RESPONSE OF SOWING TIME AND HORMONES ON GROWTH AND YIELD OF OKRA

BY

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This is to certify that the thesis entitled "***Response of sowing time and hormones on growth and yield of okra***" submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE** embodies the result of a piece of *bona fide* research work carried out by **Shahana Dilruba**, Registration No. 01025 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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TO

MY BELOVED PARENTS

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RESPONSE OF SOWING TIME AND HORMONES ON GROWTH AND YIELD OF OKRA

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ABSTRACT

A field experiment was conducted to evaluate the response of sowing time and hormones on growth and yield of okra at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to August, 2007. The experiment consisted of two factors viz. Factor-A: Three sowing time i.e. March 22, April 06 and April 21 and Factor-B: Hormones (4 treatments) i.e. Control, Alga Gold, Crop care and Ripen-15. The experiment was laid out with Randomized Complete Block Design (RCBD) with three replications. In case of sowing times, 06 April produced the height yield (13.88 t ha^{-1}) and 22 March produced the lowest yield (10.22 t ha^{-1}). In case of hormone, Ripen-15 produced the highest yield of okra (14.06 t ha^{-1}) and control produced the lowest (10.06 t ha^{-1}). Combined effect of 06 April sowing with Ripen-15 produced the highest yield (15.98 t ha^{-1}) while 22 March sowing with no hormone gave the lowest yield (9.10 t ha^{-1}). Therefore, 06 April sowing with Ripen-15 is best for better growth and yield of okra.

ABBREVIATIONS AND UNITS

Abbreviation	
AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
C.V.	Coefficient of Variation
cv.	Cultivar
DAS	Days after sowing
DM	Dry matter
E	East
et al.	*et alii* (and others)
etc.	*et cetra* (and so on)
FAO	Food and Agricultural Organization
Fig.	Figure
GA	Gibberellic acid
IAA	Indole acetic acid
i.e.	id est (that is)
IW	Irrigation water
LSD	Least significant difference
N	North, Nitrogen
No.	Number
NAA	Napthalene acetic acid
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
TDM	Total dry matter
viz.	Videlicet (namely)

Unit	
%	Percentage
^{0}C	Degree Celsius
cm	Centimeter
g	Gram
ha	Hectare
kg	Kilogram
m	Meter
ppm	Parts per million
q	Quintal
t	Ton

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Introduction

CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important summer vegetable in Bangladesh (Rashid, 1999). It is a semi woody, fibrous herbaceous annual with an indeterminate growth habit. The plants form a deeply penetrating taproot with dense shallow feeder roots reaching out in all direction in the upper 45cm of the soil. The seeds of okra are dicotyledonous and kidney shaped with epigeal germination (Nonnecke, 1989). Okra is mainly a self pollinated crop however, insects such as honey bees and bumblebees do cross-pollination occasionally. Okra is one of the world's oldest cultivated crops. Okra originated in Asia and Africa (Thomson and Kelly, 1979). The Egyptians made the first recorded reference to okra in 1216 A.D. It is now grown in all parts of the tropics and during the summer in the warmer parts of the temperate region (Baloch, 1994). In Bangladesh, it is known as 'Dherosh', which is also called 'Bhindi' in India and Pakistan (Rashid, 1999). Its tender pods are used as vegetables. It is cultivated throughout Bangladesh but its average national yield is poor, only 3.07 t ha^{-1} (Anon., 2000). The yield is very low as compared to the yield 9.7-10 t ha^{-1} of other developed countries of the world (Thomson and Kelly, 1979). The yield could reach as high as 30 t ha^{-1} (Koay and Chua, 1978).

Okra is a nutritious vegetable which plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market (Ahmed, 1995). These green fruits are rich sources of vitamins, calcium, potassium, and other minerals. Okra is specially valued in different parts of the

country for its tender and delicious fruits. It has been reported to have an average nutritive value, which is higher than that of tomato, eggplant and most cucurbits except bitter gourd (Grubben, 1977). Studies have confirmed the potential of okra seed (dried seed) as a good source of oil and protein for both the temperate regions and the tropics (Oyenuga, 1968; Karakoltsidis and Constantinides, 1975; Martin and Ruberte, 1979). Woodruff (1927) reported that a high protein meal remains after oil extraction of okra seed similar to that of cottonseed meal. The protein content of okra seed is as high as 45% after extraction of oil (Oyenuga, 1968). The plant fibre can be used by the paper industry (Nadkarni, 1927).

It is good for people suffering from renal colic, leucorrhoea and general weakness. Due to its high iodine content, the fruit is considered useful for the control of goitre. Leaves of okra are used in Turkey for the preparation of medicine to reduce inflammation (Mehta, 1959). Bland mucilage is also used for the control of dysentery and as a clarifying agent in the preparation of *gur*.

Sowing time has a great impact on seed production and quality of okra (Singh *et al.,* 1986; Hossain *et al.,* 1999; Yadav and Dhankhar, 2001). Different cultivars require different climatic condition as well as different sowing time and a good cultivars sown at improper time give poor yield (Tindall, 1983 and Nonnecke 1989). Therefore proper and suitable date of sowing is critical to increase the production of crop.

Plant growth regulators (PGR's) affect the physiology of plant growth and influence the natural rhythm of a plant. Indole acetic acid (IAA) and

gibberellic acid (GA_3) can manipulate a variety of growth and developmental phenomena in various crops. IAA has been found to increase the plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in groundnut (Lee, 1990), cotton (Kapgate *et al.*, 1989), cowpea (Khalil and Mandurah, 1989) and rice (Kaur and Singh, 1987). It also increases the flowering, fruit set, the total dry matter of crops (Gurdev and Saxena, 1991). Likewise, GA_3 stimulated stem elongation (Harrington *et al.*, 1996), increase dry matter accumulation (Hore *et al.*, 1988) and enhance total yield of okra (Deotale *et al.*, 1998; Maske *et al.*, 1998). Very limited works have been carried out regarding the use of growth regulators on okra in Bangladesh. Ilias *et al.* (2007) reported that Stem and leaf dry masses and stem length were significantly enhanced by the application of exogenous GA_3

Therefore, the present investigation was carried out to fulfil the following objectives:

i. to observe the effect of sowing time on the growth and yield of okra

ii. to observe the effect of hormones on the growth and yield of okra

iii. to find out the optimum sowing time and proper hormone combination for production of okra.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Okra is one of the important vegetable crops in Bangladesh. It carries a great impact to mitigate the vegetable crisis especially in summer season. But the yield of okra is not up to the mark comparing the world average. This is due to lack of management practices. Different sowing time as well as application of growth regulator can enhance the production of okra. Some research works have been done in different parts of the world on these two factors to find out the production of okra. Some of these are cited here.

2.1 Effect of sowing time

Different cultivars require different climatic condition as well as different sowing time and a good cultivars sown at improper time give poor yield. Therefore proper and suitable date of sowing is critical to increase the production of crop.

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

2005. Minimum days to emergence (10.93) and days to first picking (75.60) was observed when different okra cultivars sown on 08th June, 2005. They concluded that okra cultivar should be sown on 28th May, for high yield at the agro climatic condition of Skardu.

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

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

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

Alegbejo (2001) investigated the effect of sowing date (30 June, 15 July and 30 July) on the incidence of okra mosaic virus (OkMV) during 1997 and 1998 at Samaru, Nigeria. Two okra cultivars were used in the study, the resistant ABK 102 and the highly susceptible JOKOSO. The average number of virus vectors caught per plot decreased with delay in sowing. These vectors were identified as *Podagrica spp.*, *Syagrus calcaratus* and *Nisotra dilecta*. The percentage of OkMV-infected plants increased with delay in sowing, while fruit yield decreased.

Amjad *et al.* (2001) reported that maximum germination percentage was observed when crop was sown on either 25 April or 5 May. Plant height, number of days to flower and length of green pod were not affected by the sowing dates. Number of leaves per plant, number of pods per plant and green pod yield were higher when crop was sown on 15 April or 5 May. Germination percentage, number of days to flower and length of green pods were not influenced by the interaction between sowing time and fertilizer rate. Maximum plant height, number of leaves per plant, number of pods per plant and green pod yield were recorded when the crop was sown on 5 May and given the highest rate of fertilizers (150 kg N + 80 Kg P_2O_5 ha^{-1}).

Gulshan *et al.* (2001) studies the performance of three okra cultivars, viz. Parbhani Karanti, Pusa Sawni and Punjab-7, under three sowing dates (16 June, 29 June 29 and 12 July) were conducted in Himachal Pradesh, India during the kharif season of 1996-97. Prabhani Kranti obtained the highest green pod yield (85.9 q ha^{-1}), followed by Pusa Sawni (80.4 q ha^{-1}) and Punjab-7

(72.5 q ha^{-1}). Punjab-7 exhibited the lowest yellow vein mosaic virus infection (0.3%), while Pusa Sawni showed the highest (41.4%). Sowing of okra on 16 June produced the highest pod yield (92.1 q ha^{-1}); the green pod yield decreased by 9.95 and 33.37% for 29 June and 12 July sowing dates, respectively. The first sowing date (16 June) was the most favourable in promoting plant growth and green pod yield, while sowing on 12 July was the least. Prabhani Kranti sown on 16 June produced the highest green pod yield (101.8 q ha^{-1}).

Incalcaterra *et al.* (2000) evaluated the effect of 2 sowing dates (1 and 15 April 1996) on okra cultivated with or without transparent polyethylene film mulch (1.2 m wide and 0.05 mm thick) in a field trial in Sicily, Italy. Air and soil temperature (5 cm depth) were recorded during the growing season. Data on plant height and number of pods per plant at different dates were also collected. Fruiting pattern was recorded by twice weekly harvest. Mulching had a significant positive effect on soil temperature, seed germination, fruit production (total fruit weight and number of pods per plant) and plant growth patterns, mainly during the first two months of growth. Average soil temperatures under the plastic mulch measured at 08.00 and 12.00h were 1.7 and 2.7°C higher than temperatures without mulching. In mulched plots, plant emergence after 10 days from sowing (100%), pod production (35 t ha^{-1}) and the number of pods per plant (220) were higher compared with those observed in unmulched plots (25%, 24 t ha^{-1} and 178 pods per plant, respectively). Differences in plant emergence were more pronounced for the first sowing date

than for the second. Sowing on 1 April resulted in higher plant height, yields and number of pods per plant.

Dubey and Jha (1999) assessed the effects of planting date (1 Jan.-17 Dec.) and environmental factors (maximum and minimum temperatures, relative humidity and rainfall) on seed germination, pre- and post-germination mortality and development of collar rot disease (*Macrophomina phaseolina*) in okra cv. Prabhani Kranti. Later planting was associated with the lowest incidence of collar rot and highest crop yields.

Hossain *et al.* (1999) reported that plant height, leaf area, leaf number and fruit yield of okra was influenced significantly by different sowing time planted at any row spacing.

Rai and Satpathy (1999) reported the reduction of yield due to variation of sowing time was due to infestation of insect pest and vectors. They found that varied period of occurrence of pests in okra is mainly regulated by prevailing climatic condition. The effect of sowing date and insecticides in controlling the insect pests of okra, studied in a field experiment conducted in Varanasi, Uttar Pradesh, India during 1996 and 1997, showed that there is gradual increase in jassid population with advancement of sowing date up to mid-June. Thereafter it declined substantially. However, late-sown crops suffer more from borers. Crops sown in the second week of July (S_6) recorded maximum fruit damage which was lowest on 25 May (S_2)-sown crops.

Yadav and Dhankhar (1999) evaluated okra cv. Varsha Uphar in Haryana, India during 1997-98 using 9 sowing dates (from 5 March to 12

August at 20-day intervals) and 2 sowing distances (45 × 30 and 67.5 × 20 cm). The highest germination (97.21%) was recorded for seeds sown on 3 July, while highest values for plant height (103.83 cm), number of branches per plant (4.44) and pollen viability (95.85%) were obtained by sowing on 13 June. Days to 50% flowering were significantly affected by sowing date and spacing but their mutual interactions were non-significant for this trait. The number of days required to produce 50% flowering increased with the delay in sowing time, with the lowest number of days (45.33) attained by sowing on 25 March. A spacing of 67.5 × 20 cm resulted in earlier flowering (50.95 days) than 45 × 30 cm (51.96 days). Sowing on 13 June resulted in the highest values for fruit set (90.86%), number of fruits per plant (24.13), and fruit length (19.11 cm) and girth (1.64 cm).

Passam *et al.* (1998) reported that flowering and pod production occurred in waves, with optimum quality, combined with satisfactory yield, being obtained from sowing in March. Although the number and weight of seeds per pod was significantly higher in later sowings, this was not sufficient to outweigh the seed quality advantage from sowing early. The germination rate of Veloudo was high (80-100%) irrespective of harvest date. However, the germination of Boyiatiou was variable due to the formation of a large number of hard seeds, particularly when pods ripened during periods of high temperature. Hardseededness was overcome by acid treatment, which has a scarifying effect. Pods from late harvests required drying prior to seed extraction; even then, seeds from these pods were somewhat immature and

needed a period of after-ripening (60 days at 25°C) to acquire a germination rate of over 90%.

Satpathy and Rai (1998) reported that both sowing time and crop growth stage influenced the insect population significantly in okra crop sown from 15 May to 15 July during the 1996 and 1997 cropping season in Varanasi, Uttar Pradesh, India. The crop was found to be most susceptible to the jassids (*Amrasca biguttula*) at 50 DAS, where as peak population of jassids were observed in the first sown crop. With the advancement of sowing time jassid infestation decreased and borer (*Earias vittella*) damage increased. However, maximum yield was obtained from the crop sown in the first week of June. Although a considerable number of jassids were present during this period, suitable growing conditions resulted in maximum yield.

Muoneke *et al.* (1997) found that okra was either sown the same day as, or 2 weeks before or after maize or *Vigna unguiculata*. Intercropping reduced the growth and yield of okra, maize and *V. unguiculata* relative to their sole crops. However, okra yield was depressed more by maize than by *V. unguiculata*, especially when okra was sown two weeks after maize. Comparative assessment of okra/maize and okra/V. *unguiculata* mixtures suggested that it is better to grow okra and *V. unguiculata* together than intercropping okra and maize because yield advantages were always higher in okra/*V. unguiculata* (67% and 59% in 1990 and 1991 respectively) than in okra/maize (15% and 29%). The results are discussed in the light of competitive abilities of the various components in the mixtures.

Cerri and Vilella (1996) reported photoperiod and interception of photosynthetically-active radiation at floral inception and the progress of temperatures throughout development differed between the 2 sowing dates. Leaf area index at floral initiation and dry matter accumulation differed between the sowing dates and although node appearance rate was highest following late sowing, fruit growth rate was highest following early sowing. Following a total growth cycle of 93 days, cv. Clemson Spineless sown in December gave a total economic yield of 1171 g m^{-2} whereas sown in January the growing cycle was only 49 days and the total economic yield only 15 g m^{-2}. Colhe Bem sown in December gave a total economic yield of 855.3 g m^{-2} (for a 77-day growing cycle), compared with only 12.7 g m^{-2} when sown in January (a 38 day growing cycle). With the second sowing date, harvesting had to cease around the middle of April 1992 due to frosts. It was concluded that under the conditions of this trial, sowing at the end of January was not practical.

Raghav (1996) observed the effects of four sowing dates (21 February or 1, 11 or 21 March) on growth and yield of okra cv. Pusa Sawani. Results from the 1992 and 1993 seasons were pooled. Plant height was greatest with sowing on 1 March. Green pod yield was highest with sowing on 1 March (57.32 q ha^{-1}).

Nath and Saikia (1995) reported that he incidence of BYVMV on okra cv. Pusa sawani varied from 75 to 91% in plots sown between early Apr. and the end of Jun. Infection in plots sown during February to the end of March was progressively less. The lowest yield of okra was obtained from the plots

sown in May and June. A strong positive correlation was obtained between % of disease incidence and whitefly (*Bemisia tabaci*) population (r=0.085) whereas a strong negative correlation was obtained from disease incidence and fruit yield (r=-0.84).

