STUDIES ON THE EFFECT OF GROWTH REGULATORS ON SEX EXPRESSION AND SEX RATIO IN BITTER GOURD (*Momordica charantia* L.)

By

P. S. RAVEENDRAN

THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri P.S.Raveendran under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

PRINCIPAL
Agricultural College &
Research Institute,
Vellayani, Trivandrum
10th July, 1964.

(P.KUMARA PILLAI)
Professor of
Agricultural Botany

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INTRODUCTION

INTRODUCTION

Among the vegetable crops cultivated in South India Cucurbits constitute an important group. Many of them yield excellent vegetables. Momordica is one of the ninety genera of the natural order Cucurbitaceae. Among them Momordica charantia-L usually known as bitter gourd is widely cultivated in South India. As a vegetable its nutritive value is very important. It is a rich source of minerals and vitamins, especially in iorn, phospherous and vitamin A and C. Immature fruits when properly cooked are agreeable to many people. Both ripe and unripe fruits are used for the preparation of pickle which invariably is one of the essential items of South Indian vegetarian dish. As a medicinal herb also this plant is reported to be very valuable.

Since the dawn of agriculture, one of man's principal aims has been the promotion of plant growth. But recently effective methods for controlling the development of plant growth has been brought into practical applications in the agricultural field. According to Audus (1959) the factors which are responsible for the control of plant growth are distinguished under three groups- nutritional, hormonal and genetic factors. These two aspects, 'promotion' and 'control' in relation to

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plant growth to obtain increased crop production are by no means synonymous. It has been soon realised that the promotion of lush and leafy growth does not always produce the best results in terms of fruits or seeds, and hence well known cultural methods such as pruning balanced manuring etc. have gained wide acceptance. Within the last twenty five years, however we have seen, the arrival of certain chemical substances, which have opened new possibilities to adjust the development pattern of the plant. These newcommers in agricultural and horticultural fields are known as growth regulating substances or plant growth substances. Within a relatively short span of time these growth regulating substances have gained wide acceptance in various stages of crop production.

Application of growth regulators in plant tissues either by seed treatment or by foliar sprays or by injection, at different stages of growth is found to produce striking effects. It has become clear that growth regulators are related with root initiation, fruit development, leaf and fruit abscission and many other phenomena. Growth regulators applied to plants at suitable concentrations provoke characteristic growth modifications of practical importance.

Extensive work has been carried out for studying the effect of growth regulators on various aspects of growth of many crop plants such as rice, wheat, cotton, sugarcane, cucurbits, tomato, brinjal, chillies, grapes etc. They are also used for enhancing the flower production and fruit setting which ultimately give higher yield.

Available literature on the studies of the application of hormones on crop plants reveals that, the work done on bittergourd is negligible. In other Cucurbits hormonal traits have been conducted for studying the sex expression and sex ratio. The flower which represents the external manifestation of the sex in large number of plants is usually unisexual or bisexual. But the variations in the sexual phenomena are so wide that any number of forms with several combinations of male and female components are seen in nature.

The study of the physiological basis of sex expression is outlined in this problem. Went (1954) has pointed out that the flowering process is more or less governed by environmental factors. It has been quite convincingly demonstrated that the sex behaviour in plants can be altered by varying environmental conditions such as photoperiod, temperature, humidity etc. Even the physical disturbances like pinching, pruning etc. have been shown to modify the sex pattern.

The discovery as well as the applications of auxin has proved beyond doubt the importance of physiological factors in controlling the sex behaviour in plants. At the same time from an economic point of view also it is very important. The ordinary cultivators who are directly concerned with increasing crop production, look forward to the economic significance involved in this problem.

Generally in Cucurbits there is a large predominance of male flowers over the female. Cultivators wonder why the plant could not produce more female flowers than the male, and thereby give an increased yield. They feel encouraged from the reported results of successful alterations of sex by the application of growth regulators which may enable them to produce maximum yield from a single plant. The present work deals with such an investigation on Momordica charantia, one of our widely cultivated cucurbits.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

GROWTH

General:

Studies on the effect of growth regulators have revealed that, they profoundly influence the growth behaviour of the plant.

Kiermayer (1959) studying the influence of TIBA and NAA, reported that TIBA produced various morphological effects where as NAA at higher concentrations retarded the growth. Stambera (1960) showed that in cucumber varieties, application of 0.002% TIBA inhibited the growth of the main axis and at the same time induced the growth of the laterals.

