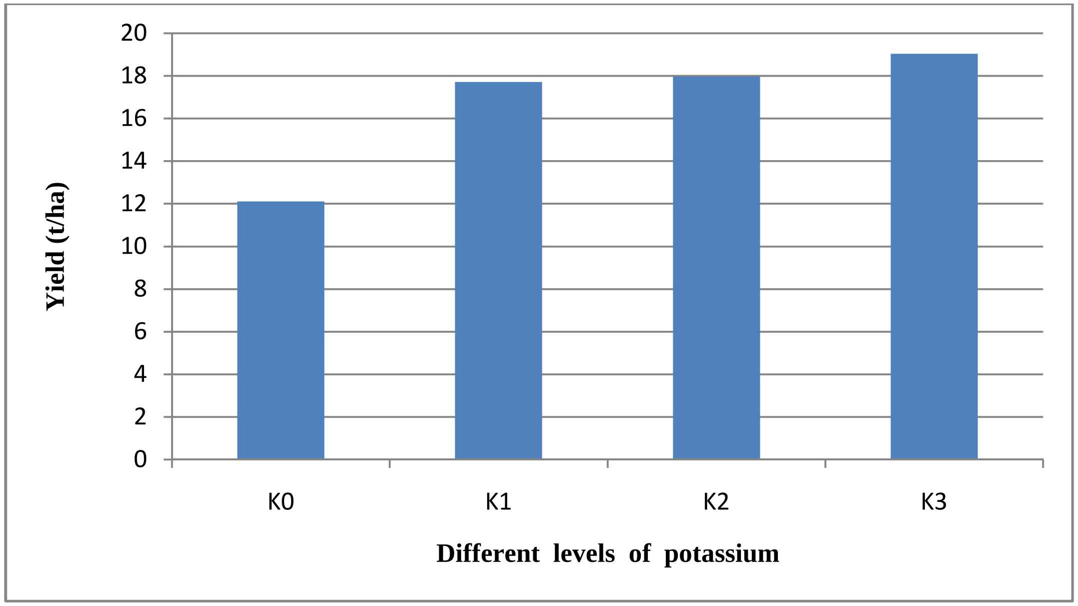
(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 20: Effect of different levels of potassium on yield/plot of okra



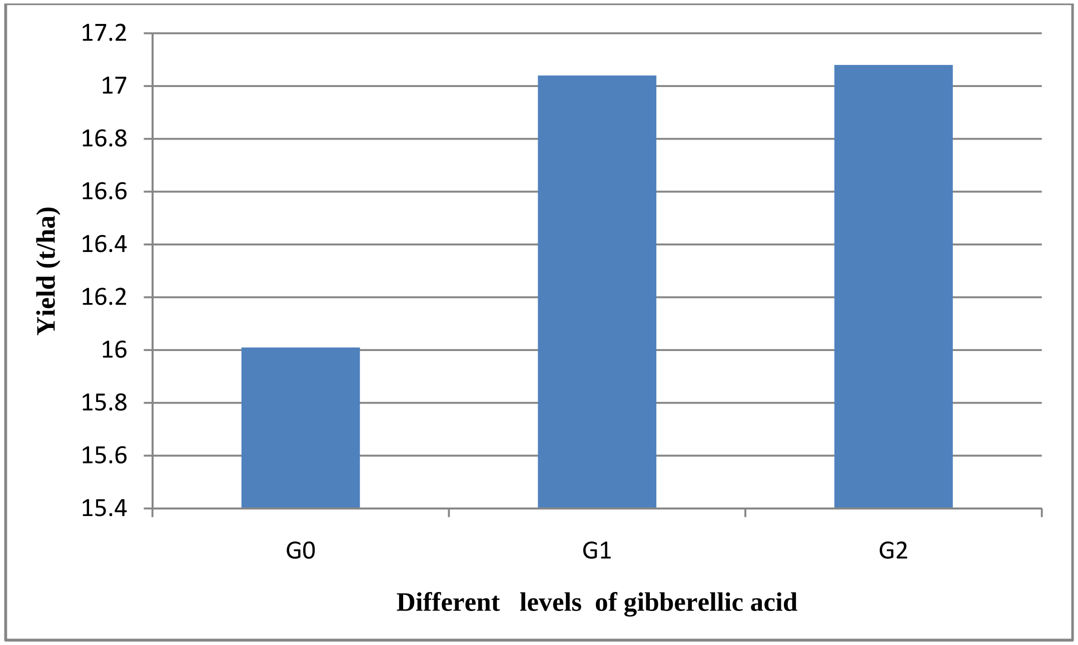
(G_0:0ppm GA_3,G_1:60ppm GA_3,G_2:90ppm GA_3).