Nath and Saikia (1995) Study the influence of 15 different sowing dates from Feb. To Mar. on bhendi yellow vein mosaic bigemini virus (BYVMV) disease of okra was studied during 1989-90. The incidence of BYVMV on okra CV. Pusa sawani vaired from 75 to 91% in plots sown between early Apr. and the end of Jun. Infection in plots sown during Feb. to the end of Mar. was progressively less. The lowest yield of okra was obtained from the plots sown in May and Jun. A strong positive correlation was obtained between % of disease incidence and whitefly (*Bemisia tabaci*) population (r=0.085) whereas a strong negative correlation was obtained from disease incidence and fruit yield (r=0.84).

Brar *et al.* (1994) reported that the percentage of fruit infestation in okras caused by Earias spp. was lowest in cv. EMS 8 in crops sown on 15 May in Ludhiana, Punjab, India. The greatest fruit yield was obtained in cv. EMS 8 from a crop sown on June 15, whereas crops sown on July 30 had the lowest yield. The losses in fruit yield were lowest on crops sown on July 30 (22.79%) and greatest on crops sown on May 30 (50.58%).

Singh *et al.* (1994) found that, in general, plants from seeds sown later in the year exhibited a higher percentage of yellow vein mosaic virus infection

and a lower yield of seeds compared with plants from seeds sown earlier in the year.

Nath *et al.* (1992) worked in field experiments over 3 yr the incidence of disease caused by okra (*bhendi*) yellow vein mosaic bigemini virus was mosaic lowest in crops sown during the period 10 February -10 March when populations of the vector, *Bemisia tabaci*, were low. Significant positive associations were recorded between disease incidence and whitefly population, temperature, RH and rainfall. Fruit yield of okra was negatively correlated with disease incidence.

Ghanti *et al.* (1991) observed that the fruit yield was maximum with optimum sowing time. They observed that in case of 7th April sowing gave the fruit yield of 1620 g plant^{-1} while 15 March and 21 April gave 1530 g and 1342 g fruit per plant.

Gadakh *et al.* (1990) conducted an experiment, seeds of the okra cultivar pusa sawani and sel-2-2 which were sown in early June, October and January to produce autumn, inter and summer crops respectively. The seeds were sown at 30× 5, 30×10, 30×15 and 30× 30 cm apart. The highest yield (up to 18.51 q ha^{-1}) were obtained with the closest spacing and in the summer season. The treatment had no appreciable effect on pod quality.

Lee *et al.* (1990) reported that okra cv. Dwarf prolific sown on April 15 or May 15 or June 15 grown at spacings of 45 × 60 or 90× 30 cm and give 40, 80 or 100 kg nitrogen per ha green pod yield of 11.36 t ha^{-1} with 40 kg N ha^{-1} 13.2 tons with 80 kg N ha^{-1} and 12.64 tons. The highest yield was obtained at

the most dense spacing and the lowest at the least dense. Green pod yield was 7.2 tons in the earliest sowing and 12.7 tons on May 1 sowing and then decreased (4.0 tons) with further of sowing delaying of sowing extending to June 15 .

Adetunji and Chheda (1989) evaluated ten newly developed lines and 5 established varieties of *Abelmoschus esculentus* were evaluated in 8 different environments (plantings at different times for 3 consecutive years). There were significant variations for seed yield between environments, even though the trials were all at the same site. A regression method of stability analysis indicated that the mean differences between environments, the varieties and their interactions were highly significant. The results suggested that, where limited resources prevent the use of several localities, different planting dates for 2 or more years could be used to evaluate varieties for seed yield without losing much information on their relative ranking.

Bhuibhar *et al.* (1989) conducted an experiment with Seeds of the cultivar Pusa Saoni were sown, during the kharif season, on 4 July, 19 July or 3 Aug. The plants were grown for both vegetable and seed production, with 5 harvesting treatments: (1) no pods harvested green but left until dry, for seeds only; (2) one green pod harvest, (3) 2 harvests, (4) 3 harvests, or (5) 4 harvests. Plants from the earliest sowing produced the highest yields and quality of green pods and seeds. The greatest seed yield (and highest quality) was obtained with treatment (1), treatment (5) gave the highest yield of green pods. The highest economic return was obtained with treatment (4).

Mondal *et al.* (1989) investigated the effects of combinations of five sowing dates (20 Apr., 5 May, 20 May, 5 June and 20 June) and 3 intra-row spacings (30, 45 and 60 cm) on growth and yield of okra were investigated. Rows were sown 45 cm apart. The highest plant height (84.5 cm), number of fruits plant^{-1} (10.9) and fruit yield (186.9 g plant^{-1}, 93.5 q ha^{-1}) were obtained with sowing on the 20 Apr. The 30-cm spacing resulted in the lowest number of fruits plant^{-1} (8.1) and fruit yield/plant (107.2 g), but the highest fruit yield ha^{-1} (79.2 q).

Singh *et al.* (1989) compared four sowing dates (20 June-4 Aug.) and 4 plant spacings were compared. Maximum seed yield (1844.12 kg ha^{-1}) was obtained when the crop was grown at 45 × 30 cm from a sowing on 20 June.

Sayeed (1988) performed a research to observe the effect of sowing time on okra in Mymensingh, Bangladesh. He found the significant effect of sowing time on plant height of okra combined with any treatment.

Singh *et al.* (1988) investigated the effect of sowing dates and spacings on the yield and quality of okra seed. Four sowing dates (20 June to 4 August) and four plant spacings were compared. Maximum seed yield (1844.12 kg ha^{-1}) was obtained when the crop was grown at 45 × 30 cm and sown on June 20.

Ariyo (1987) evaluated six *Hibiscus esculentus* genotypes from a pedigree breeding programme and 9 established varieties for agronomic characters over 5 environments in 2 sites with 2 or 3 planting dates. There was a significant genotype × environment interaction for number of days to flowering and number of branches per plant. Additive environment effects

were significant for all characters. The genotype U 1313 was stable for fruit yield per plant and edible fruit weight. A breeding line U1313 had a below average coefficient of variation for fruit per plant and above average for yield.

Iremiren and Okiy (1986) reported that Ishan Local 1 and Ishan Local 2 were sown at approximately 14 days intervals from 1st April to 1st June in 1983 and 1984 during the main rainy season to evaluate their performance. Low soil temperature and moisture high solar radiation, high atmospheric temperature and low rainfall led to poor seedling emergence at the early sowing dates. However the growth of the plants of early sowing was more vigorous than that of the plants of late sowing. In addition they flowered earlier and had longer harvest duration. This resulted the increased number of pods per plant. The increased pod length including its diameter, volume, weight and yield, indicated the compensatory growth the fewer plants emerged from the early sowing. The relatively lower values of some parameters were obtained with the late sowing dates and were also attributed to possible poor soil aeration resulting from increased rainfall during their growth period. Sowing dates did not generally affect the moisture percentage, oil and protein content in the pods. The differences between cultivars were more uniform than those between sowing dates and were mostly not significant.

Palanisamy *et al.* (1986) studied the influence of date sowing and spacing on seed quality in okra. In trials with the okra cv. Pusa sawani the crop was sown at 60 × 30 cm 60 × 20 cm at monthly intervals between March and

November. The sowing at 60 × 30 cm done in March, April or May produced the best quality seed.

Singh *et al.* (1986) stated the effect of planning dates and spacing on seed production of okra. They conducted a two year trials with the cv. Pusa sawani sown on 15 or 30 June or 15 or 30 July with a plant to plant spacing of 60× 45× 30, or 30 × 30 cm. The seed yield in both the years was highest (1.94.1 t ha^{-1}) in plots sown on 15 June with a plant to plant spacing of 60 × 30 cm.

Gupta *et al.* (1981) reported that the earliest sowing (in between 25 may to 5 November) generally gave the highest average yield which decreased with each delaying sowing date. The closest spacing and the earliest sowing gave the overall highest yield of 11.08 t ha^{-1}.

2.2 Effect of hormones

The improvement of production technology is of almost necessity for regular and reasonable supply through enhanced yield. The application of phytohormones can be promising for this purpose. Gibberellic acid or different hormones have marked effects on okra production. After the first isolation of plant hormone by F.W. Went in 1962, the research using growth-regulating chemicals has swelled at an amazing rapidity. The vast majority of the works using phytohormones however has been carried on vegetable crops, cereals and legumes, fruit trees and other garden crops. Investigations regarding this line have been carried out at different places of the world, and some of the literature relevant to the present study has been reviewed here.

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 pm.

Al-Masoum and Al-Masri (1999) reported that Cucumber cv. Beit Alpha was grown in a greenhouse in 1996-97 and ethephon applied at ethephon applied at 250 ppm 350 ppm or 450 ppm at the seedling stage (2-4 true leaves).

Date were collected on the total yield early yield number of female flower number of nodes to the first female flower number of nodes to the first male flower and plant height. All the cases positive result was found from ethephon treated plants. Ethephon induced femaleness (pistillate flowers) on the main stem that led to greater fruit production.

Das and Rabhal (1999) conducted an experiment in a greenhouse on cucumber cultivars Chinese green, Pusa Sanyog and Poinsett, NAA was applied at 30 ppm or 100 ppm kinetin at 10 ppm or 50 ppm and Ethrel at 250 ppm or 500 ppm at the 4-to 5-leaf stage and at flower bud appearance. NAA application produced the largest fruit with the highest flesh, placenta ratios.TSS and ascorbic acid content were highest when Ethrel was applied.

Singh *et al.* (1999) conducted an experiment with combinations 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 + 20 000 ppm urea, 20 000 ppm urea and 40 000 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 (3.2 g) and seed yield per hectare (19.4 q 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 20 000 ppm urea increased seed yield by 64.4, 55.9 and 42.8%, respectively.

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 inconsistent trends.

Deotale *et al.* (1998) found a significant relationship between application of hormones and yield of orra. They found that application of Ethral produced maximum fruit yield of okra compared to control.

Gedam *et al.* (1998) reported that bitter gourd [Momordica charantia] plants treated whit 15 ppm, 25 ppm or 35 ppm GA_3 50 ppm 100 ppm or 150 ppm NAA, 50 ppm 100 ppm or 150 ppm ethephon 100 ppm, 200 ppm or 300 ppm maleic hydrazide, 2 ppm, 4 ppm or 6 ppm boron or with water (control). GA_3at 35 ppm produced the earliest female and NAA at 50 ppm produced the earliest male flower. Fruit maturity was earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yields were also highest in these treatments.

Rai *et al.* (1998) studied with hormones on yield and quality of okra fibre. Seeds were treated, and foliar application with 100 ppm 0.25 potassium dihydrogen orthophosphate and 10 ppm NAA was done at Mohanpur, West Bengal, in the rainy season, of 1994. Fibre quality was generally improved by foliar application of 10 ppm NAA. Path analysis for fibre fineness revealed that cell length/width ratio had a high direct effect. Cell breadth and fibre length showed very high direct effects on tenacity, while fibre fineness and tenacity were negatively correlated.

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 Meerut 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 kg ha^{-1}, half before sowing, a quarter 30 days after sowing and a quarter at flowering. GA3 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.

Bhat 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 regulator 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 the aled 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. T_{13} 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 pm delayed it (96.75 days). Cultar at 150 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 internodal 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 effect on seed yield.

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 gibberellic 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 Jays 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} IAA, 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 GA3 (46.60 seeds pod^{-1}). GA_3 increased pod length (10. 10 cm) and diameter (1.82 cm) 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.

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 alter 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 wek1y 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 ppm GA_3, IBA and thiourea for 24 h at 25°C 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.

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. gibberllic 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.

Kim *et al.* (1994) reported that thickness or weight of rind: flesh ratio were recoded 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} or GA^3 25 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 hydrid significantly increased the IAA content of the ovary.The rtio of IAA: ABA in pollinated or naptalam or TIBA -treated ovaries was also higher than that in unpollinated controls. The unpollinated 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.

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}).

Takeno *et al.* (1992) found that female flowers of cucumber cultivars Chojitsu- Ochiai No.2 (parthenocrpic) and Mogami (non-parthenocarpic) were

bagged the day before and than artificially pollinated or left unpollinated. BA or NAA at 0.1mug or 10 mug/ fruit was applied to the peduncle of the fruit at anthesi. The growth promoting effects of both BA and NAA were greatest on unpollinated ovaries of Mogami. BA treatment increased cell well thickness in unpollinated fruits. This was due to increased cell number and size which were 19% and 6% greatest than the control. BA treatment had no effect on endogenous levels of IAA in pollinated or unpollianted fruit.

Pandita *et al.* (1991) conducted an experiment with 4 varieties of okra and found that dry matter of okra fruit was different due to different sowing time. Among the hormones, Ethephon showed the best result.

Islam *et al.* (1990) reported that the bottle gourd plants treated with NAA 200 ppm produced fruits of maximum length and girth in control. Numbers of fruits per plant were also found maximum in plants where NAA 200 ppm was applied. Hormone application at the rate the rate of 200 ppm NAA produced maximum yield (48.15 t ha^{-1}).

Kapgate *et al.* (1989) found that application of NAA produced 34% more branches production in cotton plant compared to control.

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.

Deore *et al.* (1987) performed a trial with growth substances 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 the 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 combined 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.

Rattan *et at.* (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.

Seeramulu (1987) found that ethrel 100 g l^{1} increased the number of flowers and also hastened the appearance of the female flower compared to the control in sponge. It also delayed the appearance of the first staminate flower and also decreased the total number of male flower.

Vashisht *et al.* (1987) studied with germination of okra by applying k acid and 2.4-dichlorophenoxv acetic acid. Seeds - of okra cv. Pusa Sawani were treated with 1-1000 ppm GA_1 and 0.5-20 ppm 2, 4-D for 24 h at 29°C. GA_3 decreased germination at all concentrations, where 17% germination at 1ppm, 1% germination at 300 ppm, and nil at 500 and 1000 ppm were noticed. The control treatment showed 41% germination. However, 2,4-D increased germination to 75% at 0.5 ppm but decreased it to 10% at 15 ppm, and tonilat 2O ppm.

Shabab Uddin *et al.* (1986) treated local and exotic varieties of snake gourd with 1% and 2% of potassium naphthenate (KNap). The number of fruits per plant and average weight of fresh fruit increased significantly following treatment with 1% Knap in both varieties.

Abdul *et al.* (1985) studied the influence of some growth regulators on the growth and yield of okra. In 2-year 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.

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 applications reduced the ratio of male to male flowers.

Choudhury and Phatak (1981) reported the effect of concentration of MA, NAA and 2, 4-D on the sex expression and sex ratio of cucumber. MH 200 ppm and NAA 100 ppm increased the number of female flower significantly over the control. MH 600 ppm and 800 ppm NAA100 and IAA 200 ppm and IAA 100 ppm suppressed the number of male flowers over the control. IAA 100 ppm and 200 ppm and NAA 200 ppm stimulated the growth.

Irshad Ahmad and Gupta (1981) found that the minimum ratio of male to female flower was reached at 1000 ppm of cycocel in case of smooth gourd and snake gourd. Nodes per female flower as well as days to flower were minimum at 1000 ppm in sake gourd was observed at 1000 ppm in smooth gourd and bottle gourd. Earliest node first female flower was observed at 1000 ppm in smooth gourd and snake gourd but at 1500 ppm in bottle gourd.

Mangal *et al.* (1981) investigated the influence of various chemicals (Ethrel NAA, Cycocel, MH, PCPA, Ascorbic acid and Boron) on the growth flowering and yield of bitter gourd was conducted. PCPA at 100 ppm improved plant growth significantly. The treatment of CCC at 250 and 500 ppm produced

female flowers about 12 days earlier in comparison to control plant. Maximum fruit yield per plant (3123.00) was produced under Cycocel 250 ppm follower by Ascorbic acid 25 ppm and Cycocel 500 ppm.

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 radicle and hypocotyl elongation and on cotyledon expansion.