Schoene and Hoffmann (1949) found that tomato plants treated with MH at a concentration of 2000 ppm did not grow for a period of two months. Erickson and Price (1950) observed an inhibition in the growth of sugar beet seedlings sprayed with MH at 0.1%. Fillmore (1950) found that MH treated plants, in general, inhibited vegetative bud formation. McIlrath (1950) working in cotton revealed the characteristic effect of MH (growth inhibition) in that plant. Erickson et al (1952) studying the response of orange and grape fruit trees to MH noticed that, it delayed spring growth of Valencia orange and grape fruit, at concentrations ranging from 500 ppm to 100 ppm, but not at 100 ppm. Leopold and Klein (1952) also found the inhibitory effects of MH on peas. Andreae and Andreae (1953) suggested that MH might inhibit growth by causing excessive oxidation of IAA.

John (1940) treated bean seedling with 2% NAA in lanolin. The treatment resulted in swelling of the internode and inhibition of growth above the point of treatments. Kiermayer (1959) found that application of NAA at higher concentrations in tomato produced abnormal flower formation, the formation of lateral shoots and morphological changes in the leaves.

Height of the plant:

Erickson and Price (1950) studying some effect of MH on sugar beet plants showed that spray application of 1% MH permenently inhibited terminal growth and most of the plants died within four months. Victor (1950) reported the inhibition of main axis and the production of laterals in tomato and wheat plants when sprayed with MH. Ergle and Mcllrath (1952) obtained reduced growth in height of cotton plant when sprayed with MH at seedling stage. Mikkelsen et al (1952) found that in sugar beets foliar sprays of MH resulted in apical dominance. Esther and Beek (1952) studied the effect of MH on Croft Easter lilies (from 0.025 to 1.0%). The lower concentrations increased the growth in height while the higher concentrations reduced it. Growth is completely inhibited in concentrations above 0.1%. Srinivasan and Hamner (1962) observed that the foliar application of 1000 ppm MH in Lycopersicum esculentum resulted in the inhibition of vegetative and reproductive growth. The most noticeable effects were the retardation of stem growth in height and increase in stem diameter.

Leaf deformities:

Denffer (1952) observed that the application of TIBA greatly restricted the leaf expansion particularly that of lamina in various crop plants. Joseph and Applegate (1962) studied the effect of injecting TIBA into Kalanchoe diagremontiana. They reported that low concentrations of TIBA induced hyponasty while higher levels induced epinasty.

Currier and Crafts (1950) showed that when MH was sprayed on two-week old barley plants, the leaves turned dark-green and slowly died back from the tips. In the case of young water grass and Johnson grass sprayed with 0.2% MH stopped further growth and developed anthocyanin pigments through out the plant body. Esther and Beck (1952) while working on the effect of MH on the growth and flowering of Croft Easter lilies found that the plants treated with 1% solution produced deformitive effects on leaves and flowers. Srinivasan and Hamner (1962) reported that when Lycopersicum esculentum was sprayed with MH

1000 ppm, it decreased the length, altered the colour, texture and venation of leaves.

Walther (1952) observed that the phyllotaxy of flax was affected when treated with 2,4-D at cotyledonary stage. He found that leaf anomalies may be explained on the basis of increased productivity of the growing points and an inhibition of internodal lengthening. George and Olson (1953) reported leaf deformities in barley and oats when sprayed with 2,4-D at intervals of one day and two days. Walrand and Sironual (1953-54) noted many abnormalities in the first few formed leaves of the F1 offspring of Gossypium herbaceum when treated with 2,4-D. Zanardi (1956) found that Capsicum plants sprayed with 2,4-D 6 ppm developed dwarfed and deformed leaves from the terminal bud. Krishnamurthy and Bhandari (1957) obtained modified leaves - reduced size, changed shape and lobing and increased length and width - in 2,4-D (5, 10 and 50 ppm) treated Capsicum plants. Appalanaidu (1959) studied the effect of 2,4-D in Brassica kaber, Hibiscus esculentus and Helianthus annus. In Brassica even the lowest concentration (100 ppm) was found to be lethal. But Hibiscus and Helianthus responded rapidly. In both, the leaves and petioles became twisted and blades epinastic.

Nodes:

There are various reports that growth regulators may increase the number of nodes and the length of internodes which may ultimately result in increased height of the plants. Ergle and McIlrath (1952) noticed that in cotton plants the number of nodes were decreased by MH sprays.

Branches:

Schoene and Hoffmann (1949) studied the effect of 2000 ppm MH on tomato. He reported that though the terminal growth was inhibited, the growth was resumed by lateral branches. Fillmore (1950) showed that in plants treated with MH the growth of all vegetative buds were inhibited. Victor (1950) observed that in tomato, lime tree and wheat though the apical growth was stopped a number of lateral branches developed by treatment with MH 2000 ppm. Ergle and McIlrath (1952) reported that MH treatment had reduced the number of vegetative branches in cotton plant. Choudhury and Ramphal (1960) found in cow pea that spraying with MH (50, 100, 200, 400, 600 and 800 ppm) destroyed the apical dominance and forced up a number of lateral shoots. The effect was more pronounced in the case of the highest concentration, 800 ppm.

