GROWTH, DEVELOPMENT AND YIELD OF *ABELMOSCHUS ESCULENTUS* L. FOLLOWING APPLICATION OF PLANT GROWTH REGULATORS

A
DISSERTATION
FOR FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF PHILOSOPHY
IN
BOTANY
UNIVERSITY OF DHAKA

Dil Afroz Begum
M.Sc. (Botany)

December, 1998

DECLARATION

I hereby declare that this dissertation entitled "Growth, development and yield of *Abelmoschus esculentus* (L.) Moench following application of plant growth regulators" has been composed by myself and all the works presented herein are my own.

I further declare that this work has not been submitted anywhere for any academic degree.

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২৭/১২/৯৮

December, 1998

Dil Afroz Begum

CERTIFICATE

This is to certify that the research work embodying the result reported in this dissertation entitled "Growth, development and yield of *Abelmoschus esculentus* (L.) Moench following application of plant growth regulators" and submitted by Dil Afroz Begum has been carried out under my guidance in the Botanical Garden and in the Plant Physiology Laboratory, Department of Botany, University of Dhaka, and B.C.S.I.R. Laboratory, Dhaka.

It is further certified that the work presented herein is original and suitable for submission towards the partial fulfilment of the requirement for the degree of Master of Philosophy in Botany.

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ABSTRACT

Two separate experiments were carried out at the botanical garden of the Department of Botany, University of Dhaka, during the period of March to June, 1991 and 1992. The objectives were to study the growth, development, fruit yield and biochemical characteristics of *Abelmoschus esculentus* (L.) Moench following application of plant growth regulators.

In the experiment 1, there were six treatments with three growth regulators, viz. 2500 and 5000 ppm KNap, 50 and 100 ppm TIBA and 10^{-5} M and 10^{-6} M ABA as single foliar spray. In the experiment 2, there were six treatments with different concentrations of TIBA, viz 25, 50, 75, 100, 125 and 150 ppm as single foliar spray.

During the study, physiological and yield parameters like plant height, days to first flowering, number of fruits per plant, length of fruit, weight of fruit, fruit yield per plant and the biochemical parameter, like leaf pigment were investigated in both the experiments. But, investigations on moisture, vitamin C, ß-carotene and protein content of fruits were carried out during experiment 2.

In the experiment 1, results showed that plant height, number of fruit, fruit length and fruit yield per plant increased significantly following 2500 and 5000 ppm KNap and 50 and 100 ppm TIBA treatments. The highest yield increase over control (53%) was recorded from 50 ppm TIBA treated plants.

Biochemical parameters like chlorophyll a, chlorophyll b and carotenoid content of leaves of lady's finger were influenced significantly by different growth regulators.

In the experiment 2, results showed that plant height, number of fruit and fruit yield per plant increased or decreased significantly and non-significantly following application of different concentrations of TIBA. The highest increase of fruit yield per plant over control (67.40%) was recorded from 50 ppm TIBA treated plants, but fruit length and weight of fruit varied nonsignificantly due to various treatments.

Biochemical parameters, viz. chlorophyll a and carotenoid contents of leaves were significantly influenced at 50 DAS by the treatments; but chlorophyll b of leaves and moisture content, ß-carotene content, vitamin C content and protein content of fruits were influenced nonsignificantly.

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INTRODUCTION

1. INTRODUCTION

Vegetables are plant products that do not specially belong to the group of fruits or cereals and are consumed fresh, raw or processed directly without substantial extraction. They encompass numerous organ in vegetative and reproductive stages and they are good source of vitamin A and B and also contain vitamin C. They are also rich in proteins, minerals and iodine. Dieticians recommended 285 g vegetables per capita per day for a balanced diet. Of the 285 g, leafy vegetables should be 115 g, other vegetables 85 g and root vegetables 85 g. In Bangladesh, the present vegetable consumption is about 40 g per day per capita or about 85 g per day per capita if inclusion of potato and sweet potato are taken into account (Chadha *et al.* 1995). Low consumptions of vegetables lead to problems of malnutritional diseases, such as iron deficiency anaemia and xerophthalmia, a vitamin A deficiency ailment that often leads to blindness. Each year about 30,000 children become blind in Bangladesh due to vitamin A deficiency (Anonymous 1985). Under these circumstances, people should take increased quantity of vegetables, and thereby the problem of nutrition can also be solved to some extent. So, more vegetable production and consumption are very important for good public health.

The production of vegetables plays a major role in the agriculture of Bangladesh and more than 40 different kinds of vegetables are grown here. Countless farmers and others could improve both their diet and economic position by growing more vegetables. Besides local demand, there is a good scope of exporting vegetables to the Middle East, U.K. and some other European countries, if quality vegetables of high demand can be produced and regular supply is assured. Bangladesh earned Taka 2.953 crore by exporting 920 tons of vegetables in 1981-82 whereas in 1996-97 the export figure increased to 4.577

tons having value of Taka 18.675 crore (BBS 1997). In our country, vegetables are grown in 1.08% of the total cultivable land. The annual production of vegetables was 1.78 million metric tons from 220,120 acres of land as against a total requirement of 8.2 million metric tons (Chadha *et al.* 1994). Our vegetable production is not evenly distributed throughout the year. Of the total vegetable production, about 30% is produced during *kharif* season and almost 70% in the *rabi* season (Chadha *et al.* 1994). Therefore, in addition to continuing the efforts to increase vegetable production in *rabi* season, scientific attention must be given in improving *kharif* vegetables.

Lady's finger (*Abelmoschus esculentus* [L.] Moench), commonly known as *dherash* in Bangladesh, is a popular annual vegetable crop. It can be grown round-the-year, though summer is considered to be the best season. So, it is a vegetable of *kharif* season. It is also an important vegetable crop in many parts of the world and it originated somewhere in Africa, most probably in western part, in and around Nigeria or in Asia, perhaps in both.

In our country during 1992-1993 season, the yield of lady's finger in an area of 10,630 acre (4,305.15 hectare) was 13 thousand metric tons and in 1996-97 season, in an area of 13,000 acre (5265 hectare) yielded 17 thousand metric tons of lady's finger (BBS 1998). This is a clear case of increase in yield. But the increase is not significant compared to other developed countries; because our production is about 3.23 metric tons per hectare (BBS 1998). In many developed countries the yield has been reported to be within the range of 7.54 to 12.57 metric ton per hectare.

Lady's finger belongs to the family *Malvaceae* and is an octaploid in nature, where $X=9$ and is propagated by seeds. Hairy mucilaginous fruits are up to

15-25 cm long. Fruits are picked when very tender lest they get hardened and fibrous. It is known as *dherash* in Bangladesh, *bhindi dherash* or *bendakai* in India, *youpadi* in Myanmar, *kachang burdi* in Malaysia, *kachieb* in Thailand, *chan ke* in China, *okra* in the United States of America and *lady's finger* in the United Kingdom (Chadha *et al.* 1993).

It is widely grown in the tropical regions. In Bangladesh, it is grown as home-garden crop and also as field crop. Many local and foreign varieties are grown. Varieties named *shawni*, *parbani*, *kanti*, *BARI dherash* are mostly cultivated here and the country is in the look out for virus-resistant varieties. Bangladesh Agricultural Research Institute (BARI) developed a new virus-resistant variety of lady's finger named, *BARI dherash-I* in 1992-93.

Lady's finger is a delicious vegetable crop. The young tender pods are cooked in curries, stewed, cooked into soups and also canned and dried. It is a good source of vitamin A and B, and also contain vitamin C. It is rich in protein, minerals and iodine.

The average content of lady's finger out of 100 g is as follows: 89.6 g moisture, 35 kcal energy, 1.9 g protein, 1.2 g fibre, 66 mg calcium, 1.5 mg iron, 52 μg carotene, 0.07 mg thiamin, 0.10 mg riboflavin, 0.8 mg niacin and 13 mg vitamin C, 6.4 g carbohydrate, 56 mg phosphorus, 0.2 g fat, and 0.2 g minerals (Gopalan 1978).

Lady's finger is also a good source of dietary fibre. Analysis of fibre gave the value: 81.89% cellulose and 16.98% lignin (CSIR 1959). This type of vegetable prevents constipation and plays an important role in naturalizing the acid substances produced in the course of digestion of meats, cheese and other foods. The cellulose of this vegetable plays a role in preventing colon cancer by

diluting out potential carcinogenous substances and speeding their transit through the colon. In addition to their bulk enhancing properties, they absorb organic substances, such as cholesterol and appear to play a role in the cholesterol-lowering effects of fibre (Devlin and Witham 1997). Besides, stalk of lady's finger yields fibre with potential for commercial exploitation. After fruiting, the stalks are generally allowed to go waste or are used as fuel.

Bangladesh now suffers from serious over-population. The present growth rate of population is about 2.17% and the economy of our country depends heavily on agriculture. Quantity of land per head is 0.22 acre and there is no more scope for expansion of the cultivable land area. So, to improve our economic condition, the only way is to increase crop production per unit area. It is thus essential to promote crop production per unit area of land.

To increase crop production per unit area of land, several ways are followed, like selection of high-yielding crop, resistance to pest, fungal, bacterial and viral diseases, resistance to lodging; proper use of fertilizers, use of herbicides, and other modern improved agronomic practices, including use of growth regulators.

Plant growth regulators, other than nutrients, are usually organic compounds. They are either natural or synthetic compounds and are applied directly to a plant to alter its life process or structure in some beneficial ways, so as to enhance yield, improve quality or facilitate harvesting. From the time of Darwin (1881), plant physiologists from different countries have worked on the effect of growth regulators on different physiological activities and biochemical contents in plants. In 1930s, a number of growth regulators were applied in horticulture towards increasing yield of field crops and horticultural plants. Recently, the use of growth regulators has gained much popularity in increasing yield and nutritive value of certain crops (Sing and Sharma 1979).

Quite a number of reports indicate that judicial use of a number of growth regulating chemicals in suitable concentration stimulate growth, development and yield of a number of economically important plants including vegetable crops. It has also been used on field crops, growing on hundreds of hectare of land, and in most cases significant increase in yields have been attained (Asadov 1965).

Among the growth regulating chemicals, auxins, gibberellins, tri-iodobenzoic acid (TIBA), maleic hydrazide (MH), cycocel (CCC), naphthalene acetic acid (NAA), ethapon and mixtalol, salts of naphthenic acid, etc. are well known for their marked influence on growth and development of plants (Cherry *et al.* 1960, Fattah 1969).

A number of these growth regulating chemicals are important in controlling various problems like lodging in cereals, checking excessive vegetative growth, reducing abscission of flower and immature pods. Plant growth regulators are capable of altering various physiological and biochemical functions of plants (Salisbury and Ross 1986).

The investigators at the Plant Physiology Laboratory of the Department of Botany, University of Dhaka, have been exploring possibilities of increasing yield of a number of crops, including vegetables, through the application of several growth regulators since 1970.

The naphthenic acid is one of the important plant growth regulators. It is an inexpensive synthetic organic acid of petroleum origin and its salts of sodium, potassium, copper, cobalt, manganese and nickel have been used for increasing yield and nutritive value, and it has been found to be a growth promoter in appropriate doses. In Bangladesh, experiments have been carried out on the effect of potassium naphthenates (KNap) on a number of plants of economic

importance (Fattah and Roy 1972, Fattah and Khatun 1974, Fattah and Karmoker 1975, Bano 1978, Fattah and Pasha 1978, Fattah *et al.* 1977, 1978, 1979, Hoque 1980, Uddin *et al.* 1986, Rashid *et al.* 1989, Jahan *et al.* 1991, Mondal *et al.* 1996, Jahan *et al.* 1997, Rashid 1997, Habib 1997). Extensive works on the effect of naphthenates on different crops in different parts of the world have also been carried out (Ladygina 1965, Alizade and Guseinov 1965, Bazanova and Akopova 1966, Fattah and Wort 1970a, 1970b, Wort and Patel 1970).

A number of compounds having the property of reducing growth in higher plants are known and two of them are abscisic acid (ABA) and 2,3,5-tri-iodobenzoic acid (TIBA).

The most common response due to TIBA is reduction of growth and yield (Zimmerman 1943). However, in a number of cases low concentrations of TIBA have been found to increase yield of a few crops (Thiman and Bonner 1948). Among the wide range of chemicals that have been used, TIBA has proved its potentiality for commercialization. Works on the effect of TIBA on crops have been carried out (Sebanek 1953, Greenhalgh 1965, Greer 1965, Bastidas and Buitrago 1972, Clapp 1973, Tanner and Ahmed 1974, Hussain 1976, Sultana 1976, Chung and Kim 1989, Deotale *et al.* 1995, Kuno 1996, Rahman *et al.* 1992, Rahman and Rahman 1997).

Abscisic acid (ABA) has been found to play an important role in plant during water stress and during drought conditions. The effect of exogenously applied ABA on growth development and yield have been carried out by Chakhatrakan *et al.* (1994), Matsui *et al.* (1994), Kamal *et al.* (1995) and Takahashi *et al.* (1996).

Yet, the information available about the effects of plant growth regulators on the performance of the vegetable crop, lady's finger, still require more facts and figures for an effective practical use in field. Besides KNap, TIBA and ABA, effect of a number of other growth regulator's on lady's finger is known, viz. cycocel (Meherotra *et al.* 1970, Shukla and Tewari 1973, Jasa *et al.* 1975, Chhonkar *et al.* 1977, Tosh *et al.* 1978, El Beheidi 1980, Gowda and Gowda 1983, Zayed *et al.* 1985, Rahman *et al.* 1994); gibberellic acid (Roy *et al.* 1960, Srivastava and Sing 1968, Nandpuri *et al.* 1969, Pawar *et al.* 1977, Sing *et al.* 1977, Maurya *et al.* 1987); IAA (Srivastava and Sing 1968, Nandpuri *et al.* 1969), IBA (Rahman *et al.* 1994); 2,4-D (Nandpuri *et al.* 1969); ethereal (Chhonkar *et al.* 1977); maleic hydrazide (Tosh *et al.* 1978) and benzimidazole (Tosh *et al.* 1978).

Therefore, the main objective of the present investigation was to study the effect of foliar application of potassium naphthenate (KNap), 2,3,5-tri-iodobenzoic acid (TIBA) and abscisic acid (ABA) on some physiological parameters, yield, and yield attributing characters, and also on some biochemical parameters of lady's finger.

During the present investigation, in the first set of experiment, different concentrations of potassium naphthenate (KNap), tri-iodobenzoic acid (TIBA) and abscisic acid were applied as foliar spray. Among the growth regulators, 50 ppm TIBA performed best in respect of yield and in most of the other parameters which were investigated. On the basis of the first year's results, only TIBA was used in the second year and six concentrations of the growth regulator were applied as foliar spray and the results obtained have been discussed in the light of available literature.

LITERATURE REVIEW

2. LITERATURE REVIEW

Growth is a vital process which brings about a permanent change in any plant or its part in respect of its size, form, weight and volume; and yield, is a complex heritable character influenced by many morphological and physiological characteristics of the plant interacting with environment.

Growth and yield are affected by many factors like food supply, water supply, oxygen supply, temperature, light and hormones. Within the last few years, it has been well-established that growth and yield of plants are controlled by certain endogenous organic compounds, phytohormones, present in exceedingly minute quantity. Phytohormones have been implicated in the growth and development of stems, roots, leaves; formation of branches and adventitious, roots; tubers, flowers and in fruit development and maturation; senescence, dormancy and germination of seeds (Salisbury and Ross 1986).

Hormone is a Greek word derived from *hormo*, which means to urge on or to stimulate. Thiman and Bonner (1948) suggested to use the term phytohormone for hormones of plants.

The presence of hormones first suggested by Julius Sachs (Gardner *et al.*, 1985) in the later half of the 19th century when he proposed that there were "organ-forming substances" in plants. Went (1937) developed a method using *Avena coleoptiles* for determining the amount of active substances in coleoptile tips and this became *Avena curvature* test. Actual proof of the material nature of the hormones was demonstrated by Boysen-Jensen (1910, 1911, 1913) in experiments with coleoptiles through which he explained some substances, which originated in the tip, was responsible for the bending of the coleoptiles towards the light. According to Thiman and Bonner (1948), phytohormones are organic

substances which are naturally produced in plants, control physiological functions at a site remote from its place of production and active in extremely minute quantities.

The term plant growth regulators (PGR), however, is applied to phytohormones as well as to synthetic compounds (Nickell 1978). Growth regulating substances may be classified into following categories:

1) Auxins, e.g. indole acetic acid (IAA), IBA, NAA, 2,4-D, etc.
2) Gibberellins, e.g. gibberellic acid GA_1, GA_2, GA_3, GA_4, GA_7 .... GA_{83}
3) Cytokinins, e.g. kinetin, zeatin, etc.
4) Ethylene
5) Dormins, e.g. abscisic acid (ABA), phasic acid, xanthoxin, etc.
6) 'Flowering hormones', e.g. florigen, anthesin, vernalin
7) Phenolic substances, e.g. coumarin
8) Synthetic growth retardants, e.g. CCC, AMO 1618, phosphon D, morphactins, malformins
9) Miscellaneous synthetic substances, e.g. synthetic auxins, synthetic cytokinins, etc.

The exact mechanism of the PGR action is yet to be work out, but it is known that plant growth regulators can regulate the process of growth, development and yield in many plants when applied exogeneously.