Vijay and Jalikop (1980) carried out an experiment to study the effect of growth substances on sex expression of kakrol. Application of 2,4-D and 2,4,5-T at 25 ppm and 100 ppm was effective in producing parthenocarpic fruit. The maximum fruit set of 88.88 percent was obtained at 100 ppm 2,4-D and 2, 4, 5-T. The average length per fruit and average weigh per fruit were maximum at 50 ppm 2, 4, 5-T while the average girth/ fruit was more in hand pollinated.

Bhattacharya *et al.* (1978) studied the synergistic effect of gibberellic acid I 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} and GA_3 at 5 and 10 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 pmm and 200 ppm excelled all the other treatment in producing a favorable female to male flowers ratio. TIBA from 50 ppm to 200 ppm gave a significant increased in the number of fruit and weight of fruit.

Das and Swain (1977) reported that Alar 200 ppm produced the maximum number of fruits followed by its lower concentration and ethrel as compared to the control.Alar 200 ppm with 40 kg ha^{-1} nitrogen significantly produced heaviest fruit follower by ethrel 100 ppm with 40 kg ha^{-1} of nitrogen ethrel 200 ppm with 20 kg ha^{-1} of nitrogen.

Pawar *et al.* (1977) 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 I substances (more by GA) increased seed germination, plant growth and yield, especially at 25-30 ppm.

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, cvs 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.

Singh *et al.* (1976) analysed the effect of seed treatment with plant growth regulators on yield and economic of okra. Okra seeds cvs. Pusa Sawani and Uaishali Vadhu were treated with l0-30 ppm GA and 25-100 ppm NAA. All treatments improved yield and returns, the best result being obtained with 30 ppm GA.

Beyer and Quebedeaux (1974) conducted an experiment on fruit development and set by application N-1-naphthylphthalamic Acid cucumber. They found that a single application of Naptalam at concentration ranging from 500 to 5000 ppm increased number of pistillate flowers to develop into fruits, while number of fruit were minimum on the conrols. Fruit shape was normal but the growth was slightly retarded at 500 ppm.

Bisaria (1974) found that foliar of NAA ppm increased the number of female flowers per plant and the sex ratio is reduced in cucurbits.

Patnaik *et al.* (1974) reported that application of pistillate flowers while 500 of cycocel in 100 ppm concentration produced maximum number of staminate flowers. Fruit yield was observed to be highest in the treatment of 100 ppm Cycocel followed by 2000 pm and 500 ppm of the said chemical.

Ethrel was found to be toxic the plants and yield was markedly reduced with its application.

Augustine *et al.* (1973) found that MCEB (5-methyl-7 chloro-4 ethoxycarbonylmethoxy-2,1,3-benzothiadiazole) had no effect on the androecious phenotype of cucumber while ethephon 500 ppm induced pistillate flowers. the effect of MCEB and ethephon treatment was a marked reduction in the number of ethylene induced pistillate flowers except when there was a 48-hour period between application of ethephon had on effect, and the effect of MCEB and ethephon treatment was to induce staminate flowers at relatively high concentrations of MCEB150 ppm.

Elassar *et al.* (1973) studied on the normal and parthenocarpic fruit development. They found that B-NOA (napthoxyacetic acid) at rates lower 100 ppm and IAA 10 ppm to 100 ppm were effect normal fruit development and were less effective producing parthenocarpic fruit. GA_3 (100-1000 ppm) and GA_4+7 (50ppm) slowed down the early rate of fruit development during later stages.

Cantliffe *et al.* (1972) 0bserved the response of cucumber to soil application of (2-chloroethyl) phsponicacid (ethephon). At maturity the transplants at 250 and 500 ppm were stunted but still capable of supporting a normal fruit load. Almost all of their flowers opening within 60 days of planting were pistillate. The period in which only pistillate flowers were produced, of critical importance in the production of hybrid seed was longer for the soil treatment than for foliar treatments with 125 and 250 ppm.

Ravindran (1971) reported that bitter gourd seedlings were sprayed with ethrel at concentrations ranging from 200 to 600 ppm. Stunting growth retardation and pollen sterility were induced in proportion to the dose applied and the production of male flowers was significantly reduced.

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.

Freytag *et al.* (1970) conducted an experiment on cucumber sex-expression modified by growth regulators.They found that TIBA 10 ppm and 100 ppm treated plant produced less number of female flowers.In addition the number of staminate flowers increased by 16% while the number of pistillate flowers decreased. Treatment with ethrel at 100 ppm increased femaleness.

Lower *et al.* (1970) reported that treatment of plants of the cultivar of cucumber Galaxy with ethephon at a concentration of 120 ppm at the one- leaf stage or at subsequent leaf stages increased pistillate flower formation.

McMurray and Miller (1969) found that cucumber seedlings treated with ethephon at concentrations of 120 ppm 180 ppm or 240 ppm increased the number of pistillate flowers. The staminate to pistillate flower ratio was approximately 10:1. But in case ethephon treated plants, the staminate to pistillate flower ratio ranged from 1:6 to 1:14, depending on the concentration of ethephon used.

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 I 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 ppm. Application of GA_3 at 100 and 200 ppm, IAA at 10 and 20 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 pm and PA at 50 ppm proved significantly superior in increasing the length of units and GA at 10 ppm in increasing the yields at Punjab Agric. Univ, Ludhiana.

Sims and Gledhill (1969) reported that application of ethephon at concentrations of 50-250 ppm at the fully expanded true leaf stage induced femaleness in the hybrid Piccadilly and reduced the size of the plants by shortening the internodes.

Srivastava and Singh (1968) studied the effect of pre-sowing treatments with growth substances on okra. The effects of soaking okra seeds for 6 hours in 3 concentrations of 3 different growth-promoting substances were studied. All 3 substances improved germination and increased the number weight, length, diameter and yield of pods. The best germination and pod yield were obtained at 10 ppm GA, treatment with 10 ppm IPA produced the maximum

number of pods per plant. It is concluded that yield can be considerably increased by a pre-sowing treatment with 10 ppm GA_3 or IPA, or with 50 ppm B-NOA. GA_3 positively effects on different growth components viz, germination, seedling emergence, vigour, plant height etc. and yield of okra. Many authors applied gibberellic acid in okra plants at pre-sowing and foliar stage with different concentrations. But the time of application and concentration of GA_3, which they applied, differ from many researchers. Moreover, results at often inconclusive in regards of concentrations and application times, and totally absent in the climatic conditions of Bangladesh. So it is needed to find a standard concentration and suitable time for GA_3 application.

Irving *et al.* (1968) found that TIBA at 25 ppm was particularly effective in promoting the femaleness in cucumber. The increased TIBA stimulation of female flowers ranged from 100 to 200 percent. TIMA also increased the number of male flowers but lowered the male and female raito.

Choudhury *et al.* (1967) reported that NAA100 ppm and 200 ppm and MH50 ppm and 200 ppm were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber. These effects subsequently increased the percentage of fruit set and ultimately the yield.

Bukovac and Wittwer (1961) reported that cucumber plants with gibberellim at a concentration of 100 ppm to young pickling type cucumber

seedling hastened pistillate flowers formation earlier when cucumber plants were grown under rather than long photoperiod.

Choudhury and Pahatak (1959a) found that cucumber plants treated with MH 200 ppm and NAA 100 ppm increased the number of female flowers. NAA100 ppm, IAA 200 ppm and IAA 100 ppm suppressed the number of male flowers significantly over control.

Choudhury and Phatak (1959b) reported the effects of growth regulators on sex expression of cucumber. They observed that MH 200 ppm and NAA 100 ppm significantly increased the number of female flowers and MH 600 and 800 ppm, NAA 100 ppm and IAA 200 ppm greatly suppressed the number of male flower over control. All treatments increased the female to male flower ratio when compared with the control.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

A field experiment on okra with different date of sowing and hormones was conducted during March to August, 2007 to evaluate the performance of okra crop in respect of growth and yield performances.

3.1 Experimental site

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field is located at $90^0 33'$ E longitude and $23^0 77'$ N latitude at a height of 9.2 meter above the sea level (BCA, 2004). The land was medium high and well drained.

3.2 Climate

The annual precipitation and potential evapotranspiration of the site were 2152 mm and 1297 mm, respectively. The average maximum and minimum temperature was 30.34^0C and 21.21^0C, respectively with mean temperature of 25.17^0C.

Temperature during the cropping period ranged between 22.2^0C to 37.2^0C. The humidity varied from 83.52% to 91.2%. The day length ranged between 10.5-11.0 hours only and there was heavy rainfall during the experimentation. The weekly average rainfall, air temperature and relative humidity of the site during the experimental work have been shown in Appendices I and II.

3.3 Soil

The soil of the experimental site belongs to the agro-ecological region of 'Madhupur Tract" (AEZ No. 28) classified by UNDP/FAO (1988). It was Deep Red Brown Terrace soil and belonged to "Nodda" cultivated series. The top soil is silty clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47 - 5.63.

3.4 Experimental materials

The experiment was done with BARI dherosh 1. This variety is released by Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

3.5 Experimental treatments

There were two factors in this experiment, viz. date of sowing and hormones.

The treatments were as follows:

Sowing time:

S_1= 22 March

S_2= 06 April

S_3= 21 April

Hormones:

H_0= No hormone

H_1= Application of Algagold (Micronutrients concentrations)

H_2= Application of Crops care (Napthalene Acetic Acid, NAA 4.5%)

H_3= Application of Ripen-15 (15% Ethephon)

The detail layout of the experiment are shown in Fig. 1

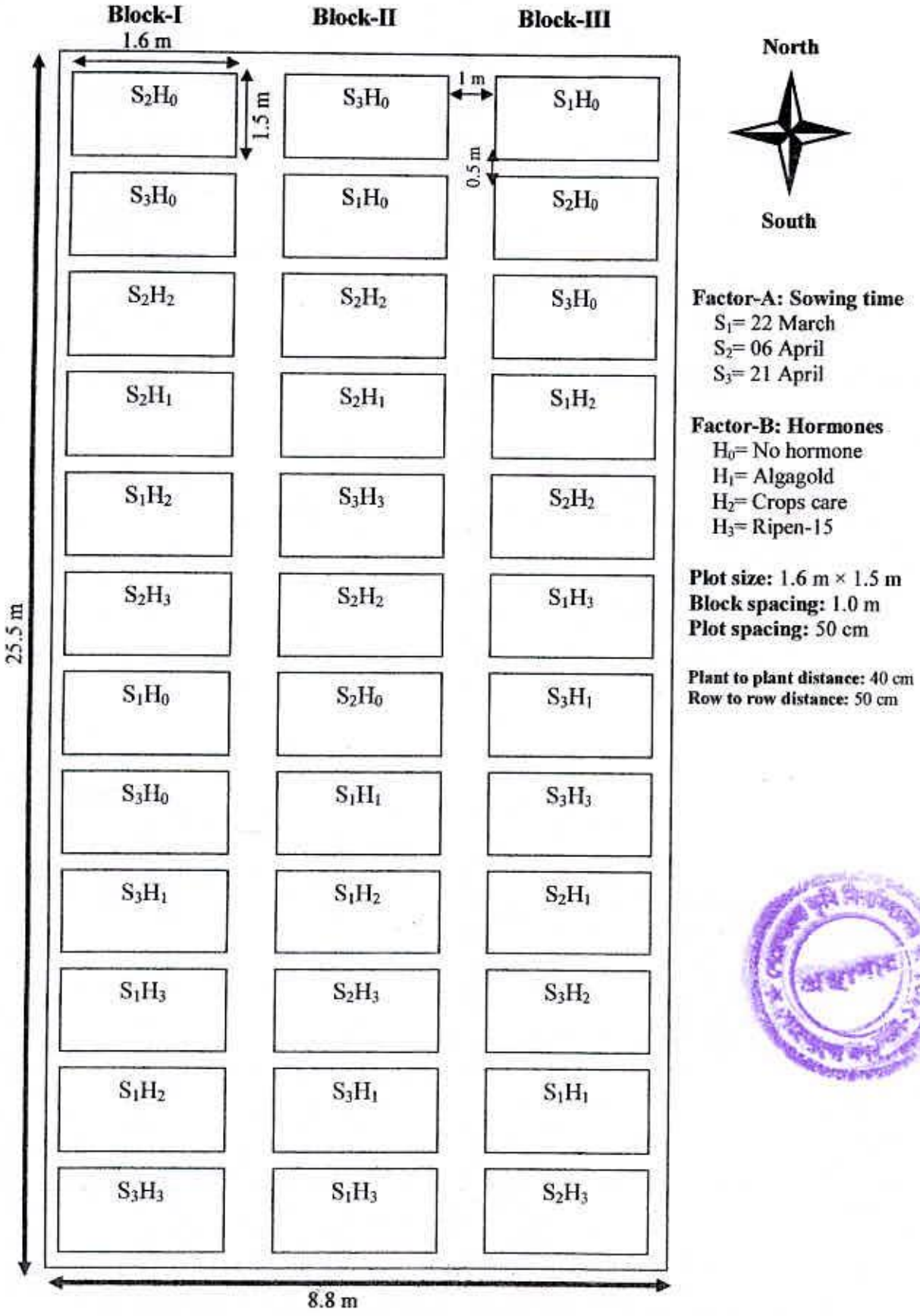


Fig. 1 Field layout of two factors experiment in randomized complete block design (RCBD)

3.6 Experimental layout and design

The experiment was laid out in randomized completely block design (RCBD) with three replications. Thus the total plot number was 36. The size of each plot was 1.6 m × 1.5 m (2.4 m^2). The distance between two adjacent unit plots was 0.5 m and distance between two replication and between two main plot was 1 m.

3.7 Cultivation method

3.7.1 Land Preparation

The experimental field was ploughed with power tiller drawn rotovator. Subsequent cross ploughing was done followed by laddering to make the land level. All weeds, stubles and residues were removed from the field.

3.7.2 Fertilization

The experimental plots were fertilized with the following recommended dose (BARC, 2005):

Name of fertilizers	Doses (kg ha^{-1})
Urea	250
Tripe superphosphate	80
Muriate of potash	130
Gypsum	100
Zinc Oxide	5
Boric acid	10

During final land preparation one half of the urea and total amount of other fertilizers were applied and incorporated into soil. Rest of the urea was top dressed at flower initiation stage.

3.7.3 Sowing of seeds

Seeds of BARI derosh 1 were sown based on different treatment variables. The row to row distance was 50 cm while the plant to plant distance was 40 cm. Seed sowing was done manually.

3.7.4 Weeding and thinning

The experimental plots were found to be infested with different kinds of weeds. Weeding was done two times manually with 'nirani'. Thinning was done in all the unit plots with care to maintaining a one plant in a hill.

3.7.5 Irrigation

Irrigation was done whenever necessary by water cane at afternoon.

3.7.6 Pest and disease management

The crop was sprayed with Ripcord, Bavistin, Admire and Malathion 60 EC to prevent infestation of insects and vectors of virus.

3.7.7 Harvesting and Processing

At maturity the crop was harvested at different intervals.

3.8 Data Collection

Ten plants were selected out randomly from each plot leaving the border plants. The following data were recorded.

i) Plant height

ii) Branches per plant

iii) Leaf per plant

iv) Leaf length

v) Leaf breadth

vi) Stem diameter

vii) Fresh weight of fruit

viii) Dry weight of fruit

ix) Fruits per plant

x) Fruit yield per plant

xi) Fruit yield per hectare

3.8.1 Plant height

The height of ten plants was measured from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

3.8.2 Branches per plant

The number of branches of ten randomly sampled plants at 15 days interval were counted and recorded. Average value of ten plants was recorded as number of branches per plant.

3.8.3 Leaves per plant

The number of leaves in all sizes of ten randomly sampled plants at 15 days interval were counted and recorded. Average value of ten plants was recorded as number of branches per plant.

3.8.4 Leaf length

The length of 10 randomly selected leaves was measured carefully from the base to the tip. The mean value was determined for each 15 days interval up to harvest.

3.8.5 Leaf breadth

The length of 10 randomly selected leaves was measured carefully from the base to the tip. The mean value was determined. It was done at 15 days interval starting from 20 DAS.