Figure 21: Effect of different levels of gibberellic acid on yield/plot(kg) of okra



(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha)

Figure 22: Effect of different levels of potassium on yield of okra



(G_0:0ppm GA_3, G_1:60ppm GA_3, G_2:90ppm GA_3).

Figure 23: Effect of different levels of gibberellic acid on yield of okra

Table 17: Combined effect of different level of potassium and gibberellic acid on yield/plot, yield (t/ha) of okra

Treatments	Yield/plot(kg)	Yield(t/ha)
K_0G_0	2.24c	11.65c

K_0G_1	2.63c	12.51c
K_0G_2	2.52c	12.17c
K_1G_0	3.86b	17.81ab
K_1G_1	3.99b	18.47ab
K_2G_2	3.65b	16.86b
K_2G_0	4.05b	18.70ab
K_2G_1	3.69b	17.07b
K_2G_2	3.93b	18.14ab
K_3G_0	4.18ab	19.30ab
K_3G_1	3.54b	16.33b
K_3G_2	4.93a	21.50a
LSD(0.5)	**0.80**	**3.68**
CV(%)	**13.17**	**13.02**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. (K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Yield per hectare of okra showed significant differences due to the combined effect of different levels of potassium and gibberellic acid (Table 17). The highest yield per hectare (21.50) was recorded from K_3G_2, while the lowest yield per hectare (11.65) was found from K_0G_0.

4.17 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of okra were recorded as per experimental plot and converted into cost per hectare. Price of okra was considered as per market rate. The economic analysis presented under the following headings-

4.17.1 Gross return

The combination of different levels of potassium and gibberellic acid showed different value in terms of gross return under the trial (Table 18). The highest gross return (Tk. 430000) was obtained from the treatment combination of K_3G_2 and the second highest gross return (Tk. 386000) was found in K_3G_0. The lowest gross return (Tk. 233000) was obtained from K_0G_0.

4.17.2 Net return

In case of net return, different levels of potassium and gibberellic acid showed different amount of net return under the present trial (Table 18). The highest net return (Tk. 319958) was found from the treatment combination of K_3G_2 and the second highest net return (Tk. 286216) was obtained from the combination of K_3G_0. The lowest (Tk. 137595) net return was obtained from K_0G_2.

4.17.3 Benefit cost ratio

In the different levels of potassium and gibberellic acid the highest benefit cost ratio (2.91) was noted from the treatment combination of K_3G_2 and the second highest benefit cost ratio (2.86) was estimated from the combination of K_3G_0. The lowest benefit cost ratio (1.30) was obtained from K_0G_2. (Table 18). From economic point of view, it is apparent from the above results that the combination of K_3G_2 was better than those of other combinations.

Table 18.Cost and return of okra cultivation as influenced by potassium and gibberellic acid

Treatments	Cost of production Tk/ha	Yield of okra Ton/ha	Gross return Tk/ha	Net return Tk/ha	Benefit cost ratio
K_0G_0	94655	11.65	233000	138345	1.46
K_0G_1	103018	12.51	250200	147182	1.42
K_0G_2	105805	12.17	243400	137595	1.30
K_1G_0	98000	17.81	356200	258200	2.63
K_1G_1	105805	18.47	369400	263595	2.49
K_2G_2	108035	16.86	337200	229165	2.12
K_2G_0	98781	18.70	374000	275219	2.78

K_2G_1	106809	17.07	341400	234591	2.19
K_2G_2	109039	18.14	362800	253761	2.32
K_3G_0	99784	19.30	386000	286216	2.86
K_3G_1	107812	16.33	326600	218788	2.0
K_3G_2	110042	21.50	430000	319958	2.91

(K_0: 0 kg K_2O/ha (control), K_1: 60 kg K_2O/ha, K_2: 90 kg K_2O/ha, K_3: 120 kg K_2O/ha, G_0:0 ppm GA_3 (control) G_1: 60 ppm GA_3, G_2: 90 ppm GA_3)