Regulation of the following plant processes by using PGRs is relatively a new area with immense potential for crop improvement:

1) Regulation of vital plant process:

   Photosynthesis,

   Respiration,

   Photrespiration (in C_3 plants),

2) Stomatal regulation,

3) Seed viability,

4) Leaf area development and maintenance,

5) Flowering synchrony, regulation of flowering of perennial fruit crop,

6) Ripening and improving the quality in fruit crop,

7) Post-harvest deterioration.

In most cases growth regulators have been applied on crops to study its physiological parameters like plant height, fresh weight and dry weight of plant, leaf number, leaf area, yield and yield attributing characters, etc., and biochemical parameters like leaf pigment, total sugar, oil content, protein, vitamins, etc.

The literature cited in this review is related to effect of three growth regulators: KNap, TIBA and ABA, on lady's finger and on different crops and also the effect of other growth regulators on lady's finger.

2.1. Potassium naphthenate (KNap)

The use of naphthenic acetic acid, an organic compound of petroleum origin, and its salts as plant growth stimulators have been utilized primarily by Russian and Bulgarian workers (Huseinov 1960, Zhukova 1965, Popoff and Boikov 1966) and later on by a few others (Wort 1969, Fattah and Wort 1970a, 1970b).

The name naphthenic acid was first suggested in 1883 by Markovnikoff and Oglobin for acids of unknown structure which Hell and Medinger (1974) had discovered from Rumanian oil.

Currently the term is used to denote the carboxylic acids occurring in and recovered from petroleum.

While the structure of higher molecular weight naphthenic acid is yet to be determined, it is known that the acids may be carboxylic derivatives of cyclopentane, cyclohexane and cycloheptane. The average molecular weight of the mixtures usually lies in the range of 205-330.

Naphthenic acids are soluble in all proportions in hydrocarbons and lower members have slight solubility in water.

Its salts of sodium, potassium, copper, cobalt, manganese and nickel have been used for increasing yield, growth and development, using appropriate doses (Wort 1969).

The literature cited in this review is related to the effects of naphthenic compounds on growth, development, yield and chemical compounds of plants.

2.1.1. Effect of KNap on plant height

Egiyani (1963) reported that in corn, height was favourably affected following naphthenate application. Yur'eva (1965) observed that naphthenates favourably affected the growth of maize plants. Eyabov and Issaeva (1966) obtained the best results for growth by spraying maize with 0.005% naphthenates.

Alizade and Guseinov (1965) obtained increase in height by application of 50 and 100 ppm naphthenate in egg plants.

Pasha (1971) found increase in height of IR8 variety of *Oryza sativa* following naphthenate application.

Fattah *et al.* (1976) reported that application of 1000 and 2000 ppm potassium naphthenate on tobacco increased plant height by 14.3 and 3.4% respectively.

Hoque (1980) found that following 1000 ppm KNap treatment height of mustard plants increased significantly. Mondal *et al.* (1996) reported that application of 1000 ppm KNap increased plant height of rapeseed.

Fattah *et al.* (1982) reported that single and combined foliar spray of 500 and 1000 ppm KNap on Italian millet influenced plant height.

Rashid *et al.* (1989) reported that following 2500 and 5000 ppm and combined 5000 + 2500 ppm KNap on sunflower plant height increased over the control.

Salam (1981) reported that foliar application of KNap increased height of lady's finger plants. Begum *et al.* (1992) reported that following application of 2500 and 5000 ppm KNap on lady's finger, plant height increased over the control.

2.1.2. Effect of KNap on days to first flowering

Roy (1972) and Khatun (1973) reported that in corn silk and tassel appeared early following treatments by potassium naphthenate.

Begum *et al.* (1992) reported that 2500 and 5000 ppm of KNap application on lady's finger had no effect on initiation of flowering.

2.1.3. Effect of KNap on number of fruits per plant

Fattah and Roy (1972) observed that number of maize grain increased by 14% following single spray of 100 ppm KNap treatment. Khan and Fattah (1976) reported that number of grains per plant of maize increased nonsignificantly when 30 ppm and 10 ppm KNap + NPK were applied.

Fattah and Karmoker (1975) reported that foliar application of three concentrations (1000, 2500 and 4000 ppm) of KNap on *Sesamun indicum* caused a significant increase in fruit number per plant by 13.89% following 1000 KNap application, but 2500 and 4000 KNap nonsignificantly decreased fruit numbers.

Fattah *et al.* (1975) reported that when 10 and 100 ppm KNap were applied in two varieties of mustard then number of siliqua per plant increased significantly

by 73.31 and 38.75% respectively in Tori-7. But in Rai-5 there was nonsignificant increase following 10 ppm and significant increase following 100 ppm KNap application.

Khan (1973) reported an increase in pod number of soybean by 22.52 and 21.77% following application of 3500 and 4000 KNap respectively.

Rashid *et al.* (1989) reported that number of seeds per plant significantly increased due to 2500, 5000 and 2500 + 5000 ppm KNap treatments as foliar spray on sunflower.

Jahan *et al.* (1991) reported that foliar treatment on lady's finger with 2000 ppm KNap increased fruit number by 14.59% over the control but 4000 and 2000 + 1000 KNap treatments resulted in decrease in fruit number by 4.30 and 11.13%. Begum *et al.* (1992) reported that a significant increase in number of fruits per plant was observed in lady's finger due to 2500 and 5000 ppm KNap application.

2.1.4. Effect of KNap on length of fruit

Jahan *et al.* (1991) reported that fruit length of lady's finger increased due to different KNap concentrations.

2.1.5. Effect of KNap on weight of fruit

Fattah and Sadeque (1979) reported that average fresh fruit weight increased significantly following treatment with 2000 ppm KNap in tomato plants.

Uddin *et al.* (1986) found that average weight of fresh fruit increased following 0.1% KNap treatment on snake gourd.

Begum *et al.* (1992) reported that application of 2500 and 5000 ppm KNap treatments showed increase in weight of fruit.

2.1.6. Effect of KNap on fruit yield

Huseinov (1960) reported 28% increase in the yield of rice following the application of 0.05% KNap. Pasha (1971) had shown that at low concentration (0.001%) KNap has stimulatory effect on IR8 variety of rice. Fattah *et al.* (1975) reported that 32.56, 31.46 and 8.02% increase of yield of IR8 variety of rice were obtained due to soak + foliar spray, soak and double spray of KNap respectively.

Yur'eva (1965) also found that application of naphthenates favourably affected the grain yield of maize. Fattah and Roy (1972) observed that weight of maize grain increased by 15% following single spray of 100 ppm KNap. Khan and Fattah (1976) reported that weight of grains per plant of maize increased significantly when 30 ppm KNap and 10 ppm KNap + NPK were applied.

Shakizade (1963) reported that the winter wheat increased by 30% following treatments with naphthenates. Popoff and Boikov (1966) reported that the yield of winter rye increased by 10% following naphthenate treatment.

Wort (1969) and Fatth and Wort (1970a, b) reported that yield increased due to KNap treatments on bush bean.

Khan (1973) reported an increase in seed weight by 39.75 and 13.63% following application of 3500 and 4000 ppm of KNap on soybean respectively.

Fattah and Karmoker (1975) reported that foliar application of three concentrations (1000, 2500 and 4000 ppm) of KNap on *Sesamum indicum* caused a significant increase with 1000 KNap in the weight of seeds by 34.38% but 2500 and 4000 ppm KNap showed nonsignificant decrease over the control.

Huseinov (1960) obtained increase in the yield of tobacco by 12-13% following naphthenate application. Fattah *et al.* (1976) found that KNap treatment on two

varieties of tobacco increased dry weight of leaves by 21.76 and 59.84% due to 1000 and 2000 ppm respectively in "Harrison's special" but in "FCV special" the dry weight of leaves decreased due to 2000 ppm KNap treatment.

Krasanova *et al.* (1965) obtained increase in yield of potato tuber by 9 to 48% using different concentrations of naphthenates.

Zhukova (1965) observed that the yield of carrot, cabbage, beat and onion increased by 5 to 10% when the seeds were treated with naphthenates along with organomineral fertilizers.

Marshaniya *et al.* (1965) found that following application of 0.05% naphthenates on tangerine plants yield increased by 18.6-21.2% and also increased weight of fruit.

Guseinov *et al.* (1956) used naphthenates along with normal fertilizers which resulted in increase up to 1.38% in the fruit yield of tomato. Huseinov (1960) used 0.005% naphthenates and as a result of which fruit yield of tomato plants increased by 40-50%. Aliev *et al.* (1965) reported that 0.05% naphthenates increased the fruit yield of tomato by 30-37%. Szekely and Gleria (1966) reported that seed treatment with naphthenates and naphthenates in combination of trace elements increased the yield of tomato fruit.

Shahabuddin *et al.* (1986) found that 0.1% KNap significantly increased the yield of fruit of snakegourd.

Rashid *et al.* (1989) reported that seed weight per plant significantly increased due to 5000 and 5000 + 2500 ppm KNap as foliar spray treatment on sunflower.

Jahan *et al.* (1991) reported that foliar spray on lady's finger with 2000, 4000 and 2000 + 1000 ppm of KNap increased the weight of fruits due to all the treatments.

Begum *et al.* (1992) reported that 2500 and 5000 ppm of KNap treatments on lady's finger increased weight of fruit per plant.

Mondal and Fattah (1996) observed that yield of rapeseed variety 'dhali' increased by 12.5% over the control by 1000 ppm KNap treatment. But 5000 ppm KNap failed to show any significant increase. Rashid (1997) observed that the yield of mustard variety 'daulat' increased by 16.07% due to 1000 ppm KNap treatment. Habib (1997) reported that seed yield of niger increased by 29.2% due to 1000 ppm KNap treatment.

2.1.7. Effect of KNap on chlorophyll content of leaves of crop plants

Chu (1969) noticed that chl-a and chl-b increased to small extent but the carotenoid pigments increased more in tomato leaves when plants were treated with potassium naphthenate solution.

Fattah and Wort (1970a) found that naphthenate treatment increased the leaf pigments of bush bean plants at different stages of plant growth.

Lilov (1970) found that foliar spray of 10 ppm naphthenates increased the photosynthetic pigments in vines.

Pasha (1971) reported more pigment in the leaves of IR8 variety of rice plants treated with 10 ppm KNap.

Roy (1972) found an increase in pigment content of maize var J-1 leaves following KNap application.

Khatun (1973) found that pigment content increased in the leaves of maize variety Ganga-5 following KNap application.

Khatun (1977) reported that soaking seeds with 10 ppm solution prior to sowing and subsequent foliar spray of 1000 ppm resulted in 24% increase in the total chlorophyll content of BR-3 rice plants.

Fattah *et al.* (1978) reported that due to KNap application on IR-8 rice as seed soaking and foliar spray chlorophyll 'a' increased nonsignificantly and chlorophyll 'b' decreased significantly and carotenoid increased significantly at different stages of plant growth.

Hossain and Fattah (1987) reported that foliar application of different concentration (1000, 2500, 4000 ppm) of KNap on sweet potato significantly increased chlorophyll content at different growth stages of growth of plants.

Jahan *et al.* (1991) observed that in lady's finger both chlorophyll a and b contents were highest due to application of 4000 ppm KNap followed by 2000 + 1000 ppm KNap, and the increase was significant.

Rashid (1997) reported that in mustard, chlorophyll a increased nonsignificantly by 45.83% but chlorophyll b increased significantly by 63.77% over the control at the age of 68 DAE due to 1000 ppm KNap treatment.

Habib (1997) reported that chlorophyll a increased significantly following 1000 ppm KNap treatment at 48, 58 and 68 DAE. On the other hand, chlorophyll b increased nonsignificantly following the same treatment at 48 and 58 DAE but significantly at 68 DAE.

2.2. Tri-iodobenzoic acid (TIBA)

Tri-iodobenzoic acid was first discovered by Zimmerman in 1943. Benzoic acid is physiologically inactive until substituted with a halogen or nitro group and these have been found to be very effective as plant growth substances. TIBA

treatment results in the appearance of modified leaf size, shape, pattern, texture and venation

In order to account for hyponosty and respiratory effects induced by TIBA, it was said that it could act as an auxin synergist and perhaps also as an auxin antagonists under different conditions (Bohlen and Applegate 1962).

In low non-inhibiting concentration 0.1 mg/l) it considerably increased the effectiveness of IAA in *Avena curvature* test (Thiman and Bonner 1948).

TIBA is one of the first growth regulator accepted for commercialization for use on a major field crop soybean in the USA (Santanna *et al.* 1970).

Since then, TIBA has been used as a growth promoter at low concentration to obtain higher fruit and seed yield.

2.2.1. Effect of TIBA on plant height

Clapp (1973) reported that the plant height of soybean was reduced by 13.3% when TIBA was applied on the four or six trifoliate leaf stage.

Hussain (1976) found a decrease of the height of soybean plants (cv. Lee-14) due to TIBA application.

Sultana (1976) reported that the height of bush bean cv. Contender decreased by 4.97 and 26.78% following 10 and 50 ppm TIBA treatments respectively.

Chowdhury *et al.* (1978) reported a decrease in the height of TK5 and EC-39752 varieties of soybean following TIBA application.

Begum *et al.* (1992) reported that foliar spray of TIBA (50 mg/l) significantly increased the plant height of lady's finger.

Deotale *et al.* (1995) reported that foliar application of 50-250 ppm TIBA on soybean decreased the plant height.

2.2.2. Effect of TIBA on days to first flowering

Sebanek (1954) reported that application of TIBA solution hastened flowering and also accelerated the ripening of grain by 7-12 days in 'spring' wheat.

Greenhalgh (1965) reported that flowering hastened following TIBA treatments and it also gave earlier fruit setting on soybean.

Greer (1965) found that TIBA treatment hastened flowering of soybean plants.

Begum *et al.* (1992) reported that foliar spray of TIBA 100 mg/l on lady's finger had inhibitory effect but 50 mg/l had no effect on the initiation of flowering.

2.2.3. Effect of TIBA on number of fruits per plant

Hartzook and Goldin (1970) reported that in three cultivars of peanut, viz. "Virginia bunch" improved, and "Spanish" and "Valencia" average number of pods were reduced following TIBA application.

Fattah and Khan (1977) reported that foliar spray of three different concentrations (25, 50 and 100 ppm) of TIBA on the five varieties of soybean at two stages of growth, second trifoliate leaf stage and 5-6th trifoliate leaf stage influenced the number of fruits per plant. They found that at 2nd trifoliate leaf stage, the maximum increase was 75.54% in the number of pods per plant following 25 ppm and treatments at the 5-6th trifoliate leaves, the number of pods increased by 55.69% following 25 ppm TIBA treatment.

Chowdhury *et al.* (1978) reported that foliar application of TIBA at 50 mg/l to the soybean, the maximum increase in the number of pods per plant was 67.1%.

Grewal (1980) observed significant increase in number of groundnut per plant by 11.60% with 25 ppm TIBA spray at flowering stage.

Chung and Kim (1989) observed that number of pods per plant increased due to TIBA application on soybean.

Zappi and Quintana (1990) recorded that number of fruit per plant increased due to TIBA application in dry bean.

Ravichandran and Ramaswami (1993) reported that pods per plant increased in soybean due to 25, 50, 75 and 100 ppm TIBA application over the control and the highest was due to 500 ppm.

Begum *et al.* (1992) reported that foliar spray 50 mg/l TIBA significantly increased fruit number of lady's finger by 37.11%.

Rahman and Rahman (1997) reported that following TIBA application, fruit number increased on bottlegourd.

2.2.4. Effect of TIBA on length of fruit

Chowdhury and Babel (1969) observed the increase of length of fruits of bottlegourd due to TIBA application.

Suryanarayana and Raju (1983) reported that in bottlegourd and cucumber, fruit length increased due to TIBA application.

Rahman *et al.* (1992) found that TIBA increased fruit length in bottlegourd.

2.2.5. Effect of TIBA on weight of fruit

Begum *et al.* (1992) reported that following TIBA application, weight of fruit increased in lady's finger.

2.2.6. Effect of TIBA on fruit yield

Sebanek (1953) found 53% increase in the yield of tomato and 23% in potato by TIBA application.

Greenhalgh (1965) reported that fruit yield of delicious apple in the 'off year' showed a very significant increase on TIBA treated trees.

Greer (1965) reported that application of TIBA at 30 to 40 ppm resulted in a seed yield increase in soybean.

Hipp and Cowley (1969) observed that maximum yield was obtained in peas in 19 inches spacing between rows when plants were sprayed with 20 g of TIBA per acre.

Bastidas and Buitrago (1972) reported that following TIBA application, an increase in the yield of 'pelican' and a decrease in 'hill', two cultivars of soybean.

Clapp (1973) reported 7-9.8% increase in the yield of Bragg soybean following 30 mg/l TIBA application.

Freytag and Coleman (1973) reported that TIBA application in concentration ranging from 5.0-62.5 g/ha in multiple foliar spray increased the yield of cotton. Agarwal and Rao (1989) reported that in groundnut, maximum yield of 2970 kg/ha was observed compared to the control's 1989 kg/ha due to 100 ml TIBA applied at 10 DAE.

Tanner and Ahmed (1974) reported that increase in the yield of soybean plants receiving TIBA application.

Hussain (1976) also reported increased yield of soybean receiving TIBA application.

Fattah and Khan (1977) reported that the weight of seeds per plant of soybean due to 25 ppm foliar spray at 2nd trifoliate leaf stage, the maximum increase obtained was 53.84% and at the 5-6th trifoliate leaves, the weight of seeds increased by 61.79% following the same treatment.