Walther (1952) observed that when flax plants were sprayed with 2,4-D, especially on the cotyledons and young leaves, the development of axillary buds were increased. But Appalanaidu (1959) reported that the effect of 2,4-D (100 ppm) sprays and injection in Hibiscus esculentus and Helianthus annus inhibited the growth of the axillary bud. In *Brassica kaber* this concentration was found to be totally lethal.

Fresh weight:

Currier *et al* (1951) recorded that when young barley plants were treated with MH, the fresh weight was found to be less than that of the control. Mikkelsen *et al* (1952) reported that the treatment with MH increased the fresh weight of sugar beets.

Root formation:

Appalanaidu (1959) reported that 2,4-D applied as sprays and injection caused abnormal root development from the stem region of *Hibiscus esculentus* and *Helianthus annus*. The roots were found to develop from the internodal region.

SEX EXPRESSION AND SEX RATIO

According to Skene (1932) the distribution of sex between flowers is usually determined by strict hereditary laws. But other factors such as auxins, daylength, nutritional status etc. may also greatly influence the sex expression in plants. The auxins are a relatively new arrival on the scene of sex determination. Attention to the influence of auxins in sex expression was first drawn by Laibach and Kribben (1950, 1951) and Laibach (1952).

A number of investigators have studied the factors which influence flowering and the ratio of male to female flowers in various members of cucurbitaceae. Whitaker (1931) and Whitaker and Davis (1962) have reported the results of studies of sex expression in 49 cultivated varieties of cucurbitaceae distributed among eight species and four genera. Each species is characterised by specific inherent qualitative types of sex expression. Staminate flowers are found to be in majority at all times in all forms studied.

Flower production:

It is evident from many of the published works that growth regulators can be used to accelerate and control flowering in many crop plants.

Galston (1947) found that in soyabean flowering could be augmented by the application of TIBA. But Laibach and Kribben (1951) reported that TIBA has no effect in inducing flower formation in the cucumber plants. Gorter (1951) observed that when young tomato plants were treated with TIBA, the inflorescence was reduced although the flower production was increased. Leopold and Guernsey (1954) obtained a higher percentage of flowering in Alaska pea (Pisum sativum) by treating with TIBA and NAA. Stambera (1961) recommended after a series of experiments that spray application of TIBA increased the production of female flowers in cucumbers.

Fillmore (1950) while studying the control of plant development with MH observed an inhibition in flowering. Naylor (1950) working on the effect of MH on flowering of tobacco, maize and cocklebur reported that the growth of flower bud was inhibited by MH treatment. Klein and Leopold (1953) stated that MH completely inhibited the production of flower primordia in winter barley, chrysanthemum and peppermint.

Clark and Kerns (1942) and Overbeek (1946) reported that flowering in pineapple could be induced by growth regulators such as NAA (50 mg/L) and 2,4-D (5 ppm). Teubner and Wittwer (1957) found that spray application of NAA specially induced greater number of flowers in tomatoes. Ueno (1957) while working in strawberries observed that the flower formation was inhibited by higher concentrations of NAA. Harley et al (1959) found that flower bud formation was increased by NAA sprays in grapes. But Kagawa (1959) found that NAA 10 ppm retarded flowering in spinach when treated in summer, while in autumn it caused an acceleration of floral induction. Satyanarayana and Rangaswami (1959) obtained reduction in total number of flowers in ribbed gourd when treated with NAA and 2,4-D at 25 ppm.

Zanardi (1956) observed a marked abortion of flower buds in *Capsicum* plants when treated with 2,4-D 6 ppm.

Sex ratio:

Wittwer and Hillyer (1954) studied the effect of TIBA and NAA on the sex expression and sex ratio in two cucumber varieties and one squash variety. The ratio of male to female flower in the two cucumber varieties and one squash variety treated with TIBA 25 ppm was reduced from 23:1, 14:1 and 1.47:1 to 8:1, 2:1 and 0.4:1, respectively. Heinze (1956) found that spraying the young melon plants with TIBA 50 and 200 mg/L affected the sex expression of flowers, although the concentrations used were too high. Ito and Saito (1956) studied the effect of several hormone sprayes in Japanese cucumber at the cotyledonary stage. They reported that female flower formation was slightly retarded by TIBA but was accelerated by 2,4-D, NAA and IAA and male flower formation was unaffected by TIBA, but was promoted by 2,4-D, NAA and IAA. Again Ito and Saito (1957) observed that when pinched stem tips of cucumber were treated with lanolin paste containimg TIBA and NAA sex reversal in lower staminate nodes was observed in the former treatment while in the latter, there was no effect. Venketram (1963) while studying the factors responsible for sex expression in snake gourd, reported that TIBA, MH and NAA increased the sex ratio in favour of the female. TIBA 500 ppm had given the highest female to male ratio of 1:17.1 closely followed by NAA 500 ppm with 1:24.8

NAA 200 ppm with 1:41.6, TIBA 200 ppm with 1:62.1, MH 500 ppm with 1:67.0 and TIBA 100 ppm with 1:79.0 as against 1:165.7 in the control.