Okra Seed @ 3250/kg
Cow dung @ 600/ton
Urea @ Tk25/kg
TSP @ Tk.30/kg
MP @Tk.30/kg,
GA_3@Tk.300/ml.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to August 2015. The objective of the study was to find the growth and yield of okra as influenced by potassium and gibberellic acid. BARI Dherosh-1 was used as test crop in this experiment. The experiment consisted of two factors. The experiment consisted of two factors: Factor A: Potassium fertilizer (4 levels) as i K_0: 0 kg K/ha (control) ii. K_1: 60 kg K/ha iii. K_2: 90 kg K/ha iv. K_3: 120 kg K/ha . Factor B: Gibberellic acid (3 levels) as i. G_0: 0 ppm GA_3 (control) ii. G_1: 60 ppm

GA_3 iii. G_2: 90 ppm GA_3. There were 12 (4 × 3) treatments combination such as the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Size of each plot was 1.8 × 1.2 m. Data were collected in respect of yield contributing characters and yield of okra and statistically significant variation was recorded. At 20, 40, 60 and 80 DAS the tallest plant (21.4, 62.58, 129.2, 146.2), the maximum number of leaves per plant (8.056, 25.72, 31.18 and 38.56), the longest petiole (6.56, 22.99, 25.29 and 28.71)cm, the highest diameter of stem (0.64, 2.21, 2.52 and 2.80)cm, the longest leaf (21.31, 40.94, 47.56 and 50.97cm), the maximum number of branches per plant (2.033, 4.889, 4.967 and 5.333) and the longest internode (3.48, 5.30, 7.4 and 9.31 cm), the minimum days required for flowering (36.44), the, the maximum number of pods per plant (29.54), the longest pod (15.11 cm), the highest diameter of pod (1.878 cm), the highest fresh weight of leaves per plant (281.30 g), the highest yield (19.04 t/ha) was recorded from K_3, maximum number of flower buds per plant (46.03) was recorded from K_2 and the highest dry matter content of leaves (10.4%) was recorded from K_1 whereas the shortest plant (18.04, 54.2, 112.7 and 129.2cm), the minimum number of leaves per plant (5.867, 22.01, 25.97 and 28.99), the shortest petiole (5.12, 17.38, 20.77 and 24.22cm), the lowest diameter of stem (0.43, 1.71, 2.00 and 1.89cm), the shortest leaf (17.57, 34.37, 39.14 and 47.67 cm), the minimum number of branches per plant (1.248, 2.811, 3.811 and 4.389) and the shortest internode (1.58, 4.63, 6.756 and 8.34cm), the minimum number of flower buds per plant (40.23) , the shortest pod (11.31 cm) the lowest diameter of pod (1.333 cm), the lowest dry matter content of leaves (8.352%) and the lowest yield (12.11 t/ha) was recorded from K_0 the maximum days required for flowering (37.78) the lowest fresh weight of leaves per plant (228.70 g) was recorded from K_1, minimum number of pods per plant (19.30)was recorded from K_2.

At 20, 40, 60 and 80 DAS the tallest plant (21.11, 62.02, 65.4 and 145.30 cm), the maximum number of leaves per plant (7.958, 25.51, 31.25 and 37.1), the longest petiole (6.52, 22.45, 25.81 and 27.68cm), the highest diameter of stem (0.625, 2.25, 2.458 and 2.675 cm), the longest leaf (20.23, 47.92, 40.17 and 50.26cm), the maximum number of branches per plant

(1.673, 4.88, 5.092 and 5.583), the longest internode (3.358, 5.492, 7.65 and 9.93cm), the minimum days required for flowering (36.67), the maximum number of flower buds per plant (45.38), the maximum number of pods per plant (22.88), the longest pod (13.86 cm), the highest diameter of pod (1.63 cm), the highest fresh weight of leaves per plant (256.80 g), the highest dry matter content of leaves (10.41%), and the highest yield (17.08 t/ha) was observed from G_2 and the shortest plant (18.57, 54.05, 114.90 and 134.40 cm), the minimum number of leaves per plant (6.367, 22.55, 27.04 and 32.47), the shortest petiole (5.80,19.06, 22.07 and 25.54cm), the lowest diameter of stem (0.45, 1.75, 2.067 and 2.075 cm), the shortest leaf (17.71, 43.34, 36.53 and 46.36cm), the minimum number of branches per plant (1.357, 3.84, 4.158 and 4.458cm), the shortest internode (2.399, 4.967, 6.717 and 8.68cm), the maximum days required for flowering (37.5), the minimum number of flower buds per plant (40.79), the minimum number of pods per plant (21.68), the shortest pod (12.57 cm), the lowest diameter of pod (1.33 cm), the lowest fresh weight of leaves per plant (236.90 g), the lowest dry matter content of leaves (8.493%) and the lowest yield (17.08t/ha) was observed from G_0.