Chowdhury *et al.* (1978) reported that foliar application of TIBA at 50 mg/l to the soybean in the variety Clark-63, the maximum increase of 70.2% in the weight of seeds per plant was obtained.

Ravichandran and Ramaswami (1993) reported that yield was increased by 50 ppm TIBA applied 42 days after sowing on soybeans cv. CO cultivars.

Deotale *et al.* (1995) reported that foliar application of 50 and 250 ppm TIBA on soybean increased seed yield and the highest seed yield was obtained due to 250 ppm TIBA.

2.2.7. Effect of TIBA on chlorophyll content of leaves of crop plants

Hussain (1976) reported that in soybean cv. Lee-74, 40 ppm TIBA decreased chl-a, chl-b and carotenoid content by 13.36, 17.26 and 44.41% respectively.

Kunokatsuji (1996) reported that by the foliar spray of TIBA on mulberry leaves, enhanced chlorophyll contents.

2.2.8. Effect of TIBA on ß-carotene content of fruit

No report could be found on this aspect.

2.2.9. Effect of TIBA on ascorbic acid content of fruit

Husain *et al.* (1979) reported that application of two concentrations of TIBA (10 and 50 ppm) and combination of 50 ppm TIBA + 2500 ppm KNap as foliar spray on tomato plant caused increase of ascorbic acid content of fresh fruit over

the control and the highest increase in ascorbic acid content was found in plants treated with 10 ppm TIBA and it was 17.6%. The other increases were 10.3% and 4.2% following 50 ppm TIBA and 50 ppm TIBA + 2500 ppm KNap treatments respectively.

2.2.10. Effect of TIBA on protein content of fruit

Sultana (1976) reported that protein content of seeds increased by 39.86% due to the application of 50 ppm TIBA solution on bush bean plants.

Hussain (1976) found that following 40 ppm TIBA treatment, protein content of seeds of soybean varieties cv. Lee-74 and 'improved pelican' increased by 3.6 and 14.01% respectively.

Chowdhury *et al.* (1978) reported that in soybean cultivar cv. TK-5, there was negligible change in the protein content of seeds following TIBA treatment.

Khan (1981) reported that protein content of seeds increased due to 50 ppm TIBA by 6.15% and 5% in two varieties of soybean cv 'davis' and 'improved pelican' respectively.

2.3. Abscisic acid (ABA)

ABA is s sesquiterpenoid composed of three isoprene units. In addition, the carbon skeleton of the molecule bears a close resemblance to the terminal rings of the carotenoids. ABA has been found to play an important role in plant during water stress and during drought conditions.

2.3.1. Effect of ABA on plant height

Matsui *et al.* (1994) reported that treated *Allium cepa* plants with ABA in late winter grew more slowly than untreated ones for one month after treatment. This was followed by sharp increases in plant height.

2.3.2. Effect of ABA on number of fruits

Takahashi *et al.* (1996) reported that when soybean cv. Tachinaga plants were sprayed with 0-100 ppm ABA, then foliar application of 1 and 100 ppm ABA increased filled pod number.

2.3.3. Effect of ABA on yield

Matsui *et al.* (1994) reported that final bulb yields were lower for ABA treated plants than untreated plants in onion.

Chakhatrakan *et al.* (1994) reported that 1000 ppm ABA on *Amaranthus* spp. increased plant weight and seed yield.

Kamal *et al.* (1995) reported that application of 1 ppm ABA at flowering stages on soybean increased yield by 12.1% over the control.

Takahashi *et al.* (1996) reported that foliar application of 1 and 10 ppm ABA on soybean increased yield but 100 ppm ABA tended to inhibit seed yield.

2.4. Effect of other growth regulators on lady's finger

Rao *et al.* (1960) reported that GA was effective over a wide range of concentrations in inducing parthenocarpic fruit set in okra. They also observed that at higher concentrations of GA, possibility of getting seedless fruits without much reduction in size of the okra fruits were present.

Srivastava and Singh (1968) studied the effects of 3 concentrations of 3 different growth promoting substances applied as soaking the lady's finger seeds for 6 hours. All 3 substances improved germination and increased the number, weight, length, diameter and yield of pods. The best germination and pod yield were obtained with GA of 10 ppm. It was concluded that yields were

considerably increased by presowing seed soaking treatment with 10 ppm GA or IAA or with 50 ppm B-NOA treatment.

Nandpuri *et al.* (1969) observed the effects of GA, IAA, BAA and 2,4-D on lady's finger. Germination was increased by soaking the seeds for 8 hours in 1 ppm of each of these compounds. GA treatment was significantly superior to the others. GA at 100 and 200 ppm was superior in increasing the growth of the plants than other treatments. Application of GA at 100 and 200 ppm also increased the total growth of plants. GA at 10 ppm was the only treatment that produced a significant increase in flower formation, whereas all the chemicals except 2,4-D at 10 ppm increased the number of fruit set but not significantly, GA at 200 ppm was significantly superior in increasing the length of fruits and GA at 10 ppm increased the yield.

Shukla and Tewari (1973) sprayed lady's finger plants with 1000 and 5000 ppm CCC. The first spray was given when seedlings had only one fully expanded leaf and two cotyledons and the second spray was given a week before anthesis. They reported that CCC at 1000 and 5000 ppm reduced shoot weight by 30 and 45% respectively, but increased the length of fruits significantly with a concomitant increase in fresh weight. An increase in the concentration of the growth retardants increased the fruit growth. The maturity of treated fruits (as judged by colour, taste and texture) was delayed by about a week when compared with control setup.

Jasa *et al.* (1975) studied the effects of soil moisture, day length and CCC application on lady's finger growth. CCC at 0.5% reduced plant height by about 8%, the reduction was more than 50% in long days (16th) and low or medium levels of soil moisture (50 or 70% capacity) produced the highest net assimilation rate (NAR) and leaf chlorophyll content.

Chhonkar *et al.* (1977) applied etheral at the rate of 100-800 ppm and CCC at the rate of 125-1000 ppm on lady's finger cv. Pusa Sawani and reported that although the control plants were the tallest, they yielded 82.06 kg/ha as against 129.87 kg/ha produced in plants treated with etheral at the rate of 200 ppm. They further noted that the plants receiving the lowest rate of CCC yielded the most (118.13 kg/ha).

Pawar *et al.* (1977) soaked the seeds of lady's finger cv. Pusa Saona in GA or IAA solutions, each at 25-100 ppm. They observed that seed germination, plant growth and yields were increased by both the growth regulators (more by GA), particularly at 25-50 ppm.

Tosh *et al.* (1979) observed that when the lady's finger plants cv. Pusa Sawani (at seedlings, flowering and fruiting stages) were sprayed with MH at 200 or 500 ppm, CCC or benzimidazole fungicide (not specified), each at 500 ppm for 10 consecutive days, plant height was increased by all treatments except CCC and application at different stages of development had little differences in growth and production. Fruit numbers per plant, average fruit size and total yield/m were enhanced by these treatments. The highest yield was obtained with the benzimidazole fungicide or MH each at 500 ppm applied at the fruiting stage; moreover, the time to maturity was advanced from 14 to 9, and 8 days respectively by MH and benzimidazole treatments and CC treatment delayed fruit maturity by 4 or 5 days only.

El Beheidi (1980) reported that in a 2-year trial with lady's finger cv. Balady, average field emergence was highest (71.5%) from seeds soaked for 24 hours in an aqueous solution containing 250 ppm CCC plus 100 ppm proline. The total yield was highest (3.37-5.55 kg/plant) in plants from seeds treated with CCC plus either proline or sucrose. In control, the yield was 2.4-4.15 kg/plant.

Suryanarayana and Rao (1981) observed that the application of GA or NAA at 50, 25, 200 and 1000 ppm respectively, alone or with 1% urea or 0.3% Agromin (containing Zn, Fe, Cu, Mn, Mg, B and Mo in chelated form) on okra cv. Pusa Sawani at 15 and again at 30 days after sowing gave high yield, i.e. 64 and 42 g/ha due to GA + Agromin and 64.22 g/ha due to NAA + Agromin respectively while the control plants produced 57.61 g/ha with same sowing.

Pandita *et al.* (1983) found that cytozyme, applied as a seed treatment at 5-10% and/or as a foliar spray at 0.75-1.25% increased the plant height, the number of branches per plant, number of pods per plant, length of pods and green pod yield of okra.

Gowda and Gowda (1983) performed an experiment with lady's finger plants growing in rows spaced at 40 or 60 cm and were treated with cycocel at 1000 or 1500 ppm after 20 or 40, or 20 and 40 days of sowing. Here, the cycocel application reduced the plant height, particularly when it was applied twice at higher concentrations. The yield was highest (over 61 q/ha) from plants spaced at 40 cm and treated once after 20 days of sowing.

Maurya *et al.* (1985) sowed lady's finger in March and applied urea at 0-3% or GA_3 at 0-100 ppm at 20 and again at 50 days after sowing. The highest yield (87.39 q/ha) was obtained from plants treated with 2% urea + 50 ppm GA_3. The control plants yielded 64.97 q/ha.

Zayed *et al.* (1985) reported that application of different concentrations (100, 250, 500, 750 mg/l) of PIX, terpol (at 500, 750, 1000 mg/l) or CCC (600, 1000 or 1500 mg/l) significantly decreased stem length while both number of branches and their length and leaf number per plant increased. Dry weight per plant tended to increase with increasing concentrations of both PIX and CCC and

decreased the number of days to flowering, while they increased both number of pods per plant and total yields. The opposite was found in case of terpol, especially at the highest concentration. The plastid pigments were increased in the leaves, chl-a and chl-b and carotenoids at all concentrations of PIX. A similar trend was observed in case of CCC with the exception of K content in the leaves which decreased compared to control. In the case of terpol, no clear effect was observed on the mineral component. Spraying of lady's finger plants with either PIX at 250 mg/l or CCC at 1000 mg/l was recommended to obtain the earliest and heaviest yield.

Rahman *et al.* (1994) reported that foliar spray of different concentration of cycocel (CCC), IBA and Gibberellic acid affect significantly on lady's finger. Plant height, length and weight of the fruits were reduced in all concentrations of CCC and IBA treatment, whereas these characteristics were positively influenced at all concentrations of GA_3 applications. More number of leaves and branches per plant were obtained with CCC treatment. CCC and GA_3 at 500 ppm and 20 ppm positively gave significantly higher number of fruits and yield per plant; but CCC at 1000 ppm decreased the fruit and yield per plant. CCC also increased, N, P, K, Mg and Fe contents, chlorophyll a, chlorophyll b content. IBA, CCC and GA_3 significantly increased vitamin C in lady's finger fruits. CCC and IBA decreased the percentage of reducing sugar but GA_3 produced the maximum of it. All the concentrations (except 50 ppm GA) increased the percentage of nonreducing sugar of lady's finger fruits but not significantly and IBA at 250 ppm followed by GA at 20 ppm produced the maximum contents of nonreducing sugar.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

Two separate experiments were conducted during the period from March to June, 1991-92. The first-year experiment was on "effect of KNap, TIBA and ABA on growth development and yield of lady's finger (*Abelmoschus esculentus* [L.] Moench)"; and because both TIBA 50 and 100 ppm gave higher yield and increased the yield significantly over the control, the second experiment was done on "effect of different concentrations of TIBA on growth, development yield and biochemical parameters of lady's finger".

3.1. Experiment 1:

Effect of KNap, TIBA and ABA on growth, development and yield of lady's finger (*Abelmoschus esculentus* [L.] Moench)

3.1.1. Experimental site

The experiment was conducted in the Botanical Garden of the Department of Botany, University of Dhaka, during the period from March to June, 1991. The biochemical analyses were carried out in the physiological laboratory of the Department of Botany, University of Dhaka, and Institute of Food Science and Technology (IFST) of Bangladesh Council of Scientific and Industrial Research (BCSIR).

3.1.2. Plant materials

Plant materials: Seeds of lady's finger plants (*A. esculentus* [L.] Moench) were used for this experiment. Seeds were collected from Professor Quazi Abdul Fattah, Department of Botany, University of Dhaka.

3.1.3. Growth regulators

Potassium naphthenate (KNap): Potassium salt of naphthenic acid was used as growth stimulator of plants. The salt of naphthenic acid of appropriate

concentrations have been found to promote the vegetative growth and yield, and also to affect physiological and biochemical activities of a number of plants. The concentrations used were 2500 and 5000 ppm.

Tri-iodo-benzoic acid (TIBA): TIBA normally has the property of reducing growth in higher plants. The most common response due to TIBA is reduction of growth and yield. However, in a number of cases certain low concentrations of TIBA have been found to increase yield of a few crops. The concentrations used during this investigation were 50 and 100 ppm.

Abscisic acid (ABA): Abscisic acid is a compound which reduces growth in higher plants. ABA has been found to play an important role in plant during water stress and drought condition. But reports on the effects of exogenously applied ABA on growth, development and yield of lady's finger are not well-known and also not well-understood. The concentrations used were 10^{-5} M and 10^{-6} M.

3.1.4. Methods

3.1.4.1. Land preparation

The nature of the field soil was sandy loam, and it was thoroughly tilled and left for 7 days for sun drying. Cowdung and chemical fertilizers were then well mixed with soil and the land was properly levelled.

3.1.4.2. Fertilizer application

To increase the soil fertility cowdung and chemical fertilizers were applied. Cowdung, urea, TSP and MP were applied at the rate of 8.8 MT, 78 kg, 68 kg and 68 kg per hectare, respectively. Half of the urea and full amount of cowdung, TSP and MP were applied during final land preparation and rest of the urea was applied as top dressing at vegetative stage on 25th day after sowing of seeds.

3.1.4.3. Sowing of seeds

Three seeds per hill were sown on 15th March 1991, directly in the field in rows. Distance between the rows, and plants in a row, were 50 cm and 60 cm respectively. The field was divided into 21 plots of equal size (1.8 m x 1.0 m). Each plot had 6 plants in 2 rows.

3.1.4.4. Cultural practices

Thinning was made on 15 days after sowing (DAS) and it was made in such a way that a healthy seedling of uniform size and vigour was allowed to grow per hill. Regular watering, mulching and weeding were made to ensure equal environmental condition throughout the field.

3.1.5. Treatments

There were seven treatments in the experiment as follows:

T_1 = Control (distilled water)

T_2 = 2500 ppm KNap as foliar application

T_3 = 5000 ppm KNap as foliar application

T_4 = 50 ppm TIBA as foliar application

T_5 = 100 ppm TIBA as foliar application

T_6 = 10^{-5} M ABA as foliar application

T_7 = 10^{-6} M ABA as foliar application

3.1.6. Experimental design and field treatment

Randomized complete block design (RCBD) was followed for the experiment with 3 replications. Treatments were assigned in plots randomly.

Treatment procedure: Single foliar spray treatment was made with 2500 and 5000 ppm of KNap, 50 and 100 ppm of TIBA and 10^{-5} M and 10^{-6} M ABA. Growth factors were applied on 31 days old plants, the age of plants was counted

from the day of sowing. Controlled plants were sprayed with distilled water. The spray was done in the morning on the 15th April 1991. During spraying, precautionary measures were taken to avoid crossing over of one chemical of any plot to other plots by using polyethylene sheet. All the plants of different plots were treated similarly for different cultural practices from sowing to harvest.

After-care: The field was watered regularly as per requirement and all other necessary inter-cultural operations, such as weeding, thinning, earthing up were done uniformly as per routine during the crop growth period.

3.1.7. Observations and data collection

To study the sequence of morphological and physiological changes, the following characters were studied at different stages of growth and development of plants. Data were collected from the plants of each treatment, such as height of plants, days to first flowering, number of harvested fruits, fresh weight of fruit and total yield per plant.

3.1.7.1. Physiological parameters

Height of the plants: Height of the plants were measured from the ground level (stem base) to the tip of the main axis. Measurements were made at an interval of 10 days from the age of 30 days and continued till 60 days.

Days to first flowering: Days to first flowering was recorded.

Number of harvested fruits: Fruits were harvested at an interval of 4 days from the time of fruitset.

Fresh weight of harvested fruits: Fresh weight of the fruits were taken immediately after harvest.

where,

C = Concentration in mg/g fresh weight

a = Chlorophyll a

b = Chlorophyll b

D = Optical density at wavelength indicated

V = Final volume of extract

W = Fresh weight of leaf material used

d = Length of lightpath in cm

The amount of carotenoids were determined by the equation of Von Wettstein (1957). The equation is as follows:

$$Cc = 4.695\ D_{440.5} - 0.268\ C\ (a + b)$$

where,

Cc = Concentration of carotenoid in mg/g fresh weight

3.1.7.3. Statistical analysis

The collected data were analyzed statistically to determine the degree of variation in the samples due to treatment effect. Analyses of variance were carried out and treatment means were compared by least significant difference (LSD) test (Steel and Torrie 1960).

3.2. Experiment 2:

Effect of different concentrations of TIBA on growth, development and biochemical parameters of lady's finger (*A. esculentus* [L.] Moench)

3.2.1. Experiment site

The experiment was conducted in the Botanical Garden of the Department of Botany, University of Dhaka, during the period from March to June 1992. The biochemical analyses were carried out in the Physiological Laboratory of the Department of Botany, University of Dhaka, and also in the Food Sciences Division of the BCSIR, Dhaka.

3.2.2. Plant materials

Seeds of lady's finger variety were used as mentioned in section 3.1.2.

3.2.3. Growth regulator

Six different concentrations of TIBA, 25, 50, 75, 100, 125 and 150 ppm, were used as foliar application.