3.8.6 Stem diameter

Ten plants were randomly selected and diameter of each pants were measured by a Slide calipers at different growth stages. Average value of ten plants was recorded as stem diameter.

3.8.7 Fresh weight of fruit

During harvesting, ten fruits were randomly collected and weighted in a balance properly. The average weight of a single fruit was then calculated.

3.8.8 Dry weight of fruit

After recording the fresh weight of fruit, the separated fruits of the plants were dried in an electric oven at 70^0 C for 48 hours and the dry weight

was measured with a digital balance. Weight of ten fruits was then calculated for the weight of single fruit and shown as gram.

3.8.9 Fruits per plant

At every harvest, 5 plants were selected and total number of fruit was counted. Then the mean values were recorded and expressed as the number of fruit per plant.

3.8.10 Fruit yield per plant

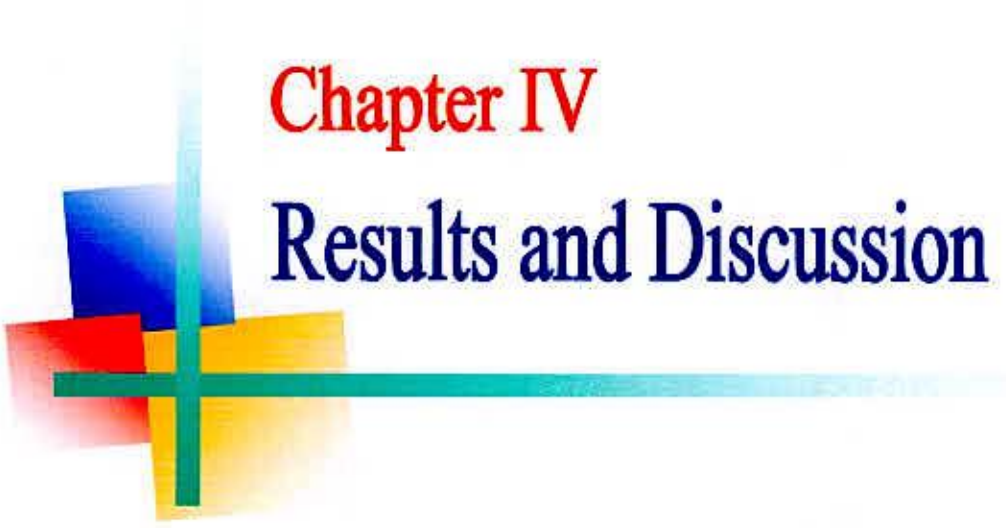
The cumulative average yield of a single plant was recorded at each harvest and expressed as fruit yield per plant.

3.8.11 Fruit yield per hectare

Total fruit yield from the harvested area (1 m^2) was recorded and was converted to t ha^{-1}.

3.9 Statistical analysis

The data were analyzed following Analysis of Variance (ANOVA) technique and mean differences were adjusted by the t-test (Gomez and Gomez, 1984). Means were compared by using Duncan's New Multiple Test (DMRT) at 5% level of significance.



Chapter IV

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to study the performance of okra as influenced by different sowing time and growth hormones. The results of the present investigation have been presented, discussed and compared as far as possible with the results of other researchers.

4.1 Plant height

In the initial stage up to 20 DAS the growth of the line was very slow and then the crop remained in rosette form. Stem elongation started with the initiation of reproductive phase of development. The rapid increase of plant height was observed from 20 DAS to 65 DAS. After 65 DAS the growth of plant height became very slow. In the initial stage the plant canopy was very small and competition was mainly negligible.

Different sowing times affected the plant height of okra plant in this experiment. But significant variation of plant height due to sowing time was observed from 50 DAS (Table 1). At every stage the tallest plant was recorded at April 06 sowing which was followed by April 21 sowing. The lowest plant height was observed with 22 March sowing (Table 1). At maturity the maximum plant height was 136.7 cm which was observed when the crop was sown on April 06. These results revealed that too early as well as too late planting of okra crop is not suitable for better plant height of okra for summer

season. Sharif Hossain *et al.* (2003) observed similar results when worked with Okra.

Table 1 Plant height of okra as affected by different sowing time and hormones at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	8.7	35.3	73.2 b	92.4 c	116.1 b	120.3 b
April 06 (S_2)	11.6	36.7	76.5 a	103.2 a	130.4 a	136.7 a
April 21 (S_3)	10.2	35.5	74.9 ab	98.7 b	120.5 b	124.5 b
$LSD_{0.05}$	**NS**	**NS**	**2.05**	**3.90**	**4.65**	**5.08**
Hormones						
Control (H_0)	8.5	28.2	65.9 d	89.6 c	109.5 d	114.3 d
Alga Gold (H_1)	10.6	34.5	70.2 c	100.5 b	123.5 c	129.6 c
Crop Care (H_2)	11.7	35	75.4 b	103.6 b	130.2 b	136.4 b
Ripen-15 (H_3)	12	37.8	80.2 a	110.8 a	141.3 a	148.9 a
$LSD_{0.05}$	**NS**	**NS**	**2.6**	**3.9**	**4.05**	**5.66**
CV (%)	**7.88**	**6.88**	**9.76**	**10.43**	**6.89**	**8.98**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

Results also revealed that different plant hormones also affected the plant height (Table 1). In this experiment the plant height was significantly affected by plant hormones at different growth stages except 20 and 35 DAS. But numerically the maximum plant height was observed with Ripen-15 at all the growth stages (Table 1). At different growth stages up to 41% increase of

plant height was noticed with the application of hormones over control treatment. Sarkar *et al.* (2002) obtained similar results.

Different interaction of sowing times and hormone also significantly affected the plant height. The significant interaction of these factors was observed in plant height at different growth stages (Table 2). At all the growth stages the treatment combination of April 06 and Ripen-15 (S_2H_3) produced the tallest plant while the 22 March sowing with no hormone (S_1H_0) produced the shortest plant. However the trend of increase was found to be more prominent from 35 DAS which stopped at 95 DAS onward. Sayeed (1988) observed this dates with any combination as the optimum sowing time for okra in relation to plant height.

Table 2 Plant height of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	7.8 b	27.2 d	63.1 e	86.4 h	103.2 de	105.2 d
S_1H_1	8.4 b	28.5 cd	65.7 de	90.1 gh	112.5 d	115.4 d
S_1H_2	9.8 ab	30.2 bcd	73.9 a-d	102.6 ef	123.8 c	127.8 c
S_1H_3	10.9 ab	31.0 bcd	75.7 abc	110.3 b-e	125.6 c	132.4 c
S_2H_0	10.0 ab	29.7 bcd	67.8 cde	92.3 gh	105.4 de	113.4 d
S_2H_1	10.5 ab	32.6 bcd	71.3 b-e	105.2 c-f	124.5 c	134.8 c
S_2H_2	10.6 ab	34.9 ab	75.8 abc	112.6 bcd	133.6 c	150.5 b
S_2H_3	12.9 a	39.3 a	82.5 a	123.5 a	155.8 a	164.7 a
S_3H_0	8.9 b	29.6 bcd	66.1 de	96.2 fg	100.8 e	110.4 d
S_3H_1	9.2 ab	30.3 bcd	72.6 bcd	104.2 def	128.5 c	136.4 c
S_3H_2	10.5 ab	33.8 bc	75.4 abc	114.2 bc	146.2 b	157.3 ab
S_3H_3	11.4 ab	34.2 abc	79.2 ab	116.7 ab	150.5 ab	163.5 a
$LSD_{0.05}$	**3.3**	**5.0**	**7.9**	**8.7**	**9.1**	**9.9**
CV (%)	**5.66**	**8.99**	**5.88**	**7.34**	**8.24**	**5.67**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.2 Branches per plant

The number of branches was started to increase significantly from 35 DAS and thus the increase of the number of branches due to different sowing times was significant from 50 DAS up to maturity (95 DAS). In every case, 06 April sowing produced the maximum branches in this experiment (Table 3). From 80 DAS onward the increase of branches in the plant was negligible whereas the effect was significantly affected by sowing times. The

result is in close conformity with that of Hossain *et al.* (1999), Palanisamy *et al.* (1986) and Singh *et al.* (1986).

Table 3 No. of branches per plant of okra as affected by different sowing time and hormones at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	1.0	1.0	1.1 c	1.6 c	2.1 c	2.3 c
April 06 (S_2)	1.8	2.0	2.5 a	3.4 a	3.7 a	3.7 a
April 21 (S_3)	1.6	2.3	2.2 b	3.0 b	3.2 b	3.2 b
$LSD_{0.05}$	**NS**	**NS**	**0.12**	**0.14**	**0.13**	**0.33**
Hormones						
Control (H_0)	1.0	1.1 d	1.4 d	2.0 d	2.2 c	2.2 c
Alga Gold (H_1)	1.5	1.7 c	2.0 c	2.4 c	2.6 c	2.7 c
Crop Care (H_2)	2.1	2.4 b	2.5 b	3.0 b	3.2 b	3.3 b
Ripen-15 (H_3)	2.5	3.0 a	3.4 a	4.0 a	4.5 a	4.7 a
$LSD_{0.05}$	**NS**	**0.12**	**0.13**	**0.43**	**0.45**	**1.02**
CV (%)	**6.44**	**5.77**	**8.66**	**8.55**	**12.23**	**6.77**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

Likewise sowing times, application of different plant hormones also significantly affected the number of branches where the effect observed significant starting from 35 DAS (Table 3). Among the treatments Ripen-15 showed the best results to produce the branches. Different hormones had a distinct differences compared to control treatments at all the growth stages except during and after maturity. At maturity the application of Alga Gold

showed similar performance like control in response to branches production. Increase of branch production in plant with the application of NAA was reported by Deotale *et al.* (1998) in soybean, Kapgate *et al.* (1989) in cotton and Kumar *et al.* (1996) in okra.

From this experiment, it was shown that different combination of sowing times and hormones had a significant effect on the number of branches per plant. From the initial stages the number of branches regularly increased up to a certain extent and the increases almost steady at 95 DAS (Table 4.). From the experiment it was observed in most of the cases 06 April sowing combined with the application of Ripen-15 (S_2H_3). However the 22 March sowing without hormone (S_1H_0) produced the shortest plant. Palanisamy *et al.* (1986) supported the findings.

Table 4 No. of branches per plant of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	1.0 c	1.2 b	1.5 b	2.2 b	2.6 b	2.6 b
S_1H_1	1.0 c	1.6 ab	1.9 ab	2.5 b	3.0 ab	3.2 ab
S_1H_2	1.8 abc	2.1 ab	2.4 ab	3.0 ab	3.2 ab	3.4 ab
S_1H_3	2.7 ab	3.0 ab	3.3 ab	3.6 ab	4.0 ab	4.2 ab
S_2H_0	1.2 bc	1.5 b	1.9 ab	2.3 b	2.8 ab	3.0 ab
S_2H_1	1.4 abc	1.9 ab	2.0 ab	2.4 b	2.8 ab	3.0 ab
S_2H_2	2.3 abc	2.7 ab	3.5 ab	4.1 a	4.5 ab	4.6 ab
S_2H_3	3.0 a	3.8 a	4.1 a	4.3 a	4.6 ab	4.7 ab
S_3H_0	1.4 abc	2.0 ab	2.3 ab	2.5 b	3.0 ab	3.1 ab
S_3H_1	1.8 abc	2.4 ab	2.6 ab	3.0 ab	3.4 ab	3.7 ab
S_3H_2	2.3 abc	3.0 ab	3.5 ab	4.1 a	4.5 ab	4.6 ab
S_3H_3	2.8 ab	3.4 ab	3.8 ab	4.3 a	4.8 a	5.0 a
$LSD_{0.05}$	**1.4**	**1.9**	**2.12**	**1.4**	**1.7**	**1.9**
CV (%)	**6.77**	**8.65**	**5.88**	**10.44**	**9.43**	**7.86**

Means separation in columns followed by the same letter(s) are not significantly different at P≤0.05

4.3 Leaves per plant

Sowing of okra seed in different dates also affected the number of leaves per plant in this study (Table 5). From the comparison it was observed that in most of the cases 21 April sowing produced the maximum number of leaves in okra plant whereas the 22 March sowing resulted the lowest number of leaves. Nonetheless, the effect was significant at 35, 50, 65 and 80 DAS. At initial

stage as well as at maturity the number of leaves was identical in relation to sowing times. Maximum increase of leaves was observed from 20 DAS to 35 DAS respected to treatment variables (Table 5). This result is corroborated with the findings of Incalcaterra *et al.* (2000) and Gupta *et al.* (1981).

Table 5 No. of leaves per plant of okra as affected by different sowing time and hormones at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	5.6	10.3 b	13.4 b	17.9 b	18.0 b	19.8
April 06 (S_2)	7.1	13.2 a	16.3 a	21.5 a	22.1 a	24.0
April 21 (S_3)	6.8	14.1 a	16.0 a	20.5 a	24.9 a	27.0
$LSD_{0.05}$	**NS**	**1.20**	**1.45**	**2.13**	**3.04**	**NS**
Hormones						
Control (H_0)	5.50	9.67 c	13.22 c	16.00 b	17.50 b	19.05 b
Alga Gold (H_1)	6.90	10.55 c	16.88 b	17.55 b	19.00 b	25.04 a
Crop Care (H_2)	7.60	12.78 b	19.04 a	23.67 a	26.04 a	29.00 a
Ripen-15 (H_3)	8.10	14.06 a	21.00 a	26.54 a	28.34 a	32.09 a
$LSD_{0.05}$	**NS**	**1.30**	**2.01**	**3.60**	**3.72**	**4.51**
CV (%)	**5.54**	**7.88**	**7.90**	**7.90**	**9.09**	**7.56**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

The response of different hormone treatments was also significant on the number of leaves per plant at different plant ages except 20 DAS. In all cases maximum leaf number was noticed with Ripen-15 treatment. However, it was statistically at per with Crop Care at all the growth stages except 35 DAS

(Table 5). The plant having no hormone produced the least number of branches in this experiment. Numbers of leaves due to application of hormones were also reported by Deotale *et al.* (1998); Abdul *et al.* (1985); Sarkar *et al* (2002) and Kapgate *et al.* (1989).

The interaction effect of sowing times and hormones had a great effect on the number of leaves per plant or okra (Table 6). Except initial stages of plant growth the effect was significant. At all the growth stages the interaction of 06 April sowing combined with the application of Ripen-15 (S_2H_3). However, the 22 March sowing without hormone (S_1H_0) produced the lower number of leaves. It was followed by S_2H_2, S_2H_1 and S_3H_3. The increase of leaf number due to the interaction effect followed a regular trend from 20 DAS to 50 DAS. From 80 DAS the rate of increase declined irrespective to treatment variables (Table 6). This finding was supported by Yadav *et al.* (2002).

Table 6 No. of leaves per plant of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	5.40 b	8.66 d	10.54 f	16.56 e	17.44 g	19.23 f
S_1H_1	6.10 ab	10.44 d	15.43 de	18.09 de	20.04 fg	25.04 de
S_1H_2	7.80 ab	11.56 cd	17.00 cd	20.54 d	24.05 cde	26.00 cde
S_1H_3	7.90 ab	14.56 b	23.21 b	24.32 c	27.00 cd	29.87 bc
S_2H_0	7.10 ab	10.06 d	13.32 ef	17.00 de	19.06 fg	22.03 ef
S_2H_1	7.50 ab	11.00 d	16.43 de	19.05 de	22.45 ef	24.06 de
S_2H_2	8.30 ab	13.98 bc	17.45 cd	25.45 c	26.88 cd	28.05 bcd
S_2H_3	8.50 a	18.00 a	26.95 a	35.56 a	37.94 a	40.06 a
S_3H_0	7.10 ab	10.05 d	18.03 cd	16.87 de	19.45 fg	22.05 ef
S_3H_1	7.50 ab	14.00 bc	15.02 de	20.12 de	23.04 def	25.06 de
S_3H_2	7.70 ab	14.67 b	20.05 c	24.54 c	27.44 c	31.55 b
S_3H_3	8.00 ab	15.89 ab	26.43 a	30.56 b	34.02 b	37.06 a
$LSD_{0.05}$	**2.59**	**2.75**	**3.04**	**3.39**	**3.66**	**4.27**
CV (%)	**8.54**	**8.90**	**9.03**	**6.45**	**7.86**	**6.45**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.4 Leaf length

Leaf length or okra was significantly affected by sowing starting from 35 DAS up to 80 DAS (Table 7). At 35 DAS the highest leaf length (18.55 cm) was observed with April 21 sowing whereas the lowest leaf length (14.77) was observed with 22 March sowing. It was next to 21 April sowing. At later stages the maximum leaf length was observed with 06 April sowing which was

statistically identical with 21 April sowing. Although the effect was not statistically significant at 20 and 95 DAS however, numerically the trend was similar to other ages. Bhuibhar *et al.* (1989) also observed similar findings in okra.