At 20, 40, 60 and 80 DAS the tallest plant (22.10, 66.73, 137.30 and 164.00 cm), the maximum number of leaves per plant (9.80, 30.00, 35.53 and 36.53), the longest petiole (8.17, 27.10, 29.90 and 31.60cm), the highest diameter of stem (.73, 2.47, 2.67 and 2.87cm), the longest leaf (23.60, 45.20, 55.90 and 54.93cm), the maximum number of branches per plant (1.96, 5.77, 6.20 and 7.33), the longest internode (3.37, 5.13, 6.40 and 9.00cm), the highest fresh weight of leaves per plant (287.60 g), the highest dry matter content of leaves (12.37%), the minimum days required for flowering (35.67), the maximum number of flower buds per plant (52.13), the maximum number of pods per plant (32.90), the longest pod (17.40 cm), the highest diameter of pod (2.10 cm),the highest yield (21.50 t/ha) was observed from K_3G_2, while the shortest (18.97, 58.50, 89.90 and 115.80cm), the minimum number of leaves per plant (4.77, 12.90, 24.47, 25.47), the shortest petiole (4.40, 16.63, 15.50 and 19.37 cm), the lowest diameter of stem (0.37,1.20,1.57and 1.50cm), the shortest leaf (14.50, 31.30, 35.54 and 43.37cm), the minimum number of branches per plant (1.03, 2.20, 3.43 and 3.53), the shortest internode (1.13, 4.57, 5.70 and 7.40 cm), the lowest fresh weight of leave (207.30 g), the lowest dry matter content of leaves (7.53%), the maximum days required for flowering (39.00), the minimum number of flower buds per plant (35.13), the minimum number of pods per plant (15.47), the shortest pod (10.17 cm), the lowest diameter of pod (1.20 cm),and the lowest yield (11.65 t/ha) was recorded from K_0G_0.

The highest gross return (Tk. 430,000), the highest net return (Tk. 319958) and the highest benefit cost ratio (2.91) was obtained from the treatment combination K_3G_2 and the lowest gross return (Tk. 233,000) was obtained from K_0G_0, the lowest net return (Tk. 137595) and the lowest benefit cost ratio (1.30) was obtained from K_0G_2. From economic point of view, it is apparent from the above results that the combination of K_3G_2 was better than rest of the combination.

Conclusion:

Considering the growth parameters, yield and economic point of view, it is apparent that the combination of K_3G_2 (K_3:120 kg K_2O/ha,G_2:90 ppm GA_3) was better than rest of the combination.

Recommendation:

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptation and other performance.

2. Another experiment may be carried out with different fertilizers and plant growth regulator with different levels.

3. The experiment was conducted only for one growing season, so such type of research works maybe needed in another season for more confirmation of the results.

REFERENCES

Abdul, K. S., Arif, L. H. A. and Yadgar, M. F. (1985). Effect of some growth regulators on the growth and yield of okra. *Iraqi J. Agril. Sci.* **3**(3):95-104.

Ahmed, C. M. S and Tahir, M. (1996). Effect to gibberellic acid as foliar spray of some of the okra plant characters. *Sarhad J. Agril.* **12**(4):405-408.

Ahmed and Tullok-Reid. 1968. Studied the response of okra to nitrogen,phosphorus,potassium and magnesium fertilization at the rate of 112 kg N,168 kg P,280 kg P,280 Kg K and 112 kg Mg per hactare at Trinida on loam soil for best yield of okra. *Haryana J. Hort. Sci.* **10**(1/20):136-140.

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.

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

Aslam, M. A. and Singh, A. K. (2003). Effect of excessive use of nitrogen fertilizers on yield of okra. *J. Hort. Sci.* **2**(1):61-66.

Bamel, L. K. and Singh, A. K. (2003). Study the effect of different fertilizer sources on *M. incognita* in okra under greenhouse conditions. *J. Hort. Sci.* **22** (3-4):21-26.

Bhai, K. L. and Singh, A. K. (1997). Effect of different levels of phosphorus,gibberellic acid and picking on seed production of okra.*Indian J. Sci.* **38**(3-4):119-122.