3.2.4. Methods

3.2.4.1. Land preparation

Land preparation was similar as mentioned in section 3.1.4.1.

3.2.4.2. Fertilizer application

Fertilizer was applied as mentioned in section 3.1.4.2.

3.2.4.3. Sowing of seeds

Seeds were sown as per method as mentioned in section 3.1.4.3.

3.2.4.4. Cultural practices

Cultural practices, such as weeding, thinning, mulching and watering were done as per method as mentioned in section 3.1.4.4.

3.2.5. Treatments

The experiment consisted of seven treatments as follows:

T_1 = Control (distilled water)

T_2 = 25 ppm TIBA as foliar application

T_3 = 50 ppm TIBA as foliar application

T_4 = 75 ppm TIBA as foliar application

T_5 = 100 ppm TIBA as foliar application

T_6 = 125 ppm TIBA as foliar application

T_7 = 150 ppm TIBA as foliar application

3.2.6. Experimental design and field layout

As mentioned in section 3.1.6.

Treatment procedure: Single foliar spray was applied on 31 days old plants as per treatments. Controlled plants were sprayed with distilled water.

3.2.7. Observation and data collection

As mentioned in section 3.1.7.

3.2.7.1. Physiological parameters

Physiological parameters like height of plants, days to first flowering, number of fruits per plant and fresh weight of fruits were recorded. Yields per plant were calculated.

3.2.7.2. Biochemical parameters

3.2.7.2.1. Quantitative determination of leaf pigments

Chlorophyll a, b and carotenoid of leaves were determined at the age of 40 and 50 days following the methods as mentioned in section 3.1.7.2.1.

3.2.7.2.2. Quantitative analysis of moisture content of fruit

The moisture contents of fruits of lady's finger were determined by drying the fruit sample at 110-120°C until a constant weight of the fruit samples obtained. A certain amount of fruit was taken in a dry weighing crucible (the weight of the crucible was noted before) and it was kept at 110°C in a drying oven for 6 hours. After cooling in a desiccator for an hour, the crucible with sample was weighed. Drying and cooling process were continued until a constant weight was obtained. Moisture content was then determined using the following formula:

$$\% \text{ moisture content} = \frac{(W_1 - W_2) \times 100}{(W_1 - W)}$$

where,

W = Weight of the crucible

W_1 = Weight of the crucible and fruit

W_2 = Weight of the crucible and dried fruit

3.2.7.2.3. Quantitative determination of ascorbic acid content of fruits

Ascorbic acid contents of fruits were measured by visual titration procedure (Glick 1957).

Reagents

5% metaphosphoric acid solution.

Fifty gram stocks or pellets of H_3PO_4 was dissolved in approximately 900 ml of distilled water. Then it was made up to one litre with distilled water. Metaphosphoric acid underwent hydrolysis in aqueous solution and formed H_3PO_4. Hence, the solution was stored in a refrigerator. Therefore, 100 ml distilled water contained 5 g metaphosphoric acid.

Ascorbic acid standard solution: 50 mg of highest purity ascorbic acid was dissolved in 50 ml of 5% metaphosphoric solution and was taken into a 250 ml volumetric flask, and the volume was made up to the flask with 5% HPO_3. Then 1 ml of this solution contained 0.2 mg of ascorbic acid. It was freshly prepared immediately before use for standardization of the indophenol reagent.

0.025% 2,6-dichlorophenol indophenol reagent: 50 mg of Na, 2,6-dichlorophenol indophenol (Eastman Organic Chemicals Dept., Rochester, NY) was placed in a beaker. After adding 150 ml distilled water, it was warmed gently until dissolved and added 42 mg of $NaHPO_3$. Then after cooling, it was taken into a 200 ml volumetric flask and was made up to volume with distilled water.

Standardization of the dye: The dye was standardized daily as follows: 5 ml of standard ascorbic acid solution containing 0.2 mg/ml was placed in a white beaker and placed over white paper and was titrated with 2,6-dichlorophenol indophenol reagent until pink end-point that persisted for 15 seconds.

As 1 mg of ascorbic acid was oxidized by the amount of indophenol used, 1 divided by the number of millilitre used on the titration gave the value (S) of the reagent in mg/ml (i.e. mg S of ascorbic acid reacting with 1 ml of reagent).

Procedure

A representative sample was taken that gave an extract containing 0.01 mg vit. C per millilitre and was blended with 5% metaphosphoric acid. The extract was collected in 50 ml volumetric flask and the volume was made up to the mark with 5% metaphosphoric acid. The extract was then centrifuged. The clear supernatant was used for the estimation of ascorbic acid.

A burrette was filled with standardized 2,6-dichlorophenol indophenol reagent, and 10 ml of homogenate was put into a white beaker and titration was made until a pink end-point which persisted for 15 seconds was obtained.

The formula for determination of ascorbic acid is as follows:

$$I \times S \times \frac{D}{A} \times \frac{100}{W} \times \text{mg ascorbic acid/100 g sample}$$

where,

I	=	Millilitre of indophenol reagent in titration
S	=	Milligram of ascorbic acid reacting with 1 ml of reagent
D	=	The volume of the extract in millilitre
A	=	The adequate titrate in millilitre
W	=	Weight of the sample in gram

3.2.7.2.4. Estimation of crude protein

Principle

The basic principle of this procedure involves digestion with concentrated sulphuric acid (H_2SO_4) and digestion mixture, which causes oxidation and destruction of protein and conversion of the organic nitrogen to ammonia which remains in the acid mixture as ammonia sulphate.

$$\text{Organic N} \xrightarrow[(\text{Heat + catalyst})]{H_2SO_4} CO_2 + H_2O + NH_4HSO_4$$

The amount of ammonia nitrogen is determined by making the digest alkaline followed by distillation of the liberated ammonia into standard acid solution and estimated titrimetrically. The nitrogen content of the sample was determined by further calculation (Hawk *et al.* 1954).

Experimental procedure

Two clean and dry 100 ml Kjeldahl flasks were taken and about 0.4 g dried sample was taken in each Kjeldahl flask with a piece of filter paper. About 15 ml of concentrated sulphuric acid and 0.3-0.4 g digestion mixture (anhydrous sodium sulphate 96%, copper sulphate 3.5% and selenium dioxide 0.5%) were added and then heated in a digestion chamber until the content became clear. After completing the digestion, the flask was cooled and the digest was transferred to a 100 ml volumetric flask and diluted up to the mark with distilled water. 5 ml of the solution was transferred to a micro-Kjeldahl distillation apparatus and after adding 8-10 ml of 4-% NaOH, the solution was distilled for 5 minutes. The distillate was collected in excess of 2% boric acid solution with indicator and was titrated by N/70 H_2SO_4. At the same time, a similar blank digestion and distillation was carried out without the sample.

Calculation

The percentage of nitrogen in the sample was calculated using the following formula:

$$N\ (\%\ \text{of nitrogen}) = \frac{(S - B) \times A \times C \times \text{Factor}}{\text{Weight of sample}} \times 100$$

where,

S = Titration reading for sample

B = Titration reading for blank

A = Strength of N/70 H_2SO_4

C = Digest taken for distillation

Factor = 0.002/1 ml of N/70 H_2SO_4 = 0.002 g N

The total N content was then converted into crude protein by multiplying with the factor 6.25.

$\therefore$ % crude protein = N x 6.25

3.2.7.2.5. ß-carotene extraction by chromatography method

ß-carotene content of fruits were determined as described by Holden (1981).

ß-carotene of fruits may be extracted from plant material by non-polar solvents, such as light petroleum and separated from other plant pigments in the extract by adsorption chromatography. The extract was applied to a column of alumina and carotene eluted with an appropriate solvent (2% acetone in light petroleum) leaving the other pigments on the column. The carotene concentration of the column effluent was estimated by taking absorbance against a water blank at 420 nm compared with a standard $K_2Cr_3O_7$ solution.

Procedure

Preparation of chromatography column: A column with a loose plug cotton wool in the bottom was seated in the stopper of a Buchner flask and poured a suspension of about 10 g in light petroleum into the column. The column was approximately 6 cm in height and after setting the column, when the eluent had percolated through, 5 ml of light petroleum was added to the top of the column and it was then ready for use.

Extraction: Five gram sample was taken and roughly cut into pieces and was grounded with 4:1 petroleum-ether and acetone solution. Some glass particles or sand was taken with the sample. Each time, 1-2 drop of acetone was added. Then the extract was collected in a round-bottom flask and was evaporated to dryness under reduced pressure and some petroleum-ether was added and extract was made.

Chromatography: The extract was poured into the top of the chromatography column. The round-bottom flask was washed 2/3 times by petroleum-ether and

passed through the column. Then the column was developed with 2% acetone in light petroleum until the orange-red band had moved of the column and was collected in a 100 ml volumetric flask and made up to 100 ml with petroleum-ether.

Colorimetry: The amount of ß-carotene in the column effluent was estimated by taking absorbance against a water blank at 420 nm.

Similarly, the reading of the absorbance of a standard 0.025% potassium dichromate solution was taken and the concentration of dichromate was equivalent to 0.16 mg carotene per 100 ml.

The calculation was made using the following formula:

$$\text{ß-carotene in effluent} = \frac{\text{Test reading}}{\text{Standard reading}} \times 0.16 \text{ mg}$$

$$= \text{mg carotene in weighed amount of plant material}$$

Result was expressed as mg carotene per 100 g plant material.

3.2.7.3. Statistical analysis

Statistical analyses were calculated as mentioned in section 3.1.7.3.

RESULTS

4. RESULTS

During the present investigation, two separate experiments were conducted. In the first set, conducted in the first year, two concentrations each of KNap, TIBA and ABA treatments as foliar spray were applied and in the second set, conducted in the second year, six different concentrations of TIBA were applied to study their effects on certain physiological and biochemical parameters of lady's finger (*Abelmoschus esculentus* [L.] Moench).

In the first experiment, the concentrations of KNap and TIBA were expressed in ppm and ABA in molar, and in the second experiment, the concentrations of TIBA were expressed in ppm. In the following texts, tables and figures, T_1, T_2, T_3, T_4, T_5, T_6 and T_7 mean control, 2500 ppm KNap, 5000 ppm KNap, 50 ppm TIBA, 100 ppm TIBA, 10^{-5} M ABA and 10^{-6} M ABA respectively in the first set.

In the second set, T_1, T_2, T_3, T_4, T_5, T_6 and T_7 mean control, 25, 50, 75, 100, 125 and 150 ppm TIBA respectively. The mean of the values obtained as results of treatments have been presented in tables, and expressed as percentages of corresponding control plant values in the text (tables) and figures. Moreover, to avoid repetitions of ppm, in the following chapter of results and discussion of second set of experiments, ppm has been omitted. Thus, 25 TIBA means 25 ppm TIBA and so on.

Results obtained on the physiological and biochemical parameters were statistically analyzed and treatment means were compared by least significant difference test at 5% level ($LSD_{0.05}$).

4.I. EXPERIMENT 1:

Effects of KNap, TIBA and ABA on physiological and biochemical parameters of lady's finger

4.1.1. Effect on physiological and yield parameters

4.1.1.1. Plant height (Table 1:I, Fig. 1:I)

Plant heights were not significantly influenced by different treatments of KNap, TIBA and ABA at 30 and 40 days after sowing (DAS) but at 50 and 60 DAS, height of plants were significantly affected.

At the age of 50 DAS, the highest plant height, 54.73 cm, was recorded from plants treated with 50 TIBA (T_4) and it was statistically identical to T_2, T_5 and T_3. The shortest plant height, 39.06 cm, was obtained from plants treated with 10^{-6} M ABA (T_7) and it was followed by T_6 and control (T_1). The percentages of increase/decrease as compared to control were 27.81, 24.84, 23.14, 17.98, 7.40 and -8.78 following T_4, T_2, T_5, T_3, T_6 and T_7 treatments respectively.

At 60 DAS, the maximum height, 100.73 cm, was found from plants treated with 50 TIBA (T_4) and it was statistically identical to T_2 and T_5. The minimum height, 69.57 cm, was recorded from plants treated with 10^{-5} M ABA (T_6) and it was followed by T_7, T_3 and T_1 (control) treatments. The percentages of increase/decrease as compared to control were 38.91, 36.00, 23.96, 11.28, 6.41 and -4.05 due to T_4, T_2, T_5, T_7, T_3 and T_6 treatments respectively.

4.1.1.2. Days to first flowering (Table 1:II)

In case of flowering, it took 41 days to first flower in control plants but plants treated with 2500 KNap, 5000 KNap and 100 TIBA took 39 days to first flower. Thus, KNap and one TIBA treatments brought early flowering. On the other hand, both the ABA treatemnts and 50 TIBA treatment could not bring early flowering.

Table 1:I Effect of KNap, TIBA and ABA on the height of lady's finger plants at different ages[1,2]

Treatment	Age of the plants (DAS)			
	30	40	50	60
T_1 (Control)	20.04	28.65	42.82 cd	72.51 cd
T_2 (2500 KNap)	18.94	32.94	53.46 ab	98.62 ab
T_3 (5000 KNap)	19.73	29.97	50.52 ac	77.16 cd
T_4 (50 TIBA)	17.62	34.77	54.73 a	100.73 a
T_5 (100 TIBA)	18.77	28.70	52.73 ab	89.89 ac
T_6 (10^{-5} M ABA)	19.76	30.25	45.99 bd	69.57 d
T_7 (10^{-6} M ABA)	20.16	28.42	39.06 d	80.69 bd
LSD 0.05	NS	NS	3.07	6.91
CV%	7.07	10.55	9.05	11.72

[1]Height in cm.

[2]Average value of 18 plants in each treatment.

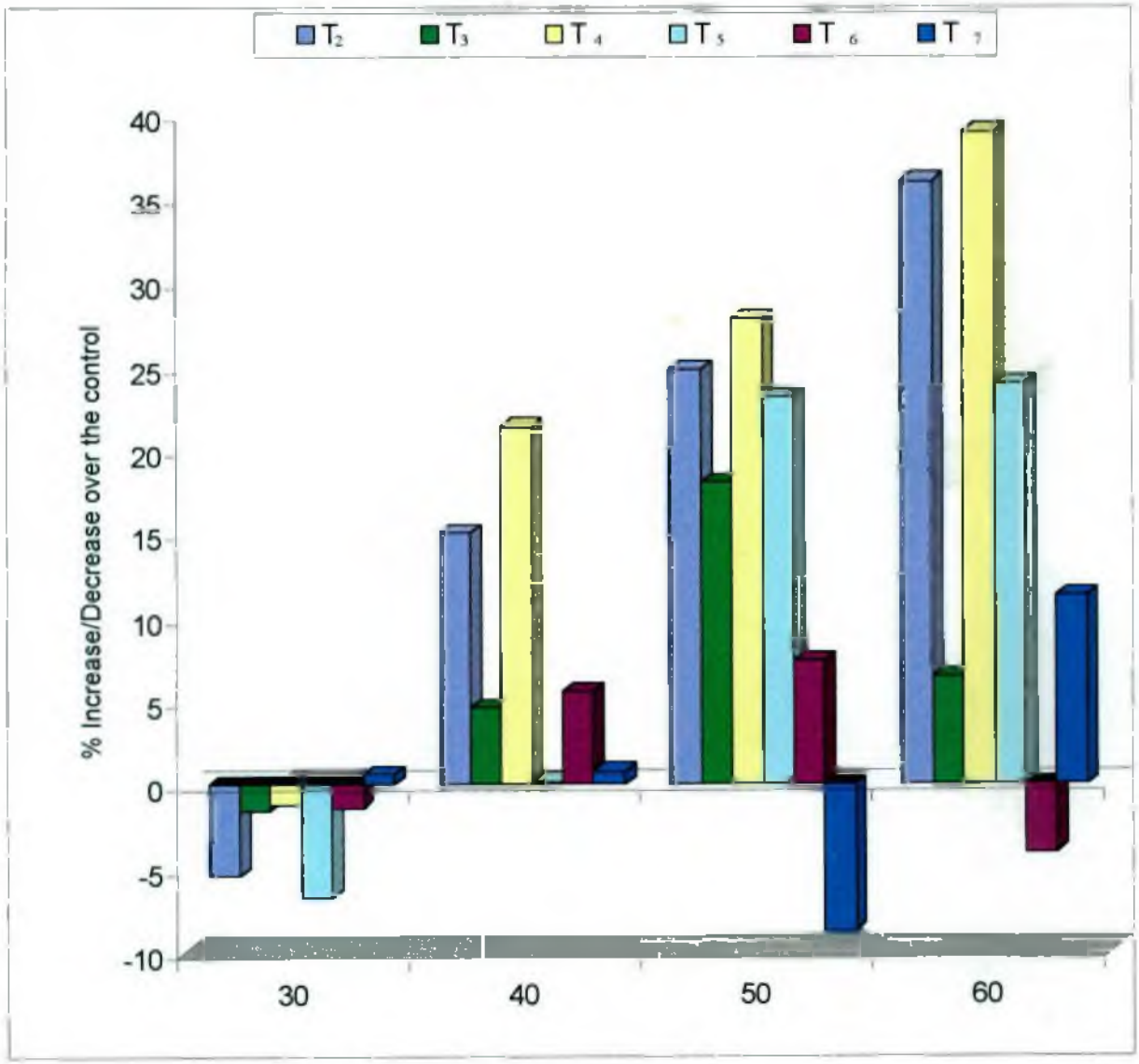

Fig. 1: 1 **Effect of KNap, TIBA and ABA on height of lady's finger plants at different ages.**

4.1.1.3. Number of fruits per plant (Table 1:II)

Maximum fruit number, 25.05, was obtained from the plants treated with 50 TIBA (T_4) and it was statistically identical with T_2 (2500 KNap) and significantly higher than all the other treatments. Minimum fruit number, 13.27, was recorded from plants treated with 10^{-5} M ABA (T_6) and which was statistically similar to T_5 and T_7. The percentages of increase/decrease over control were 37.11, 29.83, 7.00, -7.88, -16.63 and -27.36 following T_4, T_2, T_3, T_5, T_7 and T_6 treatments respectively.