Table 7 Leaf length of okra as affected by different sowing time at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	8.30	14.77 b	18.77 b	20.43 b	21.90 b	22.40
April 06 (S_2)	11.40	15.00 b	22.00 a	23.56 a	25.09 a	26.77
April 21 (S_3)	10.88	18.55 a	20.95 a	22.99 a	24.50 a	25.20
$LSD_{0.05}$	**NS**	**1.80**	**1.55**	**2.41**	**2.51**	**NS**
Hormones						
Control (H_0)	8.20 d	15.00 b	18.00 b	19.98 c	21.34 c	22.30 c
Alga Gold (H_1)	12.56 c	13.67 b	18.90 b	21.33 c	23.00 c	24.55 c
Crop Care (H_2)	14.33 b	19.07 a	26.76 a	27.89 b	29.09 b	30.50 b
Ripen-15 (H_3)	16.78 a	20.33 a	29.00 a	32.00 a	34.00 a	36.10 a
$LSD_{0.05}$	**1.35**	**2.66**	**2.70**	**3.01**	**3.22**	**4.07**
CV (%)	**4.67**	**6.76**	**6.54**	**7.08**	**6.89**	**6.94**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

Application of hormone had increased the leaf length of okra plant in this experiment (Table 7). The effect was statistically significant at all the growth stages. At 20, 35, 50, 65, 80 and 95 DAS the maximum leaf length (16.78 cm, 20.33 cm, 29.00 cm, 32.00 cm, 34.00 cm and 36.10 cm) with the

application of Ripen-15 which was followed by Crop care. The lowest leaf length was observed with control treatments (Table 7). Deotale *et al.* (1998) also observed similar result.

Likewise the single factor effect the interaction of sowing times and hormones also significantly influenced the length of leaves in this experiment (Table 8). The increment of leaf length was prominent at earlier stages while at maturity the rate of increase was steady. Irrespective to growing stages, the combination of 06 April sowing and application of Ripen-15 (S_2H_3) gave the highest leaf length. However, the 22 March sowing without hormone (S_1H_0) produced the shortest plant. This result is partially supported by Iremiren and Okiy (1986).

Table 8 Leaf length of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	8.00 e	13.78 f	17.65 d	18.90 g	20.00 f	21.60 c
S_1H_1	9.33 e	16.77 def	23.44 c	27.89 b-e	28.66 de	29.50 abc
S_1H_2	10.66 de	17.89 de	25.54 bc	30.00 bcd	31.45 cd	33.45 abc
S_1H_3	14.55 bc	18.06 de	27.55 bc	31.23 bc	34.56 bc	36.70 abc
S_2H_0	9.02 e	14.56 ef	18.03 d	22.34 fg	24.34 ef	25.80 bc
S_2H_1	10.55 de	18.90 cd	23.43 c	26.43 def	27.00 de	29.30 abc
S_2H_2	13.44 cd	19.67 cd	27.86 bc	28.00 b-e	29.33 de	31.40 abc
S_2H_3	19.43 a	28.90 a	36.78 a	38.96 a	40.00 a	41.30 ab
S_3H_0	12.56 cd	17.98 de	19.09 d	24.32 ef	26.12 de	27.80 abc
S_3H_1	16.88 ab	22.56 bc	26.85 bc	27.00 cde	28.50 de	30.09 abc
S_3H_2	17.00 ab	26.00 ab	29.06 b	32.00 b	34.88 bc	36.10 abc
S_3H_3	18.32 a	26.98 a	34.56 a	37.89 a	39.50 ab	42.40 a
$LSD_{0.05}$	**2.97**	**3.79**	**4.10**	**4.27**	**4.87**	**13.76**
CV (%)	**9.56**	**6.77**	**6.54**	**7.03**	**7.59**	**8.77**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.5 Leaf breadth

Leaf breadth of okra was significantly affected by different sowing times in this experiment (Table 9). The effect was significant at all the growth stages except initial stages (20 DAS). Maximum leaf breadth was observed with 21 April sowing at 35 and 50 DAS. But at 65, 80 and 95 DAS the maximum leaf breadth was observed with 06 April sowing. Nevertheless the

effect of 06 April and 21 April sowing was statistically similar at all the growth stages in the present study. In every growth stages, the lowest leaf breadth was observed with 22 March sowing. The similar trends were observed in okra plants by Hussain *et al.* (2006).

Table 9 Leaf breadth of okra as affected by different sowing time and hormones at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	7.47	13.29 b	16.89 b	18.39 b	19.71 b	20.16 b
April 06 (S_2)	10.26	13.50 b	18.41 a	21.20 a	22.58 a	24.09 a
April 21 (S_3)	9.79	16.70 a	19.80 a	20.69 a	22.05 a	22.68 a
$LSD_{0.05}$	**NS**	**1.08**	**1.55**	**1.89**	**2.06**	**2.12**
Hormones						
Control (H_0)	7.38 d	13.50 b	16.20 b	17.98 c	19.21 c	20.07 c
Alga Gold (H_1)	11.30 c	12.30 b	17.01 b	19.20 c	20.70 c	22.10 c
Crop Care (H_2)	12.90 b	17.16 a	24.08 a	25.10 b	26.18 b	27.45 b
Ripen-15 (H_3)	15.10 a	18.30 a	26.10 a	28.80 a	30.60 a	32.49 a
$LSD_{0.05}$	**1.54**	**1.80**	**2.26**	**2.35**	**3.01**	**3.21**
CV (%)	**7.34**	**4.67**	**5.54**	**6.43**	**4.67**	**6.54**

Means separation in columns followed by the same letter(s) are not significantly different at P≤0.05

Different hormone had also a significant effect on the leaf breadth in this experiment (Table 9). The maximum leaf breadth at different growth stages (15.10 cm, 18.30 cm, 26.10 cm, 28.80 cm, 30.60 cm and 32.49 cm) was observed by the application of Ripen-15. It was followed by Crop Care

application. At all the growth stages the lowest leaf breadth was found in the plant without treating with hormones. Harrington *et al.* (1996) also observed similar changes with the application of hormones.

The increase of leaf may help to increase the total leaf area rendering the photosynthetic capacity. The leaf breadth of okra was significantly influenced by different combination of sowing times and hormones application in this experiment (Table 10). The response was significant at all the growth stages except 20 DAS. At other stages, the significantly highest leaf breadth was observed with 06 April sowing combined with the application of Ripen-15 (S_2H_3). Irrespective to plant ages, the 22 March sowing without hormone (S_1H_0) produced the shortest plant. These results are corroborated with Mondal *et al.* (1989)

Table 10 Leaf breadth of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	7.20 g	12.40 f	15.89 d	17.01 d	18.00 e	19.44 g
S_1H_1	8.40 f	15.09 de	21.10 c	25.10 b-e	25.79 cd	26.55 ef
S_1H_2	9.59 e	16.10 d	22.99 bc	27.00 bcd	28.31 bc	30.11 cde
S_1H_3	13.10 c	16.25 d	24.80 b	28.11 bc	31.10 ab	33.03 abc
S_2H_0	8.12 fg	13.10 ef	16.23 d	20.11 fg	21.91 de	23.22 fg
S_2H_1	9.50 e	17.01 d	21.09 c	23.79 de	24.30 cd	26.37 ef
S_2H_2	12.10 cd	17.70 d	25.07 b	25.20 b-e	26.40 bcd	28.26 c-f
S_2H_3	17.49 a	26.01 a	33.10 a	35.06 a	36.00 a	37.17 ab
S_3H_0	11.30 d	16.18 d	17.18 d	21.89 ef	23.51 cd	25.02 ef
S_3H_1	15.19 b	20.30 c	24.17 bc	24.30 cde	25.65 cd	27.08 def
S_3H_2	15.30 b	23.40 b	26.15 b	28.80 b	31.39 ab	32.49 bcd
S_3H_3	16.49 a	24.28 ab	31.10 a	34.10 a	35.55 a	38.16 a
$LSD_{0.05}$	**1.09**	**2.40**	**2.96**	**3.50**	**4.89**	**5.07**
CV (%)	**6.87**	**7.65**	**7.45**	**5.78**	**9.45**	**6.98**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.6 Stem diameter

With the increase of plant age the thickness of xylem and phloem increase and thus the stem diameter increased in plant. In the present study the stem diameter of the plant was significantly differed due to variable sowing times (Table 11). The variation of stem diameter was significant due to sowing times up to 65 DAS. After this period the response was negligible. However, at

all the growth stages, the maximum diameter of stem was observed in 06 April sowing which was followed by 21 April sowing. In every case the lowest stem diameter was found in 22 March sowing. The highest stem diameter at maturity with 06 April sowing was 2.39 cm while the lowest was as 1.69 cm. This result is confirmed by Lee *et al.* (1990) and Mondal *et al.* (1989).

Table 11 Stem diameter of okra as affected by different sowing time and hormones at different growth stages

Treatment	Days after sowing					
	20	35	50	65	80	95
Sowing time						
March 22 (S_1)	0.17 b	1.33 b	1.46 b	1.60 b	1.68	1.69
April 06 (S_2)	0.50 a	1.88 a	2.07 a	2.26 a	2.37	2.39
April 21 (S_3)	0.44 a	1.56 a	1.72 a	1.87 b	1.97	1.99
$LSD_{0.05}$	**0.19**	**0.32**	**0.29**	**0.34**	**NS**	**NS**
Hormones						
Control (H_0)	0.16 b	1.28 c	1.41 c	1.54 b	1.61 b	1.63
Alga Gold (H_1)	0.24 b	1.59 bc	1.75 abc	1.91 ab	2.00 ab	2.02
Crop Care (H_2)	0.40 b	1.90 ab	2.09 ab	2.28 ab	2.39 ab	2.42
Ripen-15 (H_3)	0.65 a	2.13 a	2.34 a	2.56 a	2.68 a	2.71
$LSD_{0.05}$	**0.24**	**0.51**	**0.65**	**0.89**	**0.90**	**NS**
CV (%)	**6.44**	**6.78**	**2.33**	**4.34**	**4.67**	**6.43**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

Plant hormones also had a great role to initiate the stem expansion. In the present experiment the stem diameter was significantly affected with different hormones except at maturity (Table 11). At every stages of growth the

maximum stem diameter was observed with the application of Ripen-15 while the lowest stem diameter was found in control plots. At later stages the effect of different hormones variation showed the identical results. But the effect was clearly distinguishable from the control plots. Ravindran (1971) and Lower *et al.* (1970).

The combined effect of sowing times and hormones showed a significant effect on the stem diameter increment of okra plant in this experiment (Table 12). The result was statistically significant at all the growth stages of crop. Irrespective to plant ages, the highest stem diameter was observed from 06 April sowing combined with the application of Ripen-15 (S_2H_3). However the 22 March sowing without hormone (S_1H_0) produced the shortest plant. The increase of stem diameter was more prominent from 20 DAS to 35 DAS which was very negligible between 80 Das to 95 DAS. Mondal *et al.* (1989) and Hussain *et al.* (2006) found similar observations.

Table 12 Stem diameter of okra as affected by the combined effect of sowing time and hormones at different growth stages

Treatments	Days after sowing (DAS)					
	20	35	50	65	80	95
S_1H_0	0.15 d	1.29 c	1.42 b	1.55 b	1.63 b	1.64 c
S_1H_1	0.34 cd	1.69 abc	1.86 ab	2.03 ab	2.13 ab	2.15 abc
S_1H_2	0.56 abc	1.90 abc	2.09 ab	2.28 ab	2.39 ab	2.42 abc
S_1H_3	0.60 ab	2.00 abc	2.20 ab	2.40 ab	2.52 ab	2.55 abc
S_2H_0	0.18 d	1.40 bc	1.54 b	1.68 ab	1.76 b	1.78 bc
S_2H_1	0.22 d	1.80 abc	1.98 ab	2.16 ab	2.27 ab	2.29 abc
S_2H_2	0.45 bc	1.98 abc	2.18 ab	2.38 ab	2.49 ab	2.52 abc
S_2H_3	0.70 a	2.30 a	2.53 a	2.76 a	2.90 a	2.93 a
S_3H_0	0.20 d	1.50 bc	1.65 ab	1.80 ab	1.89 ab	1.91 bc
S_3H_1	0.33 cd	1.67 abc	1.84 ab	2.00 ab	2.10 ab	2.13 abc
S_3H_2	0.45 bc	1.87 abc	2.06 ab	2.24 ab	2.36 ab	2.38 abc
S_3H_3	0.54 abc	2.10 ab	2.31 ab	2.52 ab	2.65 ab	2.67 ab
$LSD_{0.05}$	**0.20**	**0.65**	**0.77**	**0.97**	**0.97**	**0.82**
CV (%)	**7.45**	**4.89**	**9.22**	**6.78**	**7.00**	**5.78**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.7 Weight of fruit

Sowing times and well as hormones significantly affected the weight of fruit of okra. The fresh weight of okra fruit was greatly affected by sowing times in this experiment (Table 13). Significantly highest fresh weight (28.60 g) was observed with 06 April sowing whereas the lowest weight was observed with 22 March sowing. Dry matter production in fruit also got the similar

effect. In case of dry matter in fruit the maximum weight was observed with 06 April sowing (2.29 g) while the lowest dry weight was found from 22 March sowing. Yadav and Dhankhar (1999) also obtained similar results.

Hormones also affected the fruit weight of okra. In case of fresh weight the application of Ripen-15 gave the highest value (32.11 g). It was followed by the results found from the application of Crop Care (28.66 g). The control plot gave the lowest fresh weight of okra in this experiment (Table 13). Application of hormones also significantly increased the dry weight of fruit which differed among the hormones. The maximum dry weight of fruit was observed due to application of Ripen-15 (2.57 g) it was next to Crop Care (2.29 g) and Alga Gold (2.05). The lowest value was observed in control plots (1.73 g). Pandita *et al.* (1991) supported these findings.

Table 13 Weight of mature fruit of okra as affected by different sowing time and hormones

Treatment	Fresh weight of single fruit (g)	Dry weight of single fruit (g)
Sowing time		
S_1	22.10 b	1.77 b
S_2	28.60 a	2.29 a
S_3	23.44 b	1.88 a
$LSD_{0.05}$	3.07	0.56
Hormones		
H_0	21.67 c	1.73 b
H_1	25.66 bc	2.05 a
H_2	28.66 ab	2.29 a
H_3	32.11 a	2.57 a
$LSD_{0.05}$	**4.39**	**0.89**
CV (%)	**5.66**	**7.89**

Means separation in columns followed by the same letter(s) are not significantly different at P≤0.05

The combined effect of sowing times and hormones had the remarkable effect on the fruit weight of okra (Table 14). The fresh weight was significantly affected by different combination of these factors. Significantly highest fresh weight (33.45 g) and dry weight (2.68 g) was observed from the combination of 06 April sowing and application of Ripen-15 (S_3H_3) while the 22 March sowing without hormone (S_1H_0) produced the lowest fresh weight (21.08 g) and dry weight (1.69 g) of okra fruit. It revealed that to ensure the maximum accumulation of photosynthate in okra fruit the proper sowing times as well as application of potential hormones should be maintained. This result was

supported by Satpathy and Rai (1998); Alegbejo (2001) and Passam *et al.* (1998).