Bhai, K. L. and Singh, A. K. (1997). Effect of different levels of phosphorus,gibberellic acid and picking on seed production of okra.*Veg. Sci*. **24**(1):4-6.

Bhattacharya, S., Bhattacharya, N. C. and Malik, C. P. (1978). Synergistic effect of gibberellic acid and indole-3-acetic acid on rooting in stem cuttings of *Abelmoschus esculentus*. *Moench.Planta*. **138**(1):111-112.

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

Chatterjee, A. and Sukul, N. C. (1995). Use of growth regulators in control of root-knot incidences in okra plants. *J. Movopathol.Res*. **33**(2):91-97.

Chauhan, D. S. and Gupta, M. L. (1973). Effect of nitrogen,phosphorus and potassium on growth and development of okra. *Indian J. Hort. Sci***. 30**(1-2):401-406.

Davies, P. J. (1995). Foliar feeding with Gibberellic acid (GA_3): A strategy for enhanced growth and yield of Okra (*Abelmoschus esculentus L.* Moench*.). African. J. Agric. Res.* **8:**3299-3302.

Deore, B. P., Patil, V. A. and Decore, D. N. (1987). Effect of growth substances on the yield and yield contributing characters of okra.Current Research Reporter,MahatmaPhule Agril.Univ. **3**(2):5-9.

Dhumal, B. S., Belorkar, P. V.,Patil, B. N., Golliwar, V. J. and Gaikwad, Y. S. (1993). Effect of seed treatment with gibberellic acid on growth and yield of okra. *J. Soils Crops*. **3**(1):27-29.

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

Elassar, G., Rudich, J., Palevitch, D. and Kedar, N. (1973). Induct of parthenoco development in cucumber by growth regulators. *Indian J. Hort*. **16**:233-235.

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.

Gopalkrishnan, P. K. and Choudhury, B. (1978). Effect of plant growth regulator sprays on modification of sex,fruit set and development in watermelon(*Citrulalanatus Thunb. Mansf.). Indian J. Hort*. **35**:235-241.

Gosh, H. S. and Basu, P. S. (1983). Effect of plant growth regulators and boron on flowering,fruiting and seed yield of bitter gourd. Hort. Abst.**54**:149.

Gowda, K. P. and Bharma, R. J. (2001). Effect of nitrogen, spacing and green fruit pickings on the seed production of okra.*Veg. Sci*. **15**(1):8-14.

Gowda, K.P. and Bharma, R. J. (2002). Effect of nitrogen spacing and green fruit pickings on the seed production of okra (*Abelmoschus esculentus* L. *Moench*). *Veg. Sci.* **15**(1): 8-14.

Gulshan, L. and Lal, G. (1997). Flowering,fruiting and seed production of okra as influenced by growth regulators and urea. *Recent Hort*. **4**:135-137.

Harrington, J. F., Rappaport, L. and Hood, K. J. (1996). The influence of gibberellins on stem elongation and flowering on endive. Science. **125**:601.

Islam, J. K. and Noor, S. P. (1982). Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. *Pakistan J. Sci. Res*. **34** (3-4): 113-119.

Kadiri, M., Mukhtar, F. and Agbola, D. A. (1997). Responses of some Nigerian vegetables of plant growth regulator treatments.*Rev. Biol.Trop*. **44-45**:23-28.

Kim, C. (1994). Nutrient content and seed quality and agronomic performance of okra in different field conditions. *Acta*

Agric. Sinc. **23**(3):32-40.

Koshioka, M., Nishijima, T. and Yamazaki, H. (1996). Endogenous gibberellins in the immature seed of okra. *J. Plant Physiol*. **149**(1-2):129-132.

Kumar, K. K., Urs and K. K. C. D. (1988). Effect of fertilizers on incidence of shoot and fruit borer of okra (*Abelmoschus esculentus*). *Indian J. Agril. Sci.* **58**(9):732-734.

Kumer, S., Singh, P., Katiyar, R. P., Vaish, C. P. and Khan, A. A. (1996). Beneficial effect of some growth regulators on the aged seeds of okra(*Abelmoschus esculentus L.*) under field conditions.*Seed Res*. **24**:11-14.

Mani, S. and Ramanthan, K. M. (1990). Effect of nitrogen and potassium on the yield behind fruit.South Indian Hort. **28**(4):136-138.

Maurya, A. N., Muthoo, A. K. and Kumar, A. (1987). A note on the use of gibberellic acid and urea sprays in increasing yield of bhindi. *Harayana J. Hort. Sci.* **16**(1 &2):148-150.