4.1.1.4. Fruit length (Table 1:II)

Fruit length of lady's finger was significantly influenced by different treatments. The highest length of fruits, 15.60 cm, was recorded from plants treated with 50 TIBA (T_4) and which was statistically identical to plants treated with T_2, T_5, T_3 and T_6. The percentages of increase/decrease over the control were 16.15, 14.14, 12.95, 11.91, 2.53 and -13.10 following T_4, T_2, T_5, T_3, T_6 and T_7 treatments respectively.

4.1.1.5. Weight per fruit (Table 1:II)

Weight per fruit of lady's finger were not significantly influenced by different treatments. The maximum weight per fruit 17.54 g was recorded from plants treated with 2500 KNap (T_2). The percentages of increase/decrease over the control were 14.86, 10.80, 10.74, 2.68, 1.24 and -6.87 following T_2, T_4, T_6, T_3, T_7 and T_5 treatments respectively. But it may be mentioned that following all the treatments, except 100 TIBA, this parameter increased nonsignificantly and the highest increase was due to 2500 KNap treatment.

4.1.1.6. Yield per plant (Table 1:II)

The results of the present investigation indicated that the yield per plant of lady's finger was significantly influenced by different treatments. Maximum fruit yield

Table 1:II Effect of KNap, TIBA and ABA on yield attributes and yield of lady's finger

Treatment	First flowering (DAS)	Number of fruits/plant	Fruit length (cm)	Weight/ fruit (g)	Yield/Plant (g)
T_1 (Control)	41	18.27 bc	13.43 bc	15.27	277.82 bc
T_2 (2500 KNap)	39	23.72 a	15.33 ab	17.54	389.69 ab
T_3 (5000 KNap)	39	19.55 b	15.03 ab	15.68	305.61 bc
T_4 (50 TIBA)	41	25.05 a	15.60 a	16.92	425.08 a
T_5 (100 TIBA)	39	16.83 bd	15.17 ab	14.22	237.54 c
T_6 (10^{-5} M ABA)	41	13.27 d	13.77 ab	16.91	225.89 c
T_7 (10^{-6} M ABA)	42	15.23 cd	11.67 c	15.46	236.28 c
LSD 0.05	-	3.69	1.9	NS	116.42
CV%	-	11.02	7.49	6.215	21.78

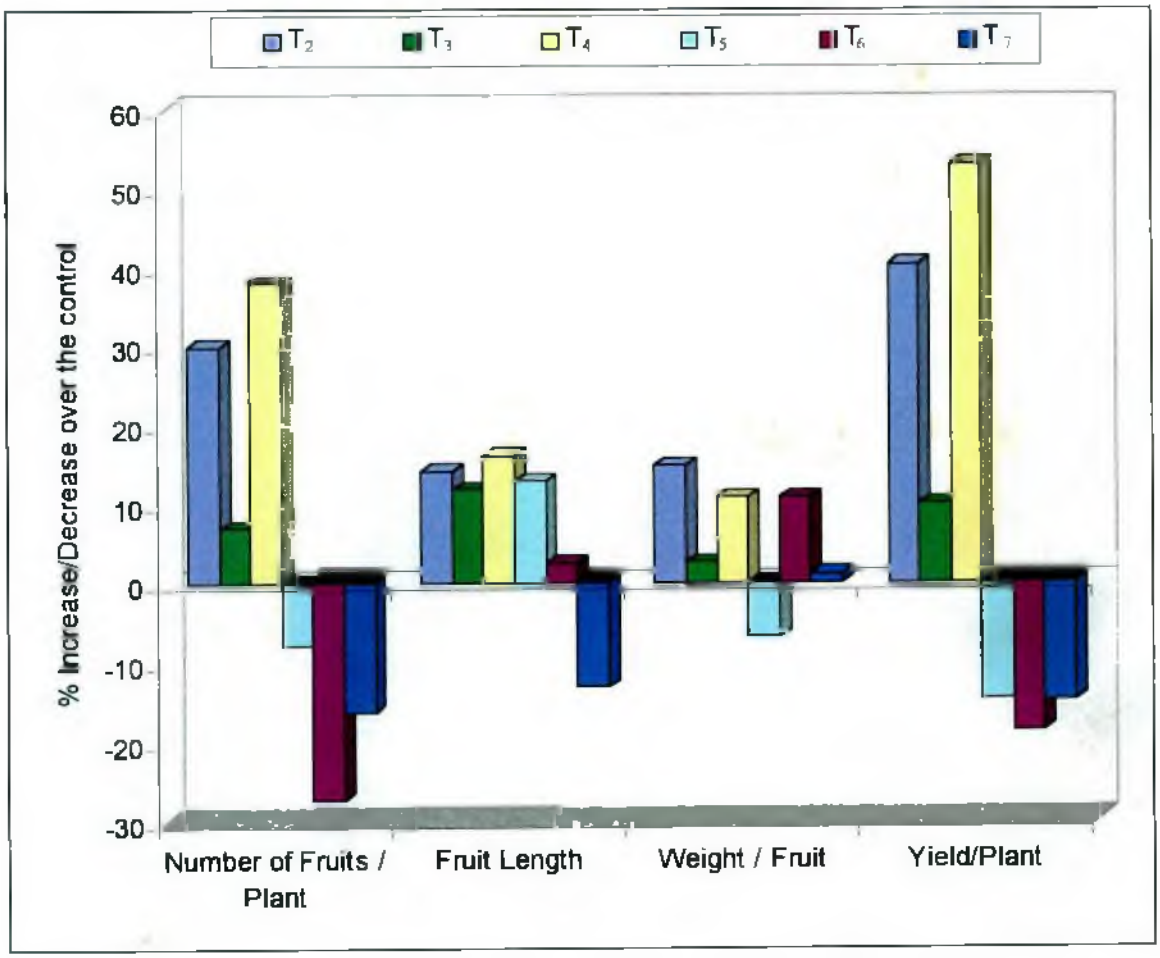

Fig. 1:II **Effect of KNap, TIBA and ABA on yield attributes and yield of lady's finger.**

per plant, 425.08 g, was recorded from the plants treated with 50 TIBA (T_4) and it was statistically identical to T_2 and T_3. The percentages of increase/decrease over the control were 53.00, 40.26, 10.00, -14.49, -14.95 and -18.69 following T_4, T_2, T_3, T_5, T_7 and T_6 treatments respectively.

4.1.2. Effect on biochemical parameters

4.1.2.1. Leaf pigments

Chlorophyll a (Table 1:III): At the age of 40 DAS, chlorophyll a content of fresh leaves of lady's finger was significantly affected by different treatments. Maximum chl a content (0.344 mg/g) of fresh leaf was recorded from plants treated with 500 KNap (T_3) and it was identical to T_2, T_4 and T_5. The percentage of increase/decrease over the control plant values were 20.27, 13.28, 6.64, 0.34, -12.58 and -17.83 due to T_3, T_2, T_4, T_5, T_6 and T_7 treatments respectively.

At the age of 50 DAS, maximum chl a content (0.380 mg/g) was recorded from plants treated with 2500 KNap (T_2) and it was identical to those of T_4 and T_3 and significantly higher than the control ones. The percentages of increase/decrease were 23.30, 19.48, 7.79, -1.23, -3.24 and -15.25 due to T_2, T_4, T_3, T_5, T_6 and T_7 treatments respectively.

Chlorophyll b (Table 1:III): At the age of 40 and 50 DAS, chl b content were significantly affected by different treatments. At the age of 40 days, the maximum chl b content (0.161 mg/g) was found from 2500 KNap (T_2) treated plants and it was identical to T_5, T_3 and T_4. The percentages of increase/decrease in comparison to control plant values were 59.40, 56.43, 39.60, 31.68, -31.68 and -60.39 following T_2, T_5, T_3, T_4, T_7 and T_6 treatments respectively.

Table 1:III Effect of KNap, TlBA and ABA on chlorophyll a, chlorophyll b and carotenoids contents of fresh leaves of lady's finger plant at different ages

Treatment	Age of plants (DAS)					
	40 days			50 days		
	chl a	chl b	carotenoids	chl a	chl b	carotenoids
T_1 (Control)	0.286 ab	0.101 bc	4.519 bc	0.308 bd	0.115 d	5.50
T_2 (2500 KNap)	0.324 a	0.161 a	5.494 ab	0.380 a	0.193 bc	5.91
T_3 (5000 KNap)	0.344 a	0.141 ab	5.701 ab	0.332 ac	0.233 ab	5.82
T_4 (50 TIBA)	0.305 ab	0.133 ab	6.107 a	0.368 ab	0.255 ab	6.30
T_5 (100 TIBA)	0.287 ab	0.158 a	5.427 ab	0.298 cd	0.279 a	6.23
T_6 (10^{-5} M ABA)	0.250 b	0.040 d	4.659 bc	0.270 cd	0.092 d	4.73
T_7 (10^{-6} M ABA)	0.235 b	0.069 d	3.386 c	0.261 d	0.133 cd	5.32
LSD 0.05	0.065	0.046	1.256	0.064	0.071	NS
CV%	12.56	22.75	14.00	11.42	22.28	11.99

Results expressed in mg/g fresh weight of leaf

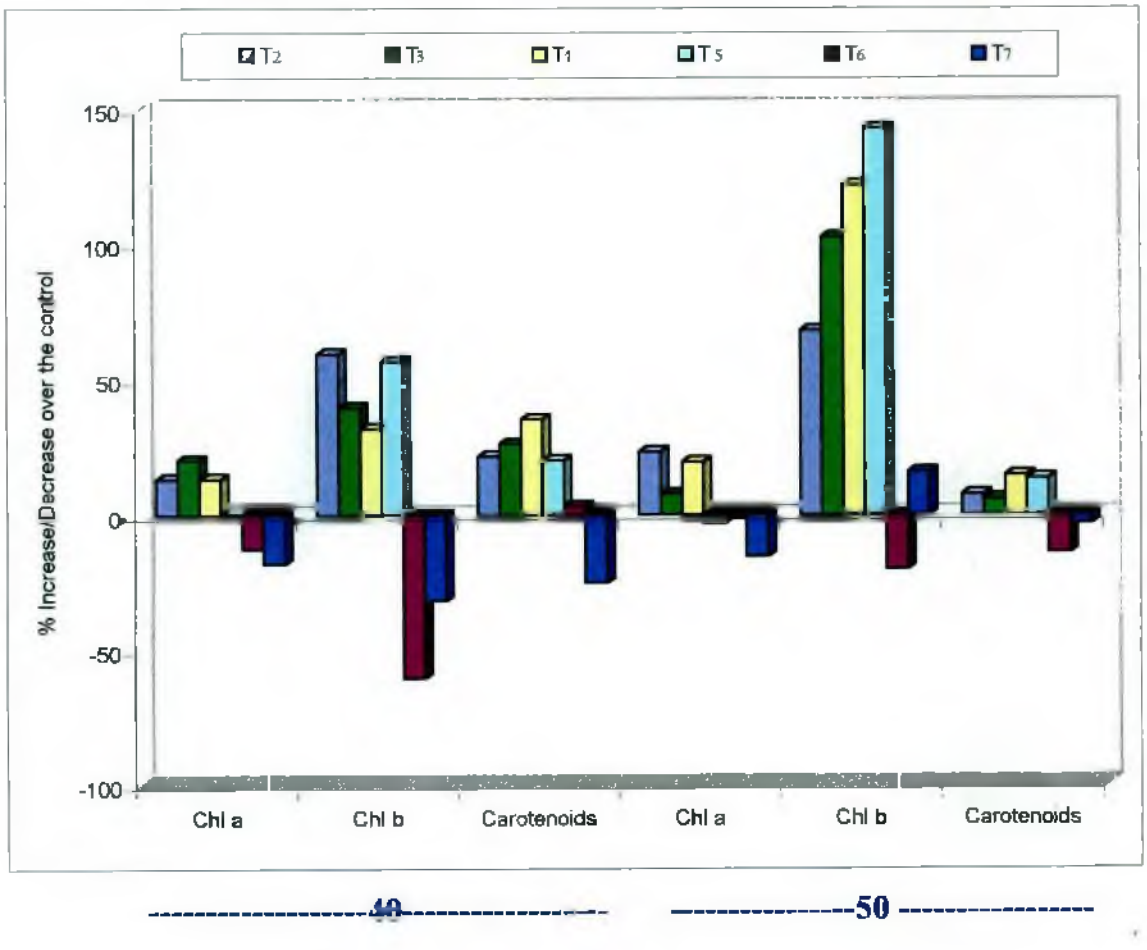

Fig1. III **Effect of KNap, TIBA and ABA on chlorophyll a, chlorophyll b and carotenoid contents of fresh leaves of lady's finger plant at different ages.**

At the age of 50 DAS, the highest chl b content (0.279 mg/g) was recorded due to 100 TIBA (T_5) treatment and it was identical to T_4 and T_3. The percentages of increase/decrease values were 142.60, 121.73, 102.60, 67.82, 15.65 and -20.00 due to T_5, T_4, T_3, T_2, T_7 and T_6 treatments respectively.

Carotenoids (Table 1:III): At 40 DAS carotenoid contents of fresh leaves were significantly influenced by different treatments. The maximum carotenoid content (6.107 mg/g) of fresh leaf was recorded from plants treated with 50 TIBA (T_4) and it was statistically identical to T_3, T_2 and T_5. The percentages of increase/decrease over the control plant values were 35.14, 26.15, 21.57, 20.09, 3.09 and -25.07 due to T_4, T_3, T_2, T_5, T_6 and T_7 treatments respectively.

At the age of 50 DAS carotenoid content of fresh leaves were not significantly influenced by different treatments.

4.2. EXPERIMENT 2:

Effects of TIBA on physiological and biochemical parameters of lady's finger

4.2.1. Effect of TIBA on physiological and yield parameters

4.2.1.1. Plant height (Table 2:I)

Plant heights were not significantly influenced by different treatments of TIBA on 30 and 40 DAS but at 50 and 60 DAS plant heights were significantly affected by the treatments.

At the age of 50 DAS, the maximum height, 51.79 cm, was found from plants treated with 50 TIBA (T_3) and it was followed by T_2. The shortest height, 43.07 cm, was recorded from 150 TIBA (T_7) treated plants and it was similar to T_6, T_4 and T_5. The percentages of increase/decrease as compared to control were 18.40, 8.71, 0.29, -1.50, -2,90 and -6.79 following T_3, T_2, T_6, T_4, T_7 and T_5 treatments respectively.

At the age of 60 DAS the highest plant height, 94.25 cm, was obtained from plants treated with 50 TIBA, and the same was statistically identical to those of T_2, T_4, T_1 and T_7 treatments. The shortest plant height, 67.43 cm, was obtained due to 125 TIBA (T_6) treatment. The percentages of increase/decrease over control were 7.50, 3.62, 3,36, -1.36, -6.02 and -23.08 due to T_3, T_2, T_4, T_7, T_5 and T_6 treatments respectively.

4.2.1.2. Days to first flowering (Table 2:II)

In case of flowering 25 TIBA (T_2) treated plants first flower appeared on 38 DAS, while those of control (T_1), 50 TIBA (T_3) and 75 TIBA (T_4) appeared on 39 DAS. 100 TIBA (T_5) and 125 TIBA (T_6) took 40 days and 150 TIBA (T_7) took 41 days for the appearance of first flower.