Table 14 Weight of mature fruit of okra as affected by the combined effect of sowing time and hormones

Treatments	Fresh weight of single fruit (g)	Dry weight of single fruit (g)
S_1H_0	21.08 c	1.69 d
S_1H_1	23.33 bc	1.87 bcd
S_1H_2	25.66 bc	2.05 bcd
S_1H_3	27.54 abc	2.20 bc
S_2H_0	22.01 bc	1.76 cd
S_2H_1	26.77 abc	2.14 bcd
S_2H_2	28.94 abc	2.32 ab
S_2H_3	33.45 a	2.68 a
S_3H_0	21.00 c	1.68 d
S_3H_1	22.35 bc	1.79 cd
S_3H_2	27.87 abc	2.23 bc
S_3H_3	29.08 ab	2.33 ab
$LSD_{0.05}$	**6.85**	**0.41**
CV (%)	**8.45**	**6.45**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.8 Fruit per plant

The number of fruit is an important factor to increase the yield of okra. In this experiment the sowing times had a significant effect on the number of fruit per plant (Table 15). Significantly highest number of fruit per plant (46.6) was found with 06 April sowing which was followed by 21 April sowing. The

number of fruit was lowest when the okra plant was sown on 22 March. This result was supported by Palanisamy *et al.* (1986) who observed the variation of increased fruit number in okra with optimum planting.

Different hormones treatments were also significantly affected the number of fruit (Table 15). Among the treatments application of Ripen-15 gave the highest number of fruit (44.1) in this study while control plots produced the lowest number of fruits (37.8). The effect of different compound of hormones on the fruit bearing was statistically at per regarding this study. Choudhury and Pahatak (1959a) and Singh *et al.* (1999) also observed the increase in fruit number with these hormones.

The significant interaction was noticed between the sowing times and hormones to produce the fruit in a plant (Table 16). The study showed that the combination of 06 April sowing and application of Ripen-15 (S_3H_3) produced the highest number of fruit (48.4) while the 22 March sowing without hormone (S_1H_0) produced the lowest number of fruit (37.4). Muoneke *et al.* (1997); Nath and Saikia (1995) and Brar *et al.* (1994) partially supported the results.

Table 15 No. of fruits and yield of okra as affected by the different sowing times and hormones

Treatment	No. of Fruit plant^{-1}	Fruit yield plant^{-1} (g)	Fruit yield (t ha^{-1})
Sowing times			
March 22 (S_1)	38.6 b	853.06 c	10.22 b
April 06 (S_2)	46.6 a	1332.76 a	13.88 a
April 21 (S_3)	44.2 a	1036.05 b	13.46 a
$LSD_{0.05}$	**3.51**	**105.66**	**1.31**
Hormones			
Control (H_0)	37.8 b	819.13 d	10.06 d
Alga Gold (H_1)	42.8 a	1098.25 c	11.25 c
Crop Care (H_2)	44.1 a	1264.48 b	12.56 b
Ripen-15 (H_3)	45.0 a	1444.95 a	14.06 a
$LSD_{0.05}$	**2.51**	**96.54**	**1.08**
CV (%)	**9.32**	**8.76**	**10.32**

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

4.9 Fruit yield per plant

In this experiment, fruit yield per plant was significantly varied due to different sowing times (Table 15). The plants gave the maximum fruit yield (1332.76 g) when it was sown on 06 April. It was followed by 21 April sowing (1036.05 g). The lowest fruit yield per plant was observed in 22 March sowing. The results revealed the appropriate sowing times can increase the fruit yield up to 182.99 g per plant which is 21.45% higher. The result is in close conformity with that of Hossain *et al.* (1999). Ghanti *et al.* (1991and Iremiren *et al.* (1986) also supported the results.

Fruit yield per plant was also significantly affected by application of plant hormones (Table 15). Among the hormones treatments, Ripen-15 produced the highest fruit yield of okra (1444.95 g plant^{-1}) which was followed by Crop Care (1264.48 g) and Alga Gold (1098.25 g). However, the control plots resulted with lowest fruit yield per plant (819.13 g). It was calculated that the application of Ripen-15, Crop care and Alga Gold gave 76.40%, 54.36%, and 34.07% higher fruit yield, respectively over control in this experiment. Pawar *et al.* (1977) found similar result. Fruit yield was found to be maximum with the application of NAA was reported by Singh and Singh (1977) and Gulshan and Lal (1997).

Like the single factors, the interaction effect of sowing times and hormones had also a significant contribution towards the seed yield in an okra plant (Table 16). In this study the interaction of 06 April sowing coupled with application of Ripen-15 (S_2H_3) produced the highest fruit yield (1618.98 g) while the combined effect of 22 March sowing and no hormones application (S_1H_0) gave the lowest yield (788.39 g) which was statistically at per with S_3H_0 (802.10 g) and S_2H_0 (818.77 g). This result was in agreement with Iremiren and Okiy (1986) and Gadakh *et al.* (1990).

Table 16 No. of fruits and yield of okra as affected by the interaction effect of sowing times and hormones

Treatment	No. of Fruit plant^{-1}	Fruit yield plant^{-1} (g)	Fruit yield (t ha^{-1})
S_1H_0	37.2 g	788.39 f	9.10 h
S_1H_1	39.0 efg	909.87 e	10.23 fg
S_1H_2	41.0 de	1052.06 d	11.24 f
S_1H_3	42.7 cd	1175.41 c	14.05 bcd
S_2H_0	37.4 fg	818.77 f	10.11 gh
S_2H_1	39.4 ef	1054.74 d	12.34 e
S_2H_2	42.4 cd	1227.06 c	13.56 cd
S_2H_3	48.4 a	1618.98 a	15.98 a
S_3H_0	38.2 fg	802.20 f	10.01 gh
S_3H_1	41.0 de	916.35 e	12.43 e
S_3H_2	43.2 c	1203.98 c	14.54 bc
S_3H_3	45.8 b	1331.86 b	14.87 b
$LSD_{0.05}$	**2.14**	**85.76**	**1.05**
CV (%)	**9.32**	**8.76**	**10.32**

Means separation in columns followed by the same letter(s) are not significantly different at P≤0.05

4.10 Fruit yield per hectare

Fruit yield is the ultimate product of different yield contributing characters. As the different plant characters of okra was greatly affected by sowing times as well as hormones, the fruit yield per hectare was also affected. Different sowing times had a significant effect on the fruit yield per hectare and in this study the highest fruit yield per hectare (13.88 ton) was obtained from

06 April sowing which was statistically similar with 21 April sowing (Table 15). However the lowest fruit yield per hectare (10.22 ton) was observed from 22 March sowing which was 30.07% and 31.70% lower than April 06 and April 21 sowing. This finding was in agreement with Palanisamy *et al.* (1986); Singh *et al.* (1986); Yadav *et al.* (2002) and Kamalanthan *et al.* (1970).

Plant hormones also significantly affected the yield of okra per unit area. In this experiment significantly highest fruit yield was observed from the application of Ripen-15 (14.06 t ha^{-1}). The next higher fruit yield was observed from Crop Care (12.56 t ha^{-1}) followed by Alga Gold (11.25 t ha^{-1}). The lowest fruit yield per hectare was observed from control treatment (10.06 t ha^{-1}) which was 39.76%, 24.85% and 6.46% lower than Ripen-15, Crop Care and Alga Gold application (Table 15). Gulshan and Lal (1997) also reported similar result in okra.

A significant variation of fruit yield of okra per hectare was also observed due to the combined effect of sowing times and hormones (Table 16). In the present study the combined effect of 06 April sowing coupled with application of Ripen-15 (S_2H_3) produced the highest fruit yield (15.98 t ha^{-1}) while the combined effect of 22 March sowing and no hormones application (S_1H_0) gave the lowest yield (37.2 t ha^{-1}) which was statistically at per with S_2H_0 (37.4 t ha^{-1}) and S_3H_0 (38.2 t ha^{-1}) and S_1H_1 (39.0 t ha^{-1}). Sajjan *et al.* (2002) confirmed this result.

4.11 Correlation and regression analysis

Table 17 revealed that number of branches plant^{-1}, number of leaves plant^{-1}, fresh weight of single fruit, dry weight of single fruit, number of fruit per plant and fruit yield of okra were positively correlated with each other. The intercorrelations were also highly significant. Number of branches plant^{-1}, number of leaves plant^{-1}, fresh weight of single fruit, dry weight of single fruit and number of fruit per plant had a significant correlation with fruit yield with the r values of 0.925, 0.923, 0.915, 0.914 and 0.941. The coefficients of determination also showed a positive linear and significant relation of number of branches plant^{-1}, number of leaves plant^{-1}, fresh weight of single fruit, dry weight of single fruit, number of fruit per plant with fruit yield with R^2=0.85**, R^2=0.85**, R^2=0.83**, R^2=0.83**, R^2=0.88**, respectively (Fig. 2, 3, 4, 5 and 6). The slope for number of branches plant^{-1}, number of leaves plant^{-1}, fresh weight of single fruit, dry weight of single fruit and number of fruit per plant over the fruit yield indicated that an increment of 1 branches plant^{-1}, 1 leaves plant^{-1}, 1 g fresh weight of single fruit, 1 g dry weight of single fruit and 1 fruit per plant increases 2.53 ton, 0.33 ton, 0.53 ton, 6.62 ton and 0.61 ton fruit yield ha^{-1} (Fig. 2, 3, 4, 5 and 6).

The fruit yield variations of okra could be attributed to the number of branches plant^{-1}, number of leaves plant^{-1}, fresh weight of single fruit, dry weight of single fruit and number of fruit per plant following different sowing

times and hormone treatments in okra plant. The above relations suggested ensuring the maximum yield it should be improved the yield attributes.

Table 17 Correlation between fruit yield and yield attributes of okra as affected by the combination effect of sowing times and hormones

Parameters	No. of leaves per plant	Fresh weight of single fruit	Dry weight of single fruit	No. of fruit per plant	Fruit yield
No. of branches per plant	0.901**	0.824**	0.826**	0.907**	0.925**
No. of leaves per plant		0.902**	0.902**	0.980**	0.923**
Fresh weight of fruit per plant			1.000**	0.912**	0.915**
Dry weight of fruit per plant				0.913**	0.914**
No. of fruit per plant					0.941**