Mishra, H. P and Pandey, R. G. (1987). Effect of nitrogen and potassium on the seed production of okra (*Abelmoschus esculentus L. Mill*) in calcarioussoil. *Indian J. Agron*. **32**(4):425-427.

Nandpuri, K. S., Randhawan, J. S. and Randhawa, K. S. (1969). Influence plant growth regulators on germination,growth,flower formation,fruitset,yield of okra. *J .Res*. Ludhiana .**6**:82-89.

Opena, R.T., Kuo, C. C. and Yoon, J. Y. (1988). Breeding and Seed Production of okra in the Tropics and Subtropics. Tech. Bul. 17, AVRDC. p. 97.

Pawar, P. R., Joshi, A. T. and Mahakal, K. G. (1977). Effect of seed treatment with plant growth regulators on germination,growth and yield of okra. *J. Maharashtra Agril.Univ*. **2**(1):26-29.

Prabu, S. K.and Pramanik, S. D. (2002).The effects of inorganic fertilizers on growth of okra. *Haryana J*. **21**(4):450-455.

Ramphal, C. and Gill, H. S. (1990). Demand and supply of vegetables and pulses in South Asia. In: Vegetable research and development in South Asia: Proceeding of a workshop held at Islamabad, Pakistan, 24-29 September, 1990. Shanmugasundaram (ed). AVRDC publication no. 90-331.AVRDC, Tainan, Taiwan.

Rain, K. M. and Lal, M. L. (1999). Effect of four fertilizer level on the growth and development of okra cultivars(Prabhani Kranti,Anamika and Pusa Sawami).*Haryana J. Hort. Sci*. **109**:7-14.

Rattan, R. S., Ghimire, N. P. and Kohli, U. K. (1987). Effect of different levels of plants growth regulators on some agronomic trains in okra.Haryana Agril. Univ. *J. Res.* **17**(2):181-186.

Rehm, G. and Schmitt, M**. (**2002)**.** Potassium for crop production. Retrieved February 2, 2011, from Regents of the university of Minnesota.website:http://www.extension.umn.edu/distribution/cropsystems/dc6794.html.

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

Sahai, R., Agrawal, N. and Roy, P. S. (1980). Action of growth regulators on seed germination,early seedling growth and cotyledon expansion of *Hibiscus esculentus L. Acta Botanica Indica*. **8**(1):81-86.

Sarkar, P. K., Haque, M. S. and Karim, M. A. (2002). Effects of GA and IAA and their Frequency of Application on Morphology, Yield Contributing Chracters and Yield of Soybean. *Pakistan J. Agron*. **1**(4):119-122.

Sayed, A.,Hussain, S. A., Nawab, A., Asghar, S. and Ali, N. (1997). Effect of exogenous growth regulators on growth,flowering and yield of okra. *Sarhad J. Agril.* **13**(5):449-453.

Singh, D. K., Jain, S. K. and Lal, G. (1999). Response of plant bio-regulators and foliar feeding of urea on seed yield of okra cv. Pusa Sawani during spring-summer season. *Sci. Hort*. **6**:121-124.

Singh, K. P. and Pande, M. L. (1982). Response of various levels of nitrogen and phosphorus on seed crop of okra. *Indian J. Agril. Res*. **30**:100-105.

Singh, P. V., Jitendra, K. and Kumar, J. (1998). Effect of gibberellic acid as a presowing seed treatment and different levels of nitrogen on germination,growth,flowering and yield of okra. *Indian J. Agric. Res.* **32**(1):31-36.

Singh, R. K. and Singh, K. P. (1977). Effect of seed treatment with plant growth substance on germination,vegetative growth and yield of okra.Proceedings of the Bihar.*Aca. Agric. Sci.* **25**(2):24-27.

Singh. R. K., Singh, K. P. and Mandal, G. (1976). Effect of seed treatment with PGR on yield and economics of okra. Proceedings of the Bihar *Acta. Agric. Sci.* **24**(2):108-109.

Sharma, C. B. and Shukla, V. (1973). Nature of response in okra (*Abelmoschus esculentus* L. *Moench*). To nitrogen, phosphorus and potassium applications and their economic optima. *Indian J. Agril. Sci***. 43**(10): 930-933.

Srivastava,V. K. and Sachan, S .S. P. (1971). Effect of indole acetic acid and gibberellic acid on growth and yield of okra.*Indian. J. Hort*. **28**(3):237-239.