Table 2:I Effect of different concentrations of TIBA on plant height of lady's finger plant at different ages

Treatment	Age of the plants (DAS)			
	30	40	50	60
T_1 (Control)	18.89	26.08	43.73 bc	87.68 ab
T_2 (25 TIBA)	18.05	26.69	47.54 ab	90.85 ab
T_3 (50 TIBA)	18.92	21.15	51.79 a	94.25 a
T_4 (75 TIBA)	16.78	24.86	43.07 bc	90.62 a
T_5 (100 TIBA)	18.77	24.81	40.76 c	82.39 b
T_6 (125 TIBA)	19.76	26.79	43.86 bc	67.43 c
T_7 (150 TIBA)	20.21	25.29	42.46 c	86.48 ab
LSD 0.05	NS	NS	1.68	3.33
CV%	9.98	21.2	5.37	5.55

Height in cm

Average value of 18 plants in each treatment

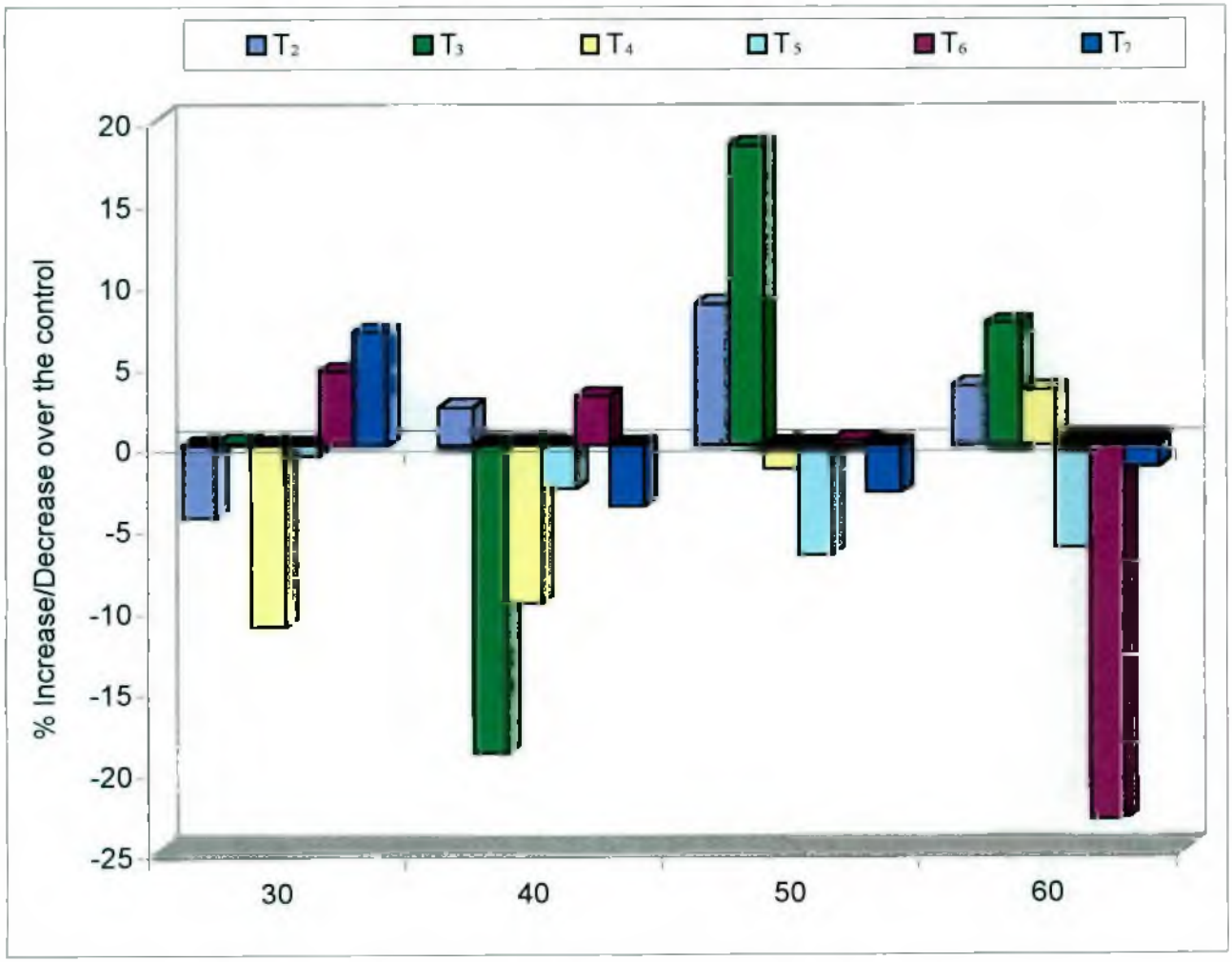

Fig. 2:I. Effect of different concentration of TIBA on the height of lady's finger plant at different ages.

4.2.1.3. Number of fruits per plant (Table 2:II)

Total number of fruits per plant were significantly influenced by different concentrations of TIBA. Maximum number of fruit, 28.5, was obtained from plants treated with 50 TIBA (T_3) and the same was statistically higher than those of all the other treatments. The percentages of increase/decrease over the control were 53.62, 33.33, 12.32, 9.45, 8.67 and -4.12 following T_3, T_2, T_4, T_7, T_6 and T_5 treatments respectively.

4.2.1.4. Fruit length (Table 2:II)

Maximum length of fruit, 14.88 cm, was recorded from plants treated with 25 TIBA (T_2) and it was followed by T_2, T_5 and T_4. The percentages of increase/decrease over the control were 10.46, 7.12, 4.00, 1.18, -3.78 and -4.60 due to T_2, T_3, T_5, T_4, T_6 and T_7 treatments respectively.

4.2.1.5. Weight per fruit (Table 2:II)

Weight per fruit were not significantly influenced by different treatments of TIBA. The maximum weight per fruit 18.27 g was found from plants treated with 50 TIBA (T_3). The percentages of increase/decrease over the control were 17.41, 17.22, 8.99, -2.05, -8.54 and -11.11 due to T_3, T_2, T_4, T_5, T_7 and T_6.

4.2.1.6. Fruit yield per plant (Table 2:II)

The results of present investigation indicated that the yield per plant was significantly influenced by different treatments of TIBA. The maximum yield per plant, 528.44 g, was found from plants treated with 50 TIBA (T_3) and it was identical to T_2 and significantly different from all the other treatments. The percentages of increase/decrease over the control were 67.40, 48.85, -3.14, -3.81, -3.81 and -5.87 due to T_3, T_2, T_4, T_6, T_7 and T_5 treatments respectively.

Table 2:II Effect of TIBA on yield attributes and yield of lady's finger

Treatment	First flowering (DAS)	Number of fruits/plant	Fruit length (cm)	Weight/ fruit (g)	Yield/Plant (g)
T_1 (Control)	39	20.33 c	13.47	15.56	315.66 c
T_2 (25 TIBA)	38	25.44 b	14.88	18.24	469.89 ab
T_3 (50 TIBA)	39	28.55 a	14.43	18.27	528.44 a
T_4 (75 TIBA)	39	22.22 c	13.63	16.96	377.89 bc
T_5 (100 TIBA)	40	20.11 c	14.01	15.24	305.72 c
T_6 (125 TIBA)	40	21.66 c	12.96	13.83	297.11 c
T_7 (150 TIBA)	41	21.78 c	12.85	14.23	303.61 c
LSD 0.05	-	2.74	NS	NS	92.52
CV%	-	8.63	5.67	1.99	14.01

Average value of 18 plants in each treatment

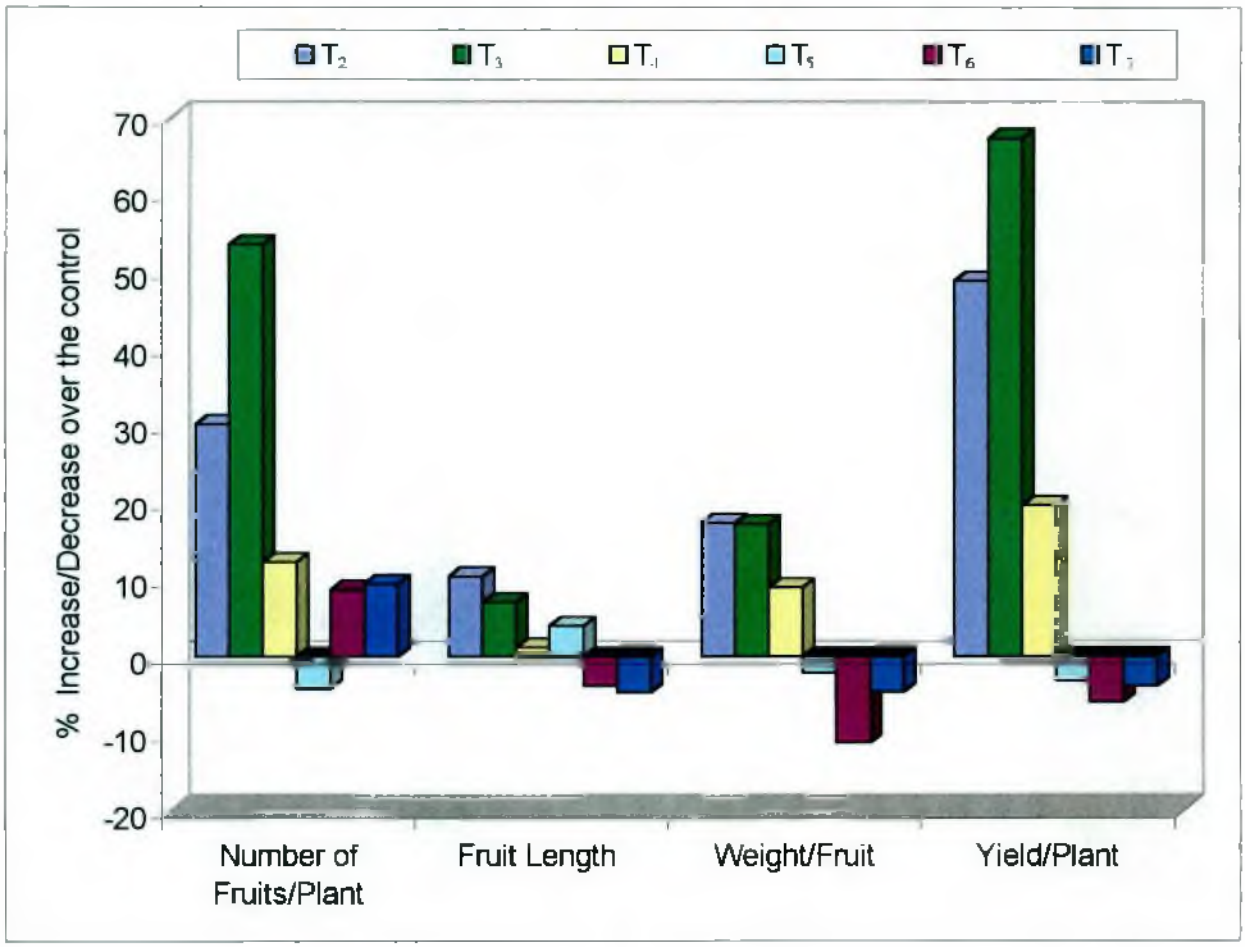

Fig. 2.11 Effect of TIBA on yield attributes and yield of lady's finger.

4.2.2. Effect on biochemical parameters

4.2.2.1. Leaf pigments

Chlorophyll a content (Table 2:III): At the age of 40 DAS, chl a contents of fresh leaves of lady's finger were significantly influenced by different treatments of TIBA. The maximum chl a content was 0.767 mg/g of fresh leaf found from the leaves of the plants treated with 50 TIBA (T_3) and it was statistically identical with T_2 and T_5 treatments. The percentages of increase/decrease over the control were 75.11, 63.24, 60.73, 35.84, 7.76 and -11.18 due to T_3, T_2, T_4, T_5, T_6 and T_7 treatments respectively. At the age of 50 DAS chl a content were influenced nonsignificantly.

Chlorophyll b content (Table 2:III): At the age of 40 and 50 DAS chl b content fresh leaves of lady's finger were not significantly influenced by different treatments of TIBA.

Carotenoid (Table 2:III): At the age of 40 and 50 days carotenoid contents of fresh leaves of lady's finger were significantly influenced by the different treatments of TIBA. The maximum carotenoid content at 40 DAS (6.385 mg/g of fresh leaf) was found from the leaf of the plants treated with 50 TIBA (T_3) and it was statistically identical with those of T_2, T_4 and T_5 treatments. The percentages of increase over the control were 29.30, 23.04, 17.82, 12.48, 0.10 and -14.45 due to T_3, T_2, T_4, T_5, T_6 and T_7 treatments respectively.

At 50 DAS, the maximum carotenoid content of leaves (6.12 mg/g of fresh leaf) was recorded from plants treated with 50 TIBA (T_3) and it was statistically identical to T_2 treatment. The percentages of increase/decrease over the control were 13.47, 9.58, -1.594, -4.133, -5.82 and -18.77 due to T_3, T_2, T_4, T_6, T_5 and T_7 treatments respectively.

Table 2:III Effect of TIBA on chlorophyll a, chlorophyll b and carotenoid contents of fresh leaves of lady's finger plant at different ages[1,2]

Treatment	Age of plants (DAS)					
	40 days			50 days		
	chl a	chl b	carotenoids	chl a	chl b	carotenoids
T_1 (Control)	0.438 b	0.260	4.938 bc	0.416 b	0.335	5.395 abc
T_2 (25 TIBA)	0.715 a	0.317	6.076 ab	0.542 a	0.307	5.912 ab
T_3 (50 TIBA)	0.767 a	0.313	6.385 a	0.481 a	0.305	6.122 a
T_4 (75 TIBA)	0.709 a	0.313	5.818 ab	0.444 a	0.327	5.309 bc
T_5 (100 TIBA)	0.595 ab	0.297	5.485 ac	0.448 ab	0.262	5.081 cd
T_6 (125 TIBA)	0.472 b	0.315	4.943 bc	0.450 b	0.407	5.172 bc
T_7 (150 TIBA)	0.389 b	0.329	4.224 c	0.398 b	0.334	4.382 d
LSD 0.05	0.216	NS	1.271	NS	NS	0.765
CV%	20.82	16.44	13.21	12.79	20.176	8.05

[1]Results expressed in mg/g fresh weight of leaf

[2]Average value of three replicates in each case

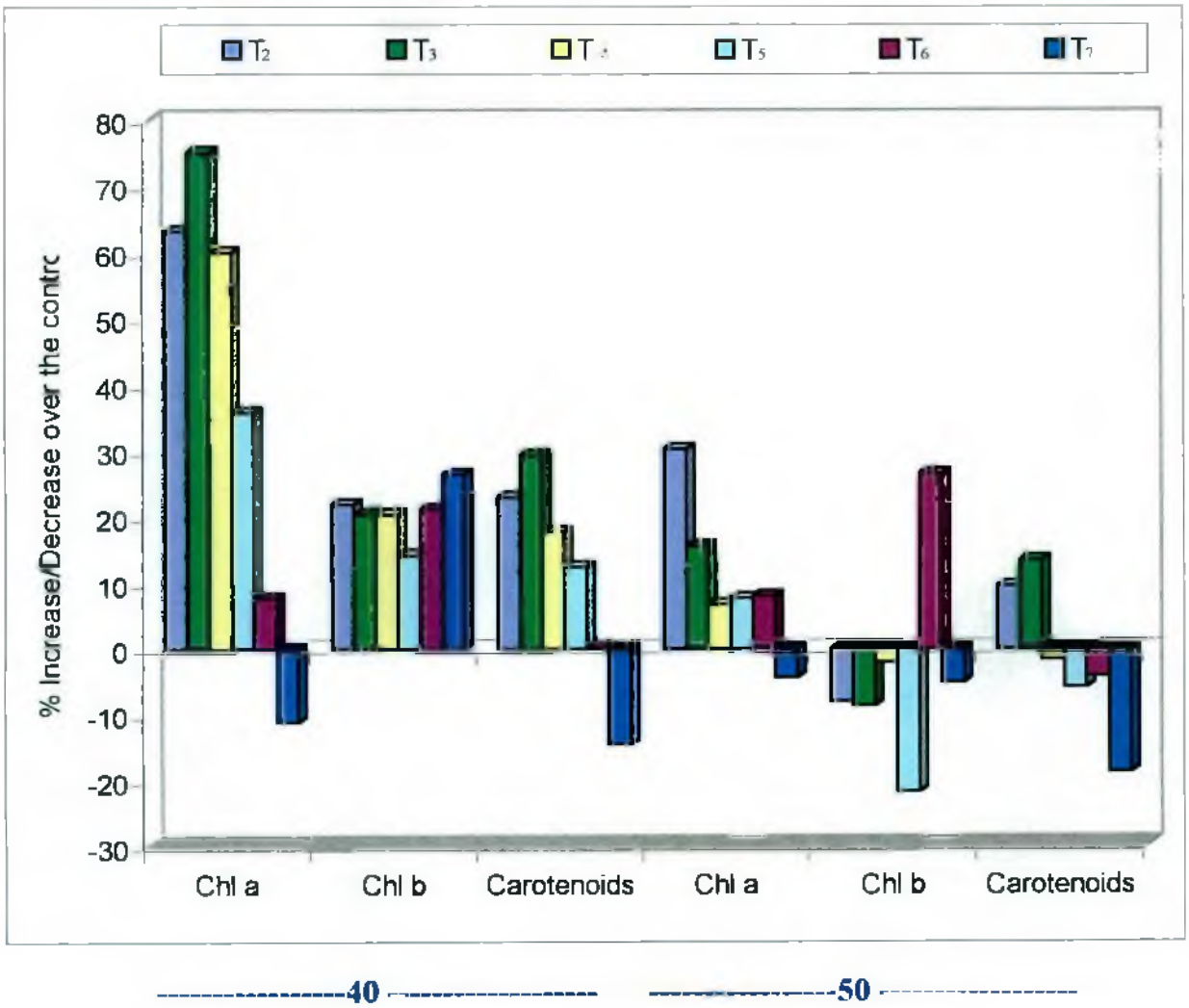

Fig. 2:III **Effect of TIBA on chlorophyll a ,chlorophyll b and carotenoids contents of leaves of lady's finger.**

4.2.2.2. Moisture content (Table 2:IV)

No marked variation was observed in the moisture content of lady's finger fruits following the application of TIBA. It ranged from 90.45 to 91.50% (Table 2:IV).

4.2.2.3. ß-carotene content (Table 2:IV)

ß-carotene contents of lady's finger fruits were not significantly affected by different treatments of TIBA. The maximum ß-carotene content (108 mg/100 g) of the lady's finger fruit was recorded following 25 TIBA (T_2) treatment and it was followed by those of T_5 and T_7 treatments.