** Correlation is significant at the 0.01 level.

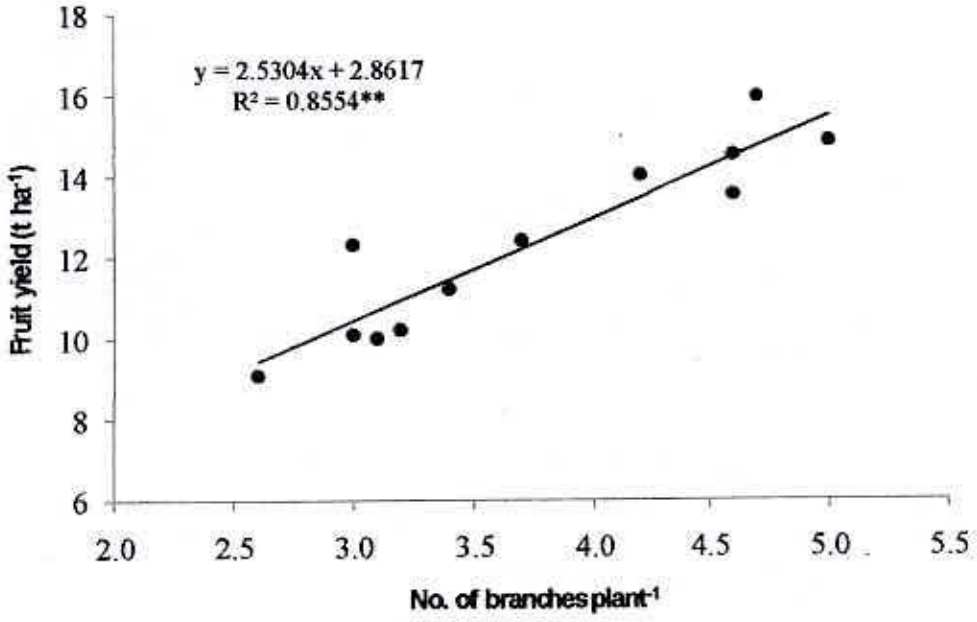


Fig. 2 Relationship between no. of branches plant^{-1} and fruit yield of okra

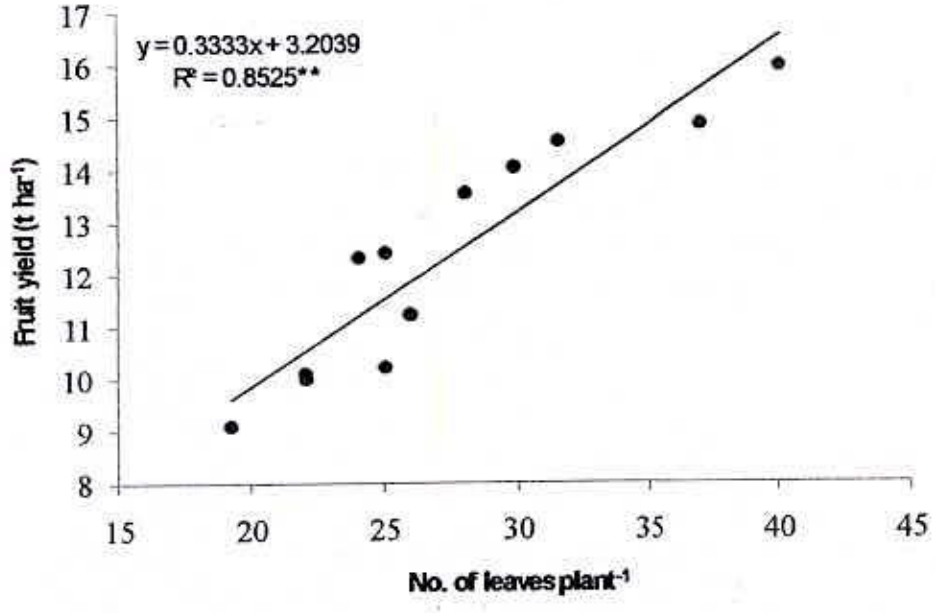


Fig. 3 Relationship between no. of leaves plant^{-1} and fruit yield of okra

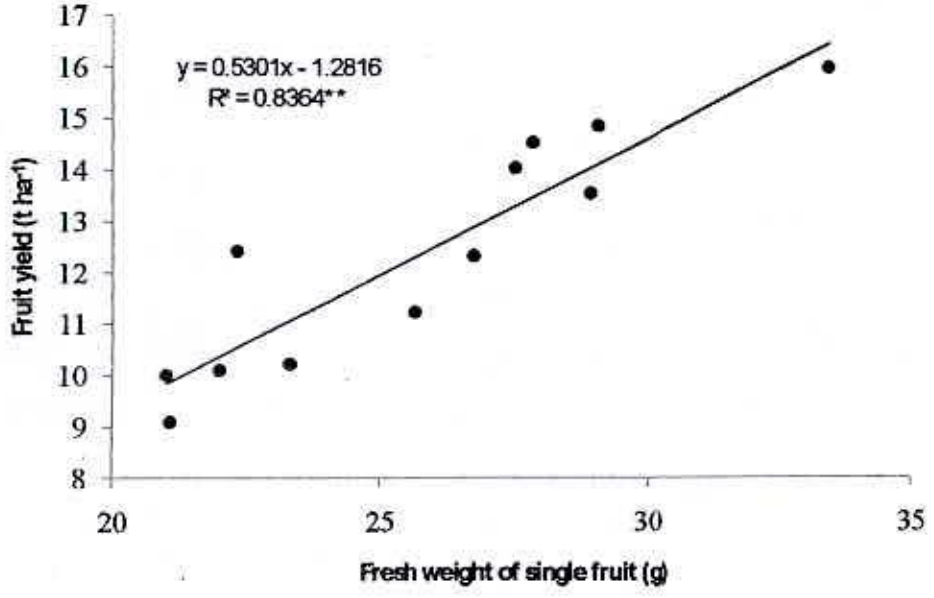


Fig. 4 Relationship between fresh weight of fruit and fruit yield of okra

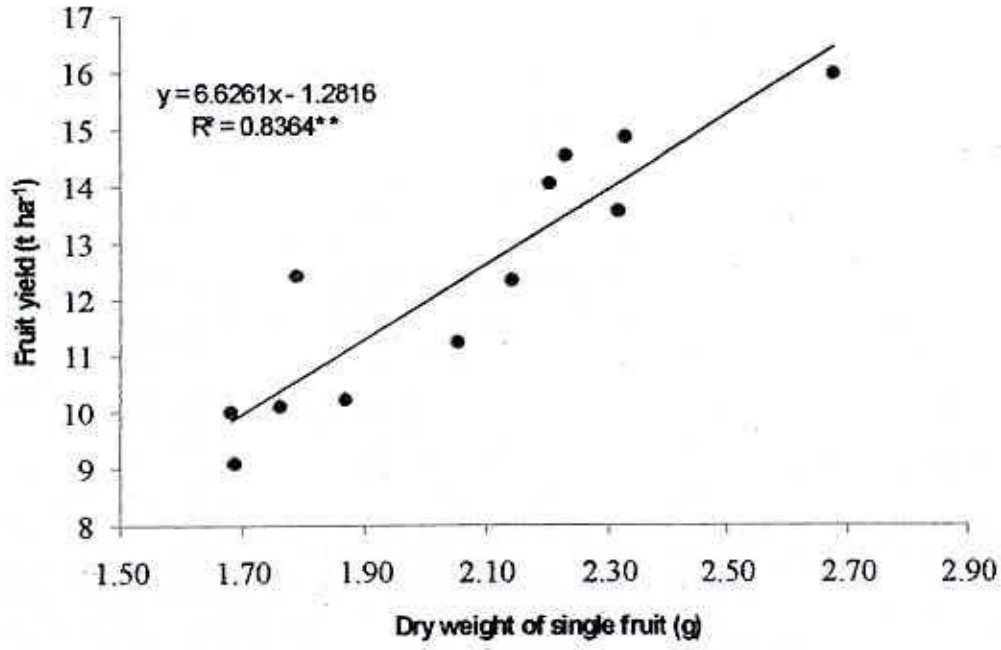


Fig. 5 Relationship between dry weight of fruit and fruit yield of okra

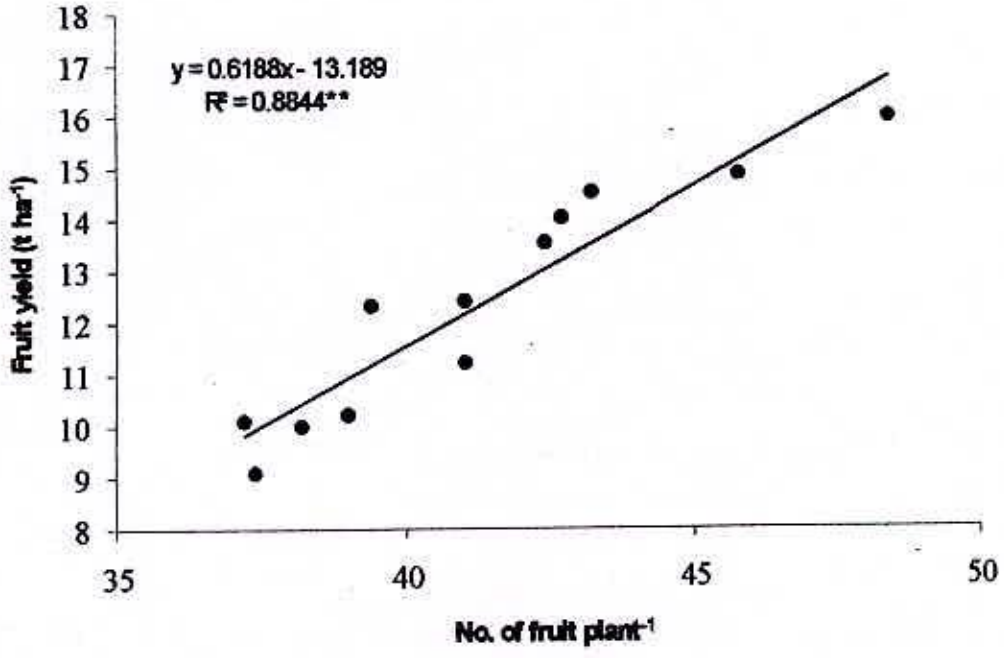
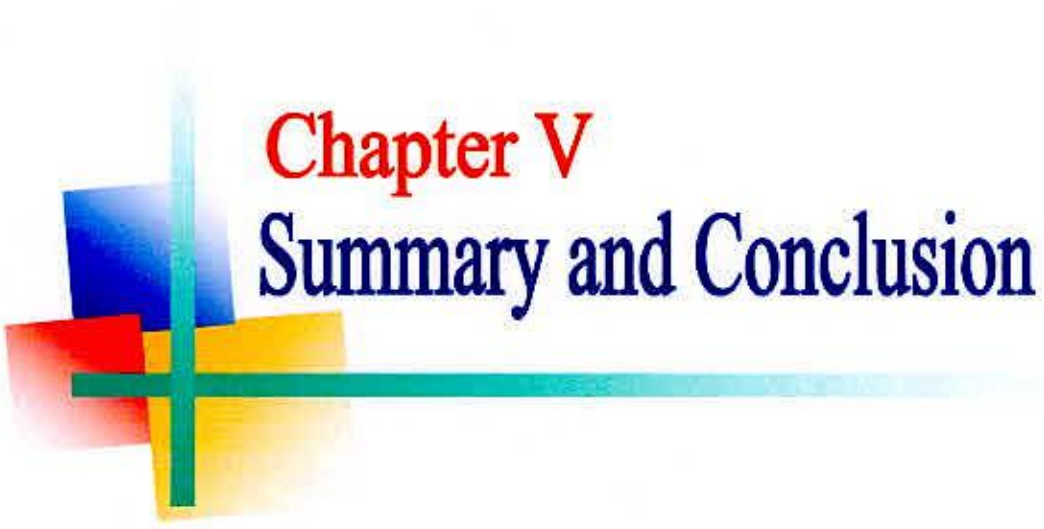


Fig. 6 Relationship between no. of fruits plant^{-1} and fruit yield of okra



Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The study was carried out at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the suitable sowing times and hormones for optimum yield of the okra. The results are summarized below.

Different sowing times affected the plant height of okra plant in this experiment. But significant variation of plant height due to sowing time was observed from 50 DAS. At every stage, the tallest plant was recorded at April 06 sowing which was followed by April 21 sowing. The maximum plant height was observed with Ripen-15 at all the growth stages. At different growth stages up to 41% increase of plant height was noticed with the application of hormones over control treatment At all the growth stages the treatment combination of April 06 and Ripen-15 (S_2H_3) produced the tallest plant while the 22 March sowing with no hormone (S_1H_0) produced the shortest plant.

In every case, 06 April sowing produced the maximum plant height in this experiment. From 80 DAS onward the increase of branches in the plant was negligible whereas the effect was significantly affected by sowing times. Among the hormones Ripen-15 showed the best results to produce the branches. Different hormones had a distinct differences compared to control treatments at all the growth stages except during and after maturity. From the

experiment it was observed in most of the cases 06 April sowing combined with the application of Ripen-15 (S_2H_3). However the 22 March sowing without hormone (S_1H_0) produced the shortest plant.

From the comparison it was observed that in most of the cases 21 April sowing produced the maximum number of leaves in okra plant whereas the 22 March sowing resulted the lowest number of leaves. In all cases maximum leaf number was noticed with Ripen-15 treatment. However, it was statistically at per with Crop Care at all the growth stages except 35 DAS. At all the growth stages the interaction of 06 April sowing combined with the application of Ripen-15 (S_2H_3). However, the 22 March sowing without hormone (S_1H_0) produced the shortest plant.

The maximum leaf length was observed with 06 April sowing which was statistically identical with 21 April sowing. At 20, 35, 50, 65, 80 and 95 DAS the maximum leaf length (16.78 cm, 20.33 cm, 29.00 cm, 32.00 cm, 34.00 cm and 36.10 cm) with the application of Ripen-15 which was followed by Crop care. Irrespective to growing stages, the combination of 06 April sowing and application of Ripen-15 (S_2H_3) gave the highest leaf length. However, the 22 March sowing without hormone (S_1H_0) produced the shortest plant.

Maximum leaf breadth was observed with 21 April sowing 35 and 50 DAS. But at 65, 80 and 95 DAS the maximum leaf breadth was observed with 06 April sowing. The maximum leaf breadth at different growth stages (15.10

cm, 18.30 cm, 26.10 cm, 28.80 cm, 30.60 cm and 32.49 cm) was observed by the application of Ripen-15. It was followed by Crop Care application. The leaf breadth of okra was significantly influenced by different combination of sowing times and hormones application in this experiment. The significantly highest leaf breadth was observed with 06 April sowing combined with the application of Ripen-15 (S_2H_3). Irrespective to plant ages, the 22 March sowing without hormone (S_1H_0) produced the shortest plant.

At all the growth stages, the maximum diameter of stem was observed in 06 April sowing which was followed by 21 April sowing. In every case the lowest stem diameter was found in 22 March sowing. At every stages of growth the maximum stem diameter was observed with the application of Ripen-15 while the lowest stem diameter was found in control plots. Irrespective to plant ages, the highest stem diameter was observed from 06 April sowing combined with the application of Ripen-15 (S_2H_3). However the 22 March sowing without hormone (S_1H_0) produced the shortest plant.

Significantly highest fresh weight (28.60 g) was observed with 06 April sowing whereas the lowest weight was observed with 22 March sowing. Dry matter production in fruit also got the similar effect. In case of dry matter in fruit the maximum weight was observed with 06 April sowing (2.29 g) while the lowest dry weight was found from 22 March sowing. Hormones also affected the fruit weight of okra. In case of fresh weight the application of Ripen-15 gave the highest value (32.11 g). Application of hormones also

significantly increased the dry weight of fruit which differed among the hormones. The maximum dry weight of fruit was observed due to application of Ripen-15 (2.57 g) it was next to Crop Care (2.29 g) and Alga Gold (2.05). The lowest value was observed in control plots (1.73 g). The fresh weight was significantly affected by different combination of these factors. Significantly highest fresh weight (33.45 g) and dry weight (2.68 g) was observed from the combination of 06 April sowing and application of Ripen-15 (S_3H_3) while the 22 March sowing without hormone (S_1H_0) produced the lowest fresh weight (21.08 g) and dry weight (1.69 g) of okra fruit.

Significantly highest number of fruit per plant (46.6) was found with 06 April sowing which was followed by 21 April sowing. Among the treatments application of Ripen-15 gave the highest number of fruit (44.1) in this study while control plots produced the lowest number of fruits (37.8). The study showed that the combination of 06 April sowing and application of Ripen-15 (S_3H_3) produced the highest number of fruit (48.4) while the 22 March sowing without hormone (S_1H_0) produced the lowest number of fruit (37.4).

The results revealed the appropriate sowing times can increase the fruit yield up to 182.99 g per plant which is 21.45% higher. Among the hormones treatments, Ripen-15 produced the highest fruit yield of okra (1444.95 g plant^{-1}) which was followed by Crop Care (1264.48 g) and Alga Gold (1098.25 g). The interaction of 06 April sowing coupled with application of Ripen-15 (S_2H_3) produced the highest fruit yield (1618.98 g).

Different sowing times had a significant effect on the fruit yield per hectare and in this study the highest fruit yield per hectare (13.88 ton) was obtained from 06 April sowing which was statistically similar with 21 April sowing. In this experiment significantly highest fruit yield was observed from the application of Ripen-15 (14.06 t ha^{-1}). The combined effect of 06 April sowing coupled with application of Ripen-15 (S_2H_3) produced the highest fruit yield (15.98 t ha^{-1}) while the combined effect of 22 March sowing and no hormones application (S_1H_0) gave the lowest yield (37.2 t ha^{-1}).

Correlation and regression study revealed that the number of branches $plant^{-1}$, number of leaves $plant^{-1}$, fresh weight of single fruit, dry weight of single fruit and number of fruit per plant had a significant correlation with fruit yield with the r values of 0.925, 0.923, 0.915, 0.914 and 0.941. The coefficients of determination also showed a positive linear and significant relation of number of branches $plant^{-1}$, number of leaves $plant^{-1}$, fresh weight of single fruit, dry weight of single fruit, number of fruit per plant with fruit yield with R^2=0.85**, R^2=0.85**, R^2=0.83**, R^2=0.83**, R^2=0.88**, respectively

The study will now provide guidelines about sowing times and hormones for the okra production. However, further field trial may be taken in different agroecological zones in relation to the physiological and biological aspects of this crop with more extended sowing times and different rates of these hormones to reestablish the findings obtained in this study.

References

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.

Adetunji, I.A. and Chheda, H.R (1989). Seed yield stability of okra as influenced by planting date. *Acta Hort.* **56**: 123-28.

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

Ahmed, K. U. (1995). *Pal-Phul O Shak-Shabji* (In Bengali) 5th ed. Mrs Mumtaj Kamal. Mirpur, Dhaka, Bangladesh. 400p.

Alegbejo, M.D. (2001). Effect of sowing date on the incidence and severity of okra mosaic. *Tymovirus. J. Veg. Crop Prod.* **7** (1): 9-14.

Al-Masoum, A. A. and Al-Masri, H. (1999). Effect of ethephon on flowering and yield of monoecious cucumber. *Egyptian J. Hort.* **26**: 229-236.

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

Anonymous. (2000). *Yearbook of Agricultural Statistics of Bangladesh*, Bangladesh Bureau of Statistics (BBS). Ministry of planning, Govt. of the People's Republic of Bangladesh. p. 96.

Ariyo, D. 1987. Genotypic variation okra germplasms in diversified field condition. *Veg. Sci.* **14** (2): 31-38.

Augustine, J. J., Baker, L. R. and Sell, H. M. (1973). Chemical reversion of sex expression on dioecious cucumber with ethephon and a benzothiadiazole. *Hort. Sci.* **8**: 218-219.

Baloch, A.F. (1994). *Vegetable Crops*. Hort. National Book Foundation, Islamabad, pp: 529-531.

BARC (Bangladesh Agricultural Research Council). (2005). *Fertilizer Recommendation Guide 2005*. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

BCA (Bangladesh Country Almanac). (2004). Agricultural Statistics Database. *In:* BCA **v.2.0** (CD ROM Version). CIMMYT Bangladesh.

Beyer E. M. and Quebedeaux, B. (1974), Induction of parthenocarpy by N-1-naphthylphthalamic acid in cucumber. *Hort. Sci.* **9**: 396-398.

Bhai, K. L. and Singh, A. K. (1998). Effect of different levels of phosphorous, GA_3 and pickings on seed production of okra. *Env. Ecol.* **16** (2): 350-352.

Bhat, 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 gibberelic acid and indole-3- acetic acid on rooting in stem cuttings of *Abelmoschus esculentus*. *Moench. Planta.* **138**(1): 111-112.

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

Bisaria, A. K. (1974). Sex expression and development in cucumber as Gibberellions. *Indian J. Hort.* **16**: 233-235.

Brar, K.S., Arora, S.K. and Ghai, T.R. (1994). Losses in fruit yield of okra due to Earias spp. as influenced by dates of sowing and varieties. *J. Insect Sci.* 7(2): 133-135.

Bukovac, M. J. and Wittwer, S. H. (1961). Gibberellin modification of flower sex expression in (*Cucumis sativus*). *Adv. Chem. Series.* **28**: 80-88.

Cantliffe, D. J., Robinson, R. W. and Basodorfe, R. S. (1972). Influence of growth regulators on sex expression on sponge gourd. *Hort. Sci.* **7**: 285-86.