Srivastava, V. K. and Sachan, S. S. P. (1971). Effect of pre-sowing treatment with growth substance on Okra.Allahabad Fmr. **42**:27-29.

Tamura, J. and Minamide, T. (1984). Harvesting..maturity, handling, and storage of Okra pods. Bulletin of the University of Osaka Prefecture. Series B. **36**:87-97.

Vadigeri, B. G. and Madalageri, B. B. (1989). Response of cucumber genotypes to ethrel and GA_3.*Karnataka J. Agric. Sci*.**2**:176-178.

Vashisht, K. D., Paul, Y. and Sharma, B. N. (1989). Influence of gibberellic acid and 2,4-dichlorophenoxyacetic acid on germination of okra. *J. Res*. **24**(2):264-271.

APPENDICES

Appendix i. Characteristics of entire farm soils as analyzed by Soil Resources Development Institute (SRDI) Khamarbari ,Farmgate , Dhaka

A . Morphological Characteristics of the experimental field

Morphological Feature	**Characteristics**
Location	Center farm SAU Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow and Brown Terrace Soil
Land Type	High Land
Soil Series	Tejgaon
Topography	Fairly leveled

Flood level	Above Flood Level
Drainage	Well Drained
Cropping Pattern	Fellow Lettuce

B.Physical and Chemical Properties of Initial Soil

Characteristics	Value
Particle size analysis(Mechanical analysis)	
%Sand %Silt %Clay	27 43 30
Textural Class	Silty Clay

Chemical analysis	
PH	5.6
Organic Carbon(%)	0.45
Organic Matter(%)	0.78
Total N(%)	0.03
Avalable P (ppm)	20.00
Exchangeable K(me/100gm soil)	0.10
Available S ppm	45

Source;SRDI

Appendix ii. Monthly records of year rainfall , relative humidity , total rainfall from 2015 January to July

Month	Air temperature(^{0}C)		R.H(%)	Total rainfall(mm)
	Maximum	Minimum		
January	28.51	11.40	74	8
February	28.10	12.70	79	32
March	34.40	17.60	70	61
April	37.30	21.40	66	137

May	36.20	23.25	72	245
June	36.42	25.50	81	315
July	34.25	27.20	80	329

*monthly average

**monthly total

Source;Bangladesh Meteorological Department (Climate division)

Agargaon, Dhaka-1207

Appendix iii: Analysis of variance of the data on the growth of okra.

Mean sum of Square													
Source of variation	DF	Plant height				No. of leave				Petiole length			
		20	40	60	80	20	40	60	80	20	40	60	80
Replication	2	3.913	20.54	150.23	137.41	0.076	.487	24.98	.91	2.412	3.303	9.37	3.402
Factor A(Potassium)	3	19.91	108.53	432.23	436.42	8.25	21.943	47.97	149.2	6.84	78.625	49.91	32.674
Factor B (Gibberellic acid)	2	19.38	198.526	427.73	482.926	7.826	26.57	54.55	65.61	4.7	68.461	56.88	14.469
Interaction	6	8.17	72.93	619.12	349.59	4.43	51.8	22.40	186.93	4.07	21.895	43.252	23.917
Error	22	1.79	82.22	142.35	92.98	.48	6.56	5.5	13.37	.89	11.227	6.649	7.214

Mean sum of Square

Source of variation	DF	Stem diameter				Leaf length				No. of branch			
		20	40	60	80	20	40	60	80	20	40	60	80
Replication	2	.003	.036	.053	.310	8.379	6.092	26.137	2.281	.037	.626	2.308	3.560
Factor A(potassium)	3	.068	.380	.423	1.248	27.511	80.860	127.636	35.812	1.143	7.44	2.483	1.461
Factor B (Gibberelic acid)	2	.092	.773	.466	1.090	22.991	47.439	104.250	77.914	.304	5.563	2.847	5.597
Interaction	6	.050	.399	.297	.673	9.597	26.102	94.241	25.039	.618	2.391	1.333	2.280
Error	22	.003	.081	.025	.088	3.318	11.507	9.627	11.062	.091	.254	.216	0.594

Mean sum of Square					
Source Of variation	DF	Length of internode			
		20	40	60	80
Replication	2	.005	1.578	5.410	.9477
Factor A(potassium)	3	11.141	4.982	1.245	3.849
Factor B (Gibberellic acid)	2	2.774	.839	3.330	5.654
Interaction	6	1.911	1.321	5.235	6.564
Error	22	0.368	0.554	.613	0.244