4.2.2.4. Ascorbic acid (Table 2:IV)

Ascorbic acid or vitamin C contents of the fruits were not significantly affected by the treatments of TIBA. The highest ascorbic acid content (22.18 mg/100 g) was recorded from plants treated with 25 TIBA which was followed by those of T_3, T_4 and T_5 treatments.

4.2.2.5. Protein content (Table 2:IV)

Protein contents of lady's finger fruits wwere not influenced significantly by different treatments of TIBA. But the highest protein content was obtained from the fruit of plants treated with 75 TIBA (T_4) which was followed by those of T_3 and T_2 treatments. The percentages of increase/decrease over the control were 45.25, 40.32, 25.04, 11.65, 2.84 and -23.31 due to T_4, T_3, T_2, T_5, T_6 and T_7 treatments respectively.

Table 2:IV Effect of TIBA on moisture content, ß-carotene, ascorbic acid and protein content of fruits of lady's finger plant

Treatment	Moisture content (%)	ß-carotene content (μg/100 g)	Ascorbic acid (mg/100 g)	Protein content (g/100 g)
T_1 (Control)	90.95	93.88	20.04	1.158
T_2 (25 TIBA)	91.05	108.81	22.18	1.448
T_3 (50 TIBA)	90.45	101.94	22.13	1.625
T_4 (75 TIBA)	90.58	97.85	21.62	1.682
T_5 (100 TIBA)	90.89	106.59	21.37	1.293
T_6 (125 TIBA)	91.49	99.18	20.37	1.191
T_7 (150 TIBA)	91.50	102.82	20.83	0.888
LSD 0.05	NS	NS	NS	NS
CV%	6.0	6.62	4.06	25.14

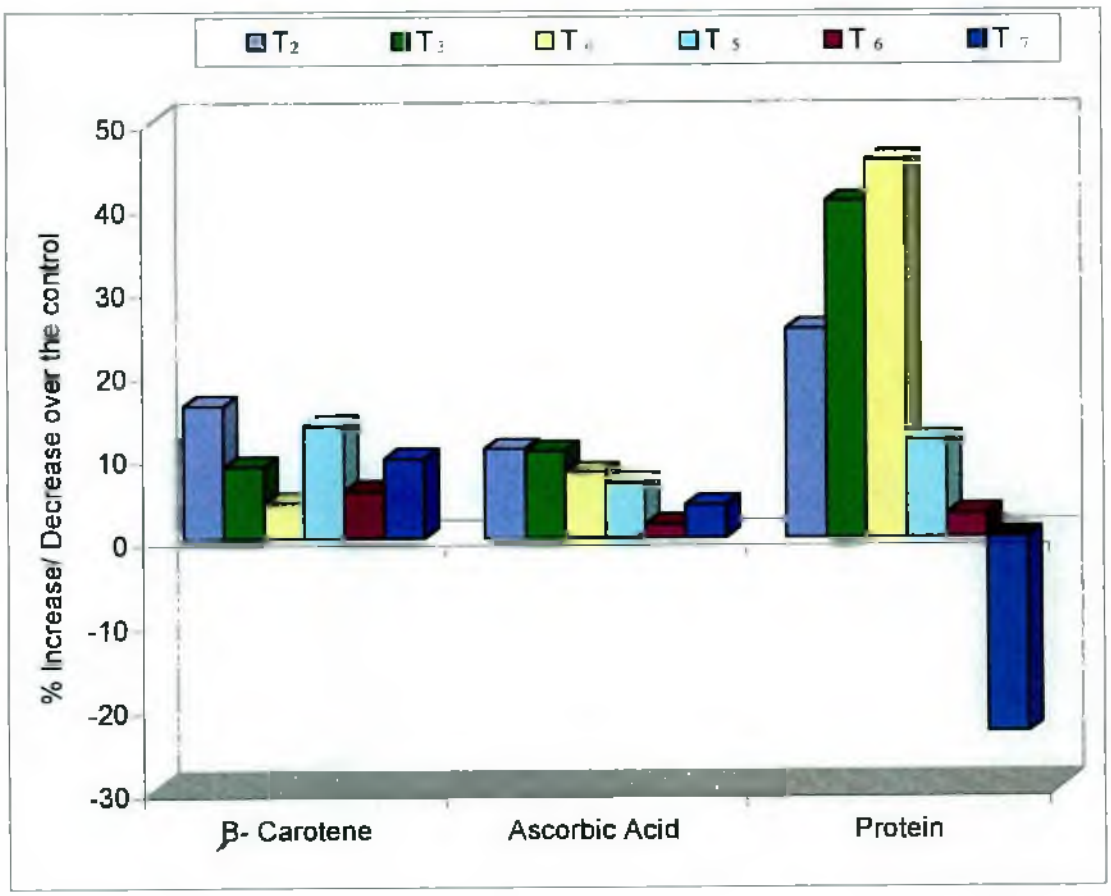

Fig. 2:IV **Effect of TIBA on β-carotene, ascorbic acid and protein content of fruits of lady's finger.**

DISCUSSION

5. DISCUSSION

There has been a wealth of research undertaken over the last 50 years to find out the mechanisms responsible for regulating plant differentiation and development. A common message that has emerged from many of the studies is that development and yield are regulated by specific endogenous chemicals like growth regulators and the metabolism of plants leading to growth development and yield. A number of regulators are used in agriculture and horticulture in this purpose. Potassium naphthenate (KNap), tri-iodobenzoic acid (TIBA) and abscisic acid (ABA) in appropriate doses have stimulatory effect on physiological and biochemical activities of different plants. Investigators around the world worked on KNap and to mention a few are Huseinov (1960), Zhukova (1965), Popoff and Boikov (1966), Fattah (1969), Fattah and Wort (1970a, b), Fattah and Roy (1972), Fattah and Khatun (1974), Fattah and Karmoker (1975), Rashid *et al.* (1989), Jahan *et al.* (1991), Hoque *et al.* (1992), Mondal and Fattah (1996), Jahan *et al.* (1997), Rashid (1997), and Habib (1997).

TIBA has been used as a growth promoter especially to obtain higher fruit and seed yield, at low concentration. Works on the effect of TIBA on different crops have been carried out by many scientists (Sebanek 1953, Greenhalgh 1965, Greer 1965, Hipp and Cowley 1969, Santana *et al.* 1970, Hartzook and Goldin 1970, Bastidas and Buitrago 1972, Clapp 1973, Tanner and Ahmed 1974, Sultana 1976, Fattah and Khan 1977, Chowdhury *et al.* 1978, Begum *et al.* 1992, Rahman *et al.* (1992), Deotale *et al.* 1995, Kuno 1996), and Rahman and Rahman (1997).

The effects of exogenously applied ABA on growth development and yield have been carried by Chakhatrakan *et al.* (1994), Matsui *et al.* (1994), Kamal *et al.* (1995), and Takahashi *et al.* (1996).

During the present investigation, it was found, following KNap, TIBA and ABA treatment, vegetative growth reproductive growth, yield and biochemical parameters of lady's finger plants were affected but the magnitude of the effect was depended on the concentrations of the chemicals.

Attempts have been made to explain and discuss the results obtained in the light of available literature.

During the first set of experiments where growth regulators, KNap, TIBA and ABA, were used, the results obtained have been discussed below.

5.1. Discussion on experiment 1

5.1.1. Physiological parameters

5.1.1.1. Plant height

Plant height is one of the factors affecting yield of some plants. It was observed to be affected by different concentrations of KNap, TIBA and ABA; and both significantly and nonsignificantly varied at 50 and 60 DAS following different treatments.

Two concentrations of KNap such as 2500 (T_2) and 5000 (T_3) increased final plant height over the control by 36.00% and 6.41% respectively. Increase of plant height by KNap treatments were reported by Begum *et al.* (1992) following application of 2500 and 5000 ppm on lady's finger, Rashid *et al.* (1989) following application of 5000 ppm and 5000 + 2500 ppm on sunflower, Khan (1973) following 2500 and 5000 ppm on soybean, Khan (1981) following 2500 ppm on soybean, Pasha (1972) on rice, Egiyani (1963) on corn, Alizade and Guseinov (1965) on peas and corn, Eyabov and Issaeva (1966) on maize, Salam (1981) on lady's finger, Fattah *et al.* (1982) on Italian millet, Hoque *et al.*

(1992), Jahan *et al.* (1997) and Rashid (1997) on mustard, Mondal and Fattah (1996) on rapeseed and Habib (1997) on niger. Thus, the results obtained during the present investigation are in accord with the findings of other workers.

Two concentrations of TIBA, 50 (T_4) and 100 (T_5) increased the plant height but among the treatments 50 (T_4) TIBA treated plants gave the highest percentage of increase (38.91%) over the control. Similar results of increased plant height due to TIBA treatments were reported by Begum *et al.* (1992) following 50 ppm TIBA on lady's finger and Hussain (1976) and Khan (1981) on soybean, but decreased in plant height following TIBA application has also been reported by Clapp (1973), Chowdhury (1978), Khan (1981), Deotale *et al.* (1995).

ABA treatments of 10^{-5} M (T_6) decrease the final plant height by -2.39% and 10^{6} M (T_7) increase the plant height by 11.77% over the control.

Matsui *et al.* (1994) reported that plants treated with ABA grow slowly than untreated ones. Thus, the results obtained during the present investigation are partially in accord with the findings of other workers.

5.1.1.2. Days of first flowering

Time of first flowering was reduced by 2 days over the control plants following the application of 2500 (T_2) and 5000 (T_3) KNap and 100 (T_5) TIBA.

Begum *et al.* (1992) reported that 2500 and 500 ppm KNap did not influence first flowering of lady's finger.

Greenhalgh (1965), Greer (1965), Sebanek (1959) reported that time required for first flowering was reduced following applications of TIBA. Thus, the results obtained during the present investigation are partially in accord with the findings of other workers.

5.1.1.3. Number of fruit per plant

Number of fruit per plant is an important yield contributing character of lady's finger. Plants treated with KNap 2500 (T_2) and 5000 (T_3) showed increase in number of fruits per plant and the percentages were 37.11% and 7.88% respectively over the control.

Increase of this parameter due to KNap treatments were reported by Begum *et al.* (1992) due to 2500 and 5000 ppm on lady's finger, Rashid *et al.* (1989) due to 500 and 5000 + 2500 ppm on sunflower, Jahan *et al.* (1991) on lady's finger, Fattah *et al.* (1972) on maize, Fattah and Karmoker (1975) on *Sesamum indicum*, Khan (1973) on soybean, Uddin *et al.* (1986) on snakegourd, Hoque *et al.* (1992) and Rashid (1997) on mustard and Habib (1997) on niger.

The maximum increase in number of fruits per plant was found in 50 TIBA (T_4) treated plants, and it was 37.11% over control. 100 TIBA (T_5) also increased this parameter by 7.88% over the control. Increase in the number of fruits per plant following TIBA application was also reported by Begum *et al.* (1992) due to 50 ppm on lady's finger, Fattah and Khan (1977) due to 50 and 100 ppm on soybean, Chowdhury *et al.* (1978) due to 50 ppm on soybean, Grewal (1980) on groundnut, Chung and Kim (1989), and Ravinchandran and Ramaswami (1993) on soybean and Hartzook and Goldin (1970) on peanut, and Rahman and Rahman (1997) on bottlegourd. Therefore, the findings obtained during the present investigation are in accord with those of previous workers.

Number of fruits per plant decreased in ABA applied plants. No report is available on the increase in number of fruits by ABA. But Takahashi *et al.* (1996) reported that ABA treated plants increased filled pod number of soybean.

5.1.1.4. Length of fruit

Fruit length of lady's finger varied both significantly and nonsignificantly following different treatments of KNap, TIBA and ABA.

Both 2500 (T_2) and 5000 (T_3) KNap increased the fruit length and the percentages were 14.14% and 11.91% respectively over the control. Jahan *et al.* (1991) also reported increase in fruit length of lady's finger due to different KNap concentrations.

The highest increase was obtained from 50 ppm TIBA (T_4) treated plants; 100 TIBA (T_5) also increased the fruit length and the increases were 16.15% and 12.95% respectively over the control. Similar results of increasing fruit length due to TIBA application have been reported by Suryanarayana and Raju (1983) and Rahman *et al.* (1992) in bottlegourd. Thus, the findings of the present study are in accord with the findings of the earlier studies of different investigators.

Plant treated with 10^{-5} M ABA (T_6) also increased the fruit length, but 10^{-6} M ABA (T_7) decreased the fruit length.

No report is yet available regarding the effect of ABA on the length of fruit.

5.1.1.5. Weight per fruit

Weight per fruit of lady's finger was influenced by different treatments of KNap, TIBA and ABA.

Both 2500 (T_2) and 5000 (T_3) KNap increased the weight per fruit and the maximum increase was obtained from 2500 KNap (T_2), and the increases were 14.86% and 2.68% respectively over the control.

Increase in weight per fruit following KNap application had been reported by Jahan *et al.* (1991) on lady's finger, El-Zawily *et al.* (1985) on *Vicia faba*, Uddin *et al.* (1986) on snakegourd and Begum *et al.* (1992) on lady's finger.

In case of 50 TIBA (T_3) increased and 100 TIBA (T_4) decreased the weight, which is similar to the results reported by Begum *et al.* (1992) on lady's finger. Thus, the results obtained during the present study are in accord with the findings of previous workers.

Plant treated with 10^{-5} M ABA (T_6) and 10^{-6} M ABA (T_7) increased the weight per fruit; and increases were 10.74% and 1.24% over the control respectively. No report is available regarding the effect of ABA on weight per fruit.

5.1.1.6. Fruit yield

The yield of lady's finger depends on weight, size and number of fruits borne on plants. General vegetative growth and vigor of plants have considerable influence on these characters.

Results obtained from this investigation with lady's finger showed that yield increased following two concentrations of KNap and the percentages of increase were 40.26% and 10.00% over the control due to 2500 KNap (T_2) and 5000 KNap (T_3) respectively.

Increase in yield following KNap application had been reported by many investigators in different crops, viz. Fattah *et al.* (1975) on IR8, Fattah and Roy (1972) on maize, Huseinov (1960) on tobacco, Fattah *et al.* (1976) on tobacco, Guseinov (1950), Alieve *et al.* (1965), Szekely and Gleria (1966) on tomato. Zhukova (1965) on carrot, cabbage, beat and onion, Fattah and Karmoker (1975) on *Sesamum indicum*, Khan (1973) on soybean, Rashid *et al.* (1989) on sunflower, Jahan *et al.* (1991) and Begum *et al.* (1992) on lady's finger.

The maximum increase in yield was obtained from 50 TIBA (T_4) treated plants and the increase was 53% over the control but 100 TIBA (T_5) decreased the yield by -14.49%.

Increase in yield following TIBA application had been reported by Chowdhury *et al.* (1978) due to 50 ppm TIBA on soybean, Begum *et al.* (1992) due to 50 ppm TIBA on lady's finger, Deotale *et al.* (1995) and Ravichandran and Ramaswami (1993) due to 50 ppm TIBA on soybean, Greer (1965), Tanner and Ahmed (1974), Fattah and Khan (1977) also reported increase in yield of soybean following different TIBA concentrations. Hipp and Cowley (1969) reported increase in yield of peas by TIBA application. But Hartzook and Goldin (1970) reported that average number of pods were reduced following TIBA application on peanut. Thus, the results of the present study are in agreement with the findings of the previous workers.

5.1.2. Biochemical parameters

5.1.2.1. Leaf pigment

The yield potential of green plants is related to its chlorophyll content of leaves. From the present investigation, it is clearly evident that KNap and TIBA treatments increased the contents of chlorophyll 'a', chlorophyll 'b' and carotenoids at 40 and 50 DAS, but ABA decreased the leaf pigments on these days.

At 40 and 50 DAS, maximum increase of chl a content of leaves were obtained due to 5000 KNap (T_4) and 2500 KNap (T_5) treatments and the maximum increase in chl b content at 40 DAS was obtained from 2500 KNap (T_5) treated plants.

Similar results showing increase in leaf pigment due to KNap applications were also reported by Fattah and Wort (1970) on bushbean, Khatun (977) on BR-3

rice, Fattah *et al.* (1978) on IR-8 rice, Fattah *et al.* (1974) on maize, Hossain and Fattah (1987) on sweet potato, Jahan *et al.* (1991) on lady's finger, Fattah *et al.* (1994), Rashid (1997) on mustard and Habib (1997) on niger.

At 40 and 50 DAS, maximum carotenoid contents were obtained from 50 TIBA (T_4) treated plants and at 50 DAS, maximum chl b content was obtained from 100 TIBA (T_5) treated plants.

Similar results showing increase in leaf pigment due to TIBA applications were also reported by Kunokatsuji (1996) on mulberry leaves. Therefore, the findings obtained during the present investigation are in accord with those of previous workers.

5.2. Discussion on experiment 2

During the second set of experiments, six concentrations of TIBA were used, the results obtained have been discussed below.

5.2.1. Physiological and yield parameters

5.2.1.1. Plant height

It was observed to be affected by the concentrations of TIBA and was significant at 50 and 60 DAS following various treatments.

Three concentrations of TIBA, such as 25 (T_2), 50 (T_3) and 75 (T_4) increased the final plant height and the maximum height (7.50%) was obtained from 50 TIBA (T_3) treated plants over the control, and three concentrations of TIBA, such as 100 (T_5), 125 (T_6) and 150 (T_7) decreased the final height.

Increase of this parameter due to TIBA treatments were reported by Begum *et al.* (1992) following 50 TIBA on lady's finger, and Khan (1981) on soybean.