Cerri, A.M. and Vilella, F. (1996). Generation of yield in okra: comparison of two cultivars on two sowing dates. *Revista de la Facultad de Agronomia Universidad de Buenos Aires.* **15**(2-3): 207-212.

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.

Choudhury, B and Phatak, S. C. (1959a). Sex expression and sex ratio in cucumber (*Cucumis sativus* L.) as affected by plant regulator sprays. *Indian J. Hort.* **16**: 162-165.

Choudhury, B. and Phatak, S. C. (1959b). Sex expression and sex ratio in cucumber (*Cucumis sativus* L.) as affected by plant regulator sprays. *Indian J. Hort.* **17**: 145-153.

Choudhury, B. and Phatak, S. C. (1981). Further studies on sex expression and sex ratio in cucumber (*Cucumis sativus* L.) as affected by plant regulator sprays. *Indian J. Hort.* **39**: 210-216.

Choudhury, B., Phayak, S. C. and Patil, A. V. (1967). Effect of plant regulator sprays on sex, fruits set and fruit development in cucumber (*Cucumis sativus* L). Proc. *Bihar Academy of Agric. Sci.* **11**: 251-257.

Das, R. and Rabhal, B. K. (1999). Effect of growth regulators on size and quality of cucumber (*Cucumis sativa* L.) in plastic green house during Rabi season. *Crop Res. Hisar.* **18**: 390-3 96.

Das, R. C. and Swain, S. C. (1977). Effect of growth substances and nitrogen on growth, yield and quality of pumpkin (*Cucurbita moschata*). *Indian J. Hort.* **34**: 51-55.

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

Deotale, R.D., Maske, V.G., Sorte, N.V., Chimurkar, B.S. and Yerne, A.Z. (1998). Effect of GA_3 and NAA on morpho-physiological parameters of soybean. *J. Soils Crops.* **8**: 91-94.

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.

Dubey, S.C. and Jha, A.K. (1999). Influence of dates of sowing and environmental factors on collar rot of okra. *Indian Phytopathol.* **52**(3): 291-293.

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.

Freytag, A. H., Lira, E. P. and Isleib, D. R. (1970). Cucumber sex expression modified by growth regulators. *Hort. Sci.* **5**: 500-501.

Gadakh., S. R., Lawande, K. E. and Kale, P. N. (1990). Effect of different seasons and spacing on yield and quality of Bhindi. *Haryana J. Hort. Sci.* **19** (3-4): 329-332.

Gedam, V. M., Patil, R B., Suiyawanshi, Y. B. and Mate, S. N. (1998). Effect of plant growth regulators and boron on flowering, fruiting and seed yield of bitter gourd. *Seed Res.* **26**: 97-100.

Ghanti, P., Sounds, O. and Verma, K. (1991). Effect of sowing dates on growth and yield of okra (*Abelmoschus esculentus* L. Moench) varieties. *Environ. Ecol.* **9**: 170-179.

Gomez, K. A. and Gomez, A. A. (1984). *Statistical procedures for Agricultural Research.* John Wiley and Sons. Inc., New York. PP. 67-215.

Gopalkrishnan, P. K. and Choudhury, B. (1978). Effect of plant regulator sprays on modification of sex, fruit set and development in watermelon (*Citrula lanatus* 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.

Grubben, G.I.H. (1977). *Okra.* In: Tropical Vegetables and their Genetic Resources. IBPGR, Rome. pp 111–114.

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.

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

Gupta, A., Reo, L.V. and Stinives, K. (1981). Response of Okra to date of sowing and plant spacing. Vegetable science. *Indian Inst. of Hort. Res.*, Bangore, India. **8**: 89-74.

Gurdev, S. and Saxena, O.P. (1991). Seed treatments with bioregulators in relation to wheat productivity. In: *New Trends in Plant Physiology*, Proceed., National Symposium on Growth and Differentiation in Plants. New Delhi, India, pp: 201-210.

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

Hore, J.K., Paria, N.C. and Sen, S.K. (1988). Effect of pre-sowing seed treatment on germination, growth and yield of (*Allium cepa*) var. Red Globe. *Harayana J. Hort. Sci.* **17**: 83-87.

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

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

Ilias, G., Ouzounidou, A., Giannakoula and Papadopoulou, P. (2007). Effects of gibberellic acid and prohexadione-calcium on growth, chlorophyll fluorescence and quality of okra plant. *Indian J. Hort.* **51**(3): 575-578.

Incalcaterra, G.,Vetrano, F. and Stoffella, P.J. (2000). Effects of two sowing dates and plastic mulch on okra production. *Acta Hort.* **53** (3): 329-336.

Iremiren, G. O. and Okiy, D. A. (1986). Effect of sowing date on the growth, yield and quality of okra (*Abelmoschus esculentus* (L.) Moench. in Southern Nigeria. *J. Agri. Sci.* **106** (1): 21- 26.

Irshad, A. and Gupta, P. K. (1981). Effect of cycocel on sex expression in three members of Cucurbitaceae. *Indian J. Hort.* **38**: 100-102.

Irving, R.M., Rogers, B. and Lanphear, F.O. (1968). Studies in growth promoting substances on cucumber. *American J. Hort. Sci.* **94**: 4 19-422.

Islam, M. S., Begum, R. A., Saha, S. R., Hossain, S. M. and Hoque, M. M. (1990). Effect of artificial pollination and hormone application on the yield of bottle gourd. *Bangladesh Hort.* **11**: 47-4 9.

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.

Kapgate, H.G., Potkile, N.N., Zode, N.G. and Dhopte, A.M. (1989). Persistence of physiological responses of upland cotton to growth regulators. *Ann. Plant Physiol.* **3**: 188-195.

Karakoltsidis, P. A., & Constantinides, S. M. (1975). Okra seeds: A new protein source. *J. Agric. Food Chem.* **23**(6): 1204–1207.

Kaur, J. and Singh, G. (1987). Hormonal regulation of grain filling in relation to peduncle anatomy in rice cultivars. *Indian J. Expl. Biol.* **25**: 63-65.

Khalil, S. and Mandurah, H.M. (1989). Growth and metabolic changes of cowpea plants as affected by water deficiency and indole acetic acid. *J. Agron. Crop Sci.* **163**: 160-166.

Kim, C. 1994. Nutrient content and seed quality and agronomic performance of okra in different field conditions. *Acta Agric. Sinc.* **23** (3): 32-40.

Koay, S. H. and Chua, S. E. (1978). Effect of fertilizers on vegetative growth and pod production in okra *(Hibiscus esculentus* L.). *Singapore J. Prio. Ind.* **6**: 76-79.

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

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.

Lee, H.S. (1990). Effects of pre-sowing seed treatments with GA3 and IAA on flowering and yield components in groundnuts. *Korean J. Crop Sci.* **35** (8): 1-9.

Lee, K. H., Cho, C.Y., Yoon, S. T. and Park, S. K. (1990). The effect of nitrogen fertilizer, planting density and sowing date on the yield of okra. *Korean J. Crop. Sci.* **35** (8): 179-183.

Lower, R.L., Miller, C.H., Baker, F.H. and McCombs, C.L. (1970). Effects of 2,chloroethylphosphonic acid treatment at various stages of cucumber development. *Hor. Sci.* **5**: 433-434.

Mangal, J.L., Pandita, M.L and Singh, G.R. (1981). Effect of various chemicals on growth, flowering and yield of bitter gourd. *Indian J. Agric. Res.* **15**: 185-188.

Martin, F. W. and Ruberte, R. (1979). Milling and use of okra seed meal at the household level. *J. Agric. Unive. Puerto Rico.* **63**(1): 1–7.

Maske, V.G., Deotale, R.D., Sorte, N.V., Goramnagar, H.B. and Chore, C.N. (1998). Influence of GA and NAA on growth and yield contributing parameters of soyabean. *J. Soils Crops.* **8**: 20-21.

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

McMurray, A. L. and Miller, C. H. (1969). The effect of 2-chioroethanephosphonic acid (etherel) on the sex expression and the yields of *Cucumis sativus*. *J. Amer. Soc. Hort. Sci.* **94**: 400-402.

Mehta, Y.R. (1959). Vegetable Growing in Uttar Pradesh. Bureau of Agricultural Information, Uttar Pradesh, Lucknow.

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

Muoneke, C.O., Asiegbu, J.E. and Udeogalanya, A.C.C. (1997). Effect of relative sowing time on the growth and yield of the component crops in okra/maize and okra/cowpea intercropping systems. *J. Agron. Crop Sci.* **179**(3): 179-185.

Nadkarni, K.M. (1927). Indian Materia Medica. Nadkarni and Co., Bombay.

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

Nath, P. and Saikia, A.K. (1995). Influence of sowing time on yellow vein mosaic virus of okra. *Indian J. Mycol. Plant Pathol.* **25**(3): 277-279.

Nath, P.D., Gupta, M.K. and Bora, P. (1992). Influence of sowing time on the incidence of yellow vein n and white fly population of okra. *Indian J. Virol.* **8**: 45-48.

Nonnecke, I.L. (1989). Vegetable Production. Van Nostrand Reinhold AVI Publishing. pp.608-609.

Oyenuga, V.A. (1968). *Nigerian foods and feeding stuff.* Ibadan, Nigeria: Ibadan University Press.

Palanisamy, V., Vanangamudi, K., Jayaraj, T. and Karivaratharaju, T.V. (1986). Influence of date of sowing in *bhindi* (*Abelmschus esculentus* (L.) Moench.). *South Indian Hort.* **34** (1): 23-25.

Pandita, M.L.N., Sharnia, K. and Arora, S.K. (1991). Effect of Miixtalol arid Vipul on growth, flowering and yield of okra (*Abelmoschus esculentus* L. Moench). *Vegetable Sci.* **18**: 32-40.

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

Patnaik, A., Mishra, R. S., Nayak, G. C. and Maharana, T. (1974). Effect of Cococel and Ethrel on sex expression and yield of Ridge gourd. *Bangladesh Hort.* **2**: 19-22.

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.

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

Rai, S. and Satpathy, S. (1999). Influence of sowing date and insecticides on the incidence of jassid and fruit borer on okra. *Veg. Sci.* **26**(1): 74-77.

Rai, S., Hossain, M. and Hossain, F. (1998). Effect of growth regulators on yield of quality of okra fibre. *Hort. J.* **11** (1): 77-82.

Rashid, M.M. (1999). *Shabjibijjaya*n (In Bengali). Rashid Publishing House, 94 Old DOHS, Dhaka-1206. p. 49.

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.

Ravindran, D. N. (1971). Effect of photoperiod and growth substances on sex expression in snake gourd. *South Indian Hort.* **15**: 1-21.

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

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

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 Characters and Yield of Soybean. *Pakistan J. Agron.* **1** (4): 119-122.

Satpathy, S and Rai, S. (1998). Influence of sowing date and crop phenology on pest infestation in okra. *Veg. Sci.* **25**(2): 178-180.

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.

Sayeed. A. (1988). Effect of date of planting and insecticidal spray on the yield and control of yellow vein mosaic of okra. M.Sc Thesis., Bangladesh Agril. Univ., Mymensingh- 2202, Bangladesh.

Shabab Uddin, M., Fattah, A. Q. and Huq, S. (1986). Effect of potassium naphthenate on yield. *Bangladesh Hort.* **14**: 3 9-40.

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

Sims, W.L and Gledhill, B.L. (1969). Ethrel effects on sex expression and growth development in pickling cucumbers. Calif. Agr. 23: 4-6.

Sing, K.P., Malik, Y.S. Lal, S. and Pandita, M.L. (1986). Effects of planting dates and spacing on seed production of okra (*Abelmoschus esculentus* (L). Moench). *Haryana J. Hortic. Sci.* **15**(3-4): 267-271.

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, D.K., Tewari, R.P. and Lal, G. (1994). Effect of sowing time on virus incidence and seed yield of okra. *Ann. Agric. Res.* **15**(3): 374-375.

Singh, K., Sarnaik, D.A. and Bisen, C.S. (1988). Effect of sowing dates and spacings on the yield and quality of okra seed (*Abelmoschus esculentus* (L.) Moench.). *Res. Dev. Reptr.* **5**(1-2): 83-86.

Singh, P., Rathore, T. and Singh, S. 1989. Performance of okra to different sowing time and spacing. *Indian Farming*. **23** (2); 45-52.

Singh, P.V., Jitendra, K. and Kumar, J. (1998). Effect of gibberelic 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 substances 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. *Proceeding of the Bihar Aca. Agric. Sci.* **24** (2): 108-109.

Sreeramulu, N. (1987). Effect of ethrel on sex expression and endogenous auxin content in sponge gourd (cylindrical poem). *Indian J. Hort.* **44**: 85-87.

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

Srivastava. R. P. and Singh, L. (1968). Effect of pre-sowing treatment with growth substances on Okra. *Allahabad Fmr.* **42**:27-29.

Takeno, K., Ise, H., Minowa, H. and Dounowaki, T. (1992). Fruit growth induced by benzyladenine on cell division, cell enlargement and indole-3-acetic acid content of okra. *J. Japanese Soc. Hort. Sci.* **60**: 915-920.

Thompson, H. C. and Kelley, W. C. (1979). *Vegetables Crops.* 5th Edition. McGraw Hill, New York. pp. 561-563.

Tindall. H. D. (1983). *Vegetables in the Tropics*. McMillan AVI. pp. 33, 325-327.

UNDP/FAO. (1988). Agroecological regions of Bangladesh. *Technical Report 2*. Project BDG/81/035; FAO, Rome.

Vadigeri, B.G. and Madalageri, B.B. (1989). Response of cucumber genotypes to ethrel and GA3. *Karnataka J. Agric. Sci.* **2**: 176-178.

Vashisht, K.D., Paul, Y. and Sharma, B.N. (1987). Influence of gibberelic acid and 2, 4-dichlorophenoxyacetic acid on germination of okra. *J. Res.* **24**(2): 264-271.

Vijay, O.P. and Jalikop, S.H. (1980). Production of parthenocarpic fruit with growth regulators in kakrol (*Cochin chinensis* Spreng). *Indian J. Hort.* **37**: 167-169.

Woodruff, J.G. (1927). *Georgia Experimental Station Bulletin* No. **145** (1927). pp. 164–185.

Yadav, S. K. and Dhankar, B.S. (2001). Seed production and quality of okra (*Abelmoschus esculentus* (L.) Moench) as affected by sowing time and position of fruit on plant. *Seed Res.* **29**(1): 47-51.

Yadav, S.K and Dhankhar, B.S. (1999). Performance of Varsha Uphar cultivar of okra [*Abelmoschus esculentus* (L.) Moench] as affected by the sowing dates and plant geometry. *Vegetable Sci.* **26** (2):180-182.

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

Appendices

APPENDICES

Appendix I Monthly average temperature of the experimental site during the study period

Month, 2007	Average air temperature (°C)		
	Maximum	Minimum	Mean
March	31.50	19.60	25.55
April	33.74	23.87	28.81
May	34.70	25.90	30.30
June	32.40	25.50	28.95
July	31.40	25.80	28.60

Appendix II Monthly total rainfall, average relative humidity and total sunshine of the experimental site during the study period

Month, 2007	Total rainfall (mm)	Average RH (%)	Total sunshine hour
March	160	47.00	255.01
April	185	69.41	234.06
May	185	70.00	241.08
June	628	81.00	96.00
July	542	80.00	97.00

Appendix III Nutrient value per 100 g of okra

Components	Amount*
Carbohydrates	7.6 g
Dietary fibers	3.2 g
Fat	0.1 g
Protein	2.0 g
Folate (Vitamin B9)	87.8 µg (22%)
Vitamin C	21 mg (35%)
Calcium	75 mg (8%)
Magnesium	57 mg (15%)
Vitamin A	660 IU

*Percentages are relative to recommendations for adults

Source: Wikipedia (2008)

Appendix IV Taxonomy of okra plant

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Malvales

Family: Malvaceae

Genus: *Abelmoschus*

Species: *esculentus*

Binomial name: *Abelmoschus esculentus* (L.) Moench