Appendix iv: Analysis of variance of the data on the yield of okra

Mean sum of Square										
Source of variation	DF	No.of flower bud	Days of flowering	No. of pod/plant	Length of pod	Dia. of pod	Fresh wt.of leave	Dry wt. of leave	Yield(kg/plot)	Yield (ton/hectare)
Replication	2	43.648	3.694	30.034	2.090	0.004	418.591	0.534	0.158	4.030
Factor A(Potassium)	3	89.220	3.481	205.143	31.985	0.569	4853.222	7.257	5.421	87.618
Factor B (Gibberellic acid)	2	111.029	2.778	16.229	11.632	0.848	1201.475	11.593	0.260	4.433
Interaction	6	79.739	2.259	64.489	7.060	0.394	1443.494	6.136	0.504	6.773
Error	22	11.638	1.149	5.968	2.716	.018	45.771	.708	.225	4.731

Appendix v: Production cost of Okra per hactare

(A) Material cost (Tk./ha)

Treatment Combination	Seed (4 kg/ha) Tk.	Fertilizer and Manure					Subtotal 1(A)
		Cowdung	Urea	TSP	MP	GA_3	
K_0G_0	13000	6000	3750	3000	-	-	25750
K_0G_1	13000	6000	3750	3000	-	7000	32750
K_0G_2	13000	6000	3750	3000	-	9000	34750
K_1G_0	13000	6000	3750	3000	1800	-	27550
K_1G_1	13000	6000	3750	3000	1800	7000	34550
K_1G_2	13000	6000	3750	3000	2700	9000	36550
K_2G_0	13000	6000	3750	3000	2700	-	28450
K_2G_1	13000	6000	3750	3000	2700	7000	35450
K_2G_2	13000	6000	3750	3000	2700	9000	37450
K_3G_0	13000	6000	3750	3000	3600	-	29350
K_3G_1	13000	6000	3750	3000	3600	7000	36350
K_3G_2	13000	6000	3750	3000	3600	9000	38350

Appendix v : contd. (B) Non- material cost (Tk./ha)

Treatment Combination	Land Preparation	Fertilizer and Manure Application	Seed Sowing	Intercultural Operation	Harvesting	Subtotal1(B)	Total Input Cost(1A+1B)
K_0G_0	17000	-	6000	10000	10000	43000	68750
K_0G_1	17000	500	6000	10000	10000	43500	76250
K_0G_2	17000	1000	6000	10000	10000	44000	78750
K_1G_0	17000	1200	6000	10000	10000	44200	71750
K_1G_1	17000	1200	6000	10000	10000	44200	78750
K_1G_2	17000	1200	6000	10000	10000	44200	80750
K_2G_0	17000	1000	6000	10000	10000	44000	72450
K_2G_1	17000	1200	6000	10000	10000	44200	79650
K_2G_2	17000	1200	6000	10000	10000	44200	81650
K_3G_0	17000	1000	6000	10000	10000	44000	73350
K_3G_1	17000	1200	6000	10000	10000	44200	80550
K_3G_2	17000	1200	6000	10000	10000	44200	82550

Okra Seed @ 3250/kg
Cow dung @ 600/ton
Urea @ Tk25/kg
TSP @ Tk.30/kg
MOP @Tk.30/kg,
GA_3@Tk.300/ml.

Appendix v : Contd. (C) Overhead cost and total cost of production (Tk.)

Treatment	Cost of	Miscellaneous Cost	Interest on running Capital for	Total	Total cost of production(Input cost +

Combination	Lease Land	(5% of Implementers cost)	6 Months(13% of total input cost)		Interest on running Capital Tk./ha)
K_0G_0	18000	3437	4468	25905	94655
K_0G_1	18000	3812	4956	26768	103018
K_0G_2	18000	3937	5118	27055	105805
K_1G_0	18000	3587	4663	26250	98000
K_1G_1	18000	3937	5118	27055	105805
K_1G_2	18000	4037	5248	27285	108035
K_2G_0	18000	3622	4709	26331	98781
K_2G_1	18000	3982	5177	27159	106809
K_2G_2	18000	4082	5307	27389	109039
K_3G_0	18000	3667	4767	26434	99784
K_3G_1	18000	4027	5235	27262	107812
K_3G_2	18000	4127	5365	27492	110042