Decrease of this parameters due to TIBA treatments were reported by Clapp (1973) on soybean, Sultana (1976) on bush bean, Chowdhury *et al.* (1978) and Deotale *et al.* (1995) on soybean. Therefore, the findings obtained during the present investigation are in accord with the findings of previous workers.

5.2.1.2. Days to first flowering

Time of first flowering was reduced by 1 day over the control by following application of 25 (T_2) TIBA, but 50 (T_3), 75 (T_4) and 100 (T_5) TIBA had no influence on this parameter.

Greenhalgh (1965), Greer (1965) and Sebanek (1959) reported that time required for first flowering was reduced by TIBA application.

Begum *et al.* (1992) reported that 100 ppm TIBA application did not influence first flowering of lady's finger.

5.2.1.3. Number of fruit per plant

The maximum increase in number of fruits were found in 50 TIBA (T_3) treated plants. The percentage of increase was 53.62% over the control.

Increase in the number of fruits following TIBA application was also reported by Begum *et al.* (1992) due to 50 ppm on lady's finger, Fattah and Khan (1977) due to 50 and 100 ppm on soybean, Chowdhury *et al.* (1978) due to 50 ppm on soybean, Chung and Kim (1989), Ravinchandran and Ramswami (1993) on soybean, and Hartzook and Goldin (1970) on peanut, Grewal (1980) on groundnut, Zappi and Quintana (1990) on dry bean and Rahman and Rahman (1997) on bottlegourd. Thus, appropriate dose of TIBA application could lead to increase in number of fruits per plant of various crops.

5.2.1.4. Length of fruit per plant

During the present investigation, it was observed that the maximum length of fruits increased in 25 TIBA (T_2) treated plants. The percentage of increase was 10.46 as compared to control.

Similar results with increasing fruit length due to TIBA application have been reported by Suryanarayana and Raju (1983) and Rahman *et al.* (1992) in bottlegourd.

5.2.1.5. Weight per fruit

Treatments with 25 TIBA (T_2), 50 TIBA (T_3) and 75 TIBA (T_4) increased the weight of fruit and the maximum increase 17.41% was obtained from 50 TIBA (T_3) treated plants, but 100 TIBA (T_5), 125 TIBA (T_6) and 150 TIBA (T_6) decreased the weight of fruit.

Increase in weight of fruit due to 50 TIBA was reported by Begum *et al.* (1992) on lady's fmger.

5.2.1.6. Fruit yield

The maximum increase in yield was found from 50 (T_3) TIBA treated plants and percentage of increase was 67.40 over the control. 25 (T_2) and 75 (T_4) TIBA treated plants also gave higher yield and the percentages were 48.85 and 19.71 respectively over the control.

Increase in yield following TIBA application had been reported by Chowdhury *et al.* (1978) due to 50 TIBA on soybean, Begum *et al.* (1992) due to 50 TIBA on lady's fmger, Deotale *et al.* (1995) and Ravichandran and Ramaswami (1993) due to 50 TIBA on soybean. Greer (1965), Tanner and Ahmed (1974), Fattah and Khan (1977) also reported increases in yield of soybean following different

TIBA concentrations. Hipp and Cowley (1969), and Rahman and Rahman (1997) reported increase in yield of peas and bottlegourd respectively by TIBA application. Therefore, the findings obtained during the present investigation are in accord with those of previous workers.

5.2.2. Biochemical parameters

5.2.2.1. Leaf pigment

At 40 DAS, maximum chl a and carotenoid were obtained from 50 TIBA (T_3) treated plants and maximum chl b was obtained from 150 (T_7) treated plants. The percentages of increase were 75.11, 26.53 and 29.30 over the control in chl a, chl b and carotenoid respectively.

At 50 DAS, maximum chl a, chl b and carotenoid were obtained from 25 (T_2), 125 (T_6) and 150 (T_3) TIBA treated plants respectively. The percentages of increase over the control in chl a, chl b and carotenoid were 30.28, 26.56 and 13.47 respectively.

Increased chlorophyll a, b and carotenoids of soybean cv. Lee-74 due to 40 TIBA was reported by Hussain (1976). Increase in leaf pigment due to TIBA applications were also reported by Khan (1981) on soybean and Kunokatsuji (1996) on mulberry leaves. Thus, the results of the present study are in agreement with the findings of previous workers.

5.2.2.2. Moisture content

No marked variation was observed in the moisture content of lady's finger fruits following application of TIBA. Moisture content of lady's finger increased in 25 (T_2), 125 (T_6) and 150 (T_7), and decreased in 50 (T_3), 75 (T_4) and 100 (T_5) TIBA treatments.

No previous report could be found on this aspect in the literatures reviewed.

5.2.2.3. ß-carotene content

Results of the present investigation with lady's finger plants treated with different concentrations of TIBA exhibited that ß-carotene content of lady's finger fruits increased following different concentrations of TIBA. Maximum increase in ß-carotene content observed in fruits from 25 TIBA (T_2) treated plants and it was 15.90% more than those of the control plants.

No previous report could be found on this aspect in the literatures reviewed.

5.2.2.4. Ascorbic acid (vitamin C) content

Results of the present investigation showed that different concentrations of TIBA increased ascorbic acid content of lady's finger fruits and the maximum increase in this parameter was observed in fruits from 25 TIBA (T_2) treated plants and the percentage of increase was 10.67% over the control.

Hussain *et al.* (1979) reported that application of two concentrations (10 and 50 ppm) of TIBA caused increase of ascorbic acid content of fresh fruit of tomato.

5.2.2.5. Protein content

Results of the present investigation with lady's finger plants treated with different concentrations of TIBA exhibited that protein content of lady's finger fruits increased following two concentrations of TIBA. Maximum increase in protein content was observed in fruits from 75 TIBA (T_4) treated plants and it was 45.25% more than those of the control plants.

Quite similar results were also obtained by a number of investigators. Application of TIBA had been found to increase protein content, viz. Hussain (1976) on soybean, Chowdhury *et al.* (1978) on soybean and Sultana (1976) on bushbean.

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APPENDIX

7. APPENDIX

ANALYSIS OF VARIANCE (ANOVA) RESULT

EXPERIMENT 1

Table-Ia. Analysis of variance of plant height of 30 days old plant

Source of variation (SV)	Degrees of freedom (DF)	Sum of squares (SS)	Mean squares (MSS)	F
Block	2	2.831524D-01	1.41576SD-01	0.49^{NS}
Treatment	6	2.288324D+00	3.810873D-01	1.32^{NS}
Error	12	3.457248D+00	2.880040D-01	
Total	20	6.028724D+00		

CV = 7.07%

Table-Ib. Analysis of variance of plant height of 40 days old plant

SV	DF	SS	MSS	F
Block	2	2.03791D+00	1.018986D+00	0.63^{NS}
Treatment	6	1.648360D+01	2.747267D+00	1.71^{NS}
Error	12	1.930283D+01	1.608569D+00	
Total	20	3.782440D+01		

CV = 10.55%

Table-Ic. Analysis of variance of plant height of 50 days old plant

SV	DF	SS	MSS	F
Block	2	1.798160D+01	8.9908ooD+00	3.01**
Treatment	6	9.883112D+01	1.647185D+01	5.52**
Error	12	3.581553D+01	2.984628D+00	
Total	20	1.526283D+02		

CV = 9.05% LSD (0.05) = 3.07

Table-Id. Analysis of variance of plant height of 60 days old plant

SV	DF	SS	MSS	F
Block	2	2.690492D+01	1.345246D+01	0.89NS
Treatment	6	4.307485D+02	7.179142D+01	4.76*
Error	12	1.180015D+02	1.508346D+01	
Total	20	6.386549D+02		

CV = 11.72% LSD (0.05) = 6.91

Table-IIa. Analysis of variance of number of fruits/plant

SV	DF	SS	MSS	F
Block	2	1.172377D+01	5.861886D+00	1.36NS
Treatment	6	3.338042D+02	5.563404D+01	12.90**
Error	12	5.176043D+01	4.313369D+00	
Total	20	3.972884+02		

CV = 11.02% LSD (0.05) = 3.69

Table-IIb. Analysis of variance of length of fruits/plant

SV	DF	SS	MSS	F
Block	2	1.820000+00	9.100000D+01	0.80^{NS}
Treatment	6	3.604571D+01	6.007619D+00	5.29**
Error	12	3.364000D+01	1.136667D+00	
Total	20	5.150571D+01		

CV = 7.46% (0.05) = 1.9

Table-IIc. Analysis of variance of weight/fruit

SV	DF	SS	MSS	F
Block	2	9.49	4.74	
Treatment	6	24.36	4.06	0.987^{NS}
Error	12	49.36	4.112	
Total	20	83.21	4.00	

CV = 6.215%

Table-IId. Analysis of variance of weight of fruits/plant

SV	DF	SS	MSS	F
Block	2	6.729955D+03	3.364978D	0.70^{NS}
Treatment	6	1.129974D+05	1.883289D	4.42*
Error	12	5.111962D+04	4.259968D+03	
Total	20	1.708469D+05		

CV = 21.78%

Table-IIIa. Analysis of variance of chlorophyll 'a' content of fresh leaf of 40 days old plant

SV	DF	SS	MSS	F
Block	2	1.861714D-03	9.308571D-04	0.70^{NS}
Treatment	6	2.660933D-02	4.434889D-03	3.34^{*}
Error	12	1.593295D-02	1.327746D-03	
Total	20	4.440400D-02		

CV = 12.56% LSD (0.05) = 0.065

Table-IIIb. Analysis of variance of chlorophyll 'b' content of fresh leaf of 40 days old plant

SV	DF	SS	MSS	F
Block	2	6.534286D-04	3.267143D-04	0.48^{NS}
Treatment	6	3.882762D-02	6.471270D-03	9.50^{**}
Error	12	8.171238D-03	6.809365D-04	
Total	20	4.765229D-02		

CV = 22.75% LSD (0.05) = 0.046

Table-IIIc. Analysis of variance of carotenoid content of fresh leaf at 40 days old plant

SV	DF	SS	MSS	F
Block	2	2.181223D+00	1.090611D+00	2.19^{NS}
Treatment	6	1.525349D+01	2.542249D+00	5.10^{**}
Error	12	5.976808D+00	4.980675D-01	
Total	20	2.341153D+01		

CV = 14% LSD (0.05) = 1.256

Table-IIId. Analysis of variance of chlorophyll 'a' carotenoid content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	9.240952D-04	4.620476D-04	0.35^{NS}
Treatment	6	3.760829D-02	6.2688048D-03	4.79^{*}
Error	12	1.568857D-02	1.307381D-03	
Total	20	5.422095D-02		

CV = 11.42% LSD (0.05) = 0.064

Table-IIIe. Analysis of variance of chlorophyll 'b' content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	4.220952D-04	2.110476D-04	0.12^{NS}
Treatment	6	9.698257D-02	1.616376D-02	9.43^{**}
Error	12	2.050457D-02	1.713714D-03	
Total	20	1.790692D-01		

CV = 22.28% LSD (0.05) = 0.074

Table-IIIf. Analysis of variance of carotenoid content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	1.319514D+00	6.597571D-01	1.42^{NS}
Treatment	6	5.469390D+00	9.115651D-01	1.96^{NS}
Error	12	5.583352D+00	4.652794D-01	
Total	20	1.237226D+01		

CV = 11.99%

EXPERIMENT 2

Table-IVa. Analysis of variance of plant height of 30 days old plant

SV	DF	SS	MSS	F
Block	2	1.011457D+00	5.057286D-01	0.93^{NS}
Treatment	6	3.524467D+00	5.874111D-01	1.08^{NS}
Error	12	6.533476D+00	5.444563-01	
Total	20	1.106940D+01		

CV = 9.98%

Table-IVb. Analysis of variance of plant height of 40 days old plants

SV	DF	SS	MSS	F
Block	2	1.594184D+01	7.970919D+00	1.82^{NS}
Treatment	6	1.028532D+01	1.714221D+00	0.39^{NS}
Error	12	5.268376D+01	4.390313D+00	
Total	20	7.891092D+01		

CV = 21.2%

Table-IVc. Analysis of variance of plant height of 50 days old plants

SV	DF	SS	MSS	F
Block	2	1.796600D+00	8.983000D+01	1.00^{NS}
Treatment	6	3.856532D+01	6.427554D+00	7.19**
Error	12	1.073233D+01	8.943611D-01	
Total	20	5.109426+01		

CV = 5.37% LSD (0.05) = 1.68

Table-IVd. Analysis of variance of plant height of 60 days old plant

SV	DF	SS	MSS	F
Block	2	1.556241D+01	7.781205D+00	2.22^{NS}
Treatment	6	2.199716D+02	3.666193D+01	10.44^{**}
Error	12	4.21399D+01	3.511166D+00	
Total	20	2.776680D+02		

CV = 5.55% LSD (0.05) = 3.33

Table-Va. Analysis of variance of number of fruits/plant

SV	DF	SS	MSS	F
Block	2	7.845457D+00	3.922729D+00	1.65^{NS}
Treatment	6	1.682001D+02	2.803336D+01	11.78^{**}
Error	12	2.85641D+01	2.380451D+00	
Total	20	2.046110D+02		

CV = 8.63% LSD (0.05) = 2.74

Table-Vb. Analysis of variance of length of fruits/plant

SV	DF	SS	MSS	F
Block	2	6.341895D+00	3.170948D+00	5.22^{*}
Treatment	6	1.000918D+01	1.668197D+00	2.75^{NS}
Error	12	7.287705D+00	6.073087D-01	
Total	20	2.363878D+01		

CV = 5.67%

Table-Vc. Analysis of variance of weight/fruit

SV	DF	SS	MSS	F
Block	2	1.320D+01	6.53	
Treatment	6	5.722D+01	9.53	1.89^{NS}
Error	12	6.028D+01	5.02	
Total	20	1.3071D+02	6.53	

CV = 1.99%

Table-Vd. Analysis of variance of weight of fruits/plant

SV	DF	SS	MSS	F
Block	2	1.573354D+04	7.866771D+03	2.91^{NS}
Treatment	6	1.5581960D+05	2.596993D+04	9.60**
Error	12	3.245560D+04	2.704633D+03	
Total	20	2.040087D+05		

CV = 14.01% LSD (0.05) = 92.52

Table-VIa. Analysis of variance of chlorophyll a content of fresh leaf at 40 days old plant

SV	DF	SS	MSS	F
Block	2	1.140410D-02	5.702048D	0.39^{NS}
Treatment	6	4.114252D-01	6.857087D-02	4.66*
Error	12	1.766219D-01	1.471849D-02	
Total	20	5.994512D-01		

CV = 20.82% LSD (0.05) = 0.216

Table-VIb. Analysis of variance of chlorophyll b content of fresh leaf at 40 days old plant

SV	DF	SS	MSS	F
Block	2	1.404371D-02	7.021857D-03	2.77^{NS}
Treatment	6	9.153143D-03	1.525524D-03	0.60^{NS}
Error	12	3.044339D-02	2.536857D-03	
Total	20	5.363914D-02		

CV = 16.44%

Table-VIc. Analysis of variance of carotenoid content of fresh leaf at 40 days old plant

SV	DF	SS	MSS	F
Block	2	2.250160D+00	1.125080D+00	2.20^{NS}
Treatment	6	1.024243D+01	1.707072D+00	3.34^{*}
Error	12	6.132478D+00	5.110399D-01	
Total	20	1.862507D+01		

CV = 13.21% LSD (0.05) = 1.272

Table-VId. Analysis of variance of chlorophyll a content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	1.245810D-03	6.229048D-04	0.18^{NS}
Treatment	6	3.943895D-02	6.573159D-03	1.95^{NS}
Error	12	4.048219D-02	3.373516D-03	
Total	20	8.116695D-02		

CV = 12.79%

Table-VIe. Analysis of variance of chlorophyll b content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	2.314667D-03	1.157333D-03	0.32^{NS}
Treatment	6	4.387581D-02	7.312635D-03	2.03^{NS}
Error	12	4.314333D-02	3.595278D-03	
Total	20	8.933381D-02		

CV = 20.17%

Table-VIf. Analysis of variance of carotenoid content of fresh leaf at 50 days old plant

SV	DF	SS	MSS	F
Block	2	0.532	0.266	
Treatment	6	5.774	0.962	5.281^{**}
Error	12	2.222	0.185	
Total	20	8.620		

CV = 8.05 LSD (0.05) = 0.765

Table-VIIa. Analysis of variance on ß-carotene content of fruit of lady's finger

SV	DF	SS	MSS	F
Block	2	3.427523D+02	1.713761D+02	3.79^{NS}
Treatment	6	4.738352D+02	7.897253D+01	1.75^{NS}
Error	12	5.430306D+02	4.525255D+01	
Total	20	1.359618D+03		

CV = 6.62%

Table-VIIb. Analysis of variance of ascorbic acid content of fruit of lady's finger

SV	DF	SS	MSS	F
Block	2	3.143895D+00	1.571	
Treatment	6	1.261938D+01	2.103	2.12^{NS}
Error	12	8.909505D+00	7.424587D-01	
Total	20	2.406278D		

CV = 4.06%

Table-VIIIc. Analysis of variance of protein content of fruit of lady's finger

SV	DF	SS	MSS	F
Block	2	6.353781D-02	3.176890D-02	
Treatment	6	1.409435D+00	2.349059D-01	0.29^{NS}
Error	12	1.335088D+00	1.112573D-01	
Total	20	2.808061D+00		

CV = 6.62%