Wittwer and Hillyer (1954) reported that MH when applied at a concentration of 250 to 350 ppm in plants in the first to second leaf stage caused a complete suppression of male flowers with no effect on the female flowers. Choudhury and Phatak (1959) studied the effect of four concentrations of MH (200, 400, 600 and 800 ppm) and 2 concentrations each of NAA (100 and 200 ppm), 2,4-D (5 and 10 ppm) and IAA (100 and 200 ppm) on the sex expression and sex ratio in cucumis sativus. MH 200 ppm and NAA 100 ppm increased the number of female flowers significantly over the control. MH 600 and 800 ppm and NAA 100 ppm suppressed the number of male flowers. All these four plant regulators thus found to increase the female to male flower ratio when compared with the control. Again Choudhury and Phatak (1960) confirmed the above result in Cucumis sativus and reported that the highest female to male ratio was obtained in the case of MH at a concentration of 200 ppm.

Laibach and Kribben (1950) found that in Cucumis sativus, NAA, 2,4-D and IAA when applied to petioles as paste favoured the production of female flowers. They again (1951) reported that NAA and IAA caused considerable increase in the number of female flowers in Cucurbita pepo. Wittwer and Hillyer (1954) reported that NAA sprays at 100 ppm reduced the male to female flower ratio from 14/1 to 2/1 in a hybrid variety of cucumber and from 23/1 to 8/1 in another variety of cucumber. Ito and Saito (1956) found that spray application of NAA at 10 ppm at 2,4,6 or 8 days intervals for a period of 40 days in cucumber accelerated female flower formation and retarded male flower formation. Brantley and Warren (1959) while studying the effect of auxins, photoperiod and nitrogen on sex expression in musk melon reported that NAA promoted female sex expression. Satyanarayana and Rangaswami (1959) studied the effect of NAA and 2,4-D on sex expression in ribbed gourd. They observed that NAA and 2,4-D when sprayed at seedling stage reduced the number of male flowers per plant, thus causing an increase in the percentage of female flowers. Brantley and Warren (1960) showed that in Cucurbits there was a great reduction in the staminate flowers and increase in the number of perfect flowers, when treated with NAA under long days.

Galun (1959) noticed a change towards maleness in cucumber plants when GA was applied on young leaves. Hensz and Mohr (1959) while working on the functional male sterility in water melon induced by chemical treatment found that the female to male sex ratio was decreased from

1:6 to 1:10 in the case of gibberallin and from 31:10 to 45:675 in FW-450 (Sodium alpha beta dichloro isobutyrate) treated plants. Paterson (1960) found that in gynoecious inbred line of cucumber plants gibberellin induced the production of staminate flowers. Bukovac and Wittwer (1961) stated that sex expression could be modified in cucumber by treating with several growth regulators. Mitchell and Wittwer (1962) obtained increased number of pistillate flowers in monoecious cucurbits when treated with allyle trimethyle ammonium bromide.

Flower size:

The application of growth regulators had also affected the time of flowering and flower size in many crop plants. Esther and Beck (1952) obtained abnormal and smaller flowers in Easter lilies when treated with MH at 0.025, 0.05, 0.1, 0.2 and 1.0%.

Time of flowering:

Currence (1932) studied the nodal sequence of flower type in cucumbers. He found that during the life of the cucumber plant, there was a gradual change from the staminate to pistillate condition. This change is related to the nodal sequence, the lower nodes being predominantly staminate and the upper ones pistillate.

White (1950) observed a delay of 24 days for flowering in black raspberries when treated with MH.

Josephson (1951) reported a delay in flowering of corn plants treated with MH. Helen (1952) while studying the effect of MH in delaying flowering and fruiting, showed that there was no delay in flowering of raspberries, strawberries and black current apples, when sprayed with MH at concentrations ranging from 10 to 1500 ppm. Nitsch _et al_ (1952) stated that in _Cucurbita pepo_, spray application with 100 ppm NAA at 2 leaved stage produced the first female flower round about the ninth node, where as in the control, female flowers were not formed upto the 20th node. Choudhury and Phatak (1959) reported that when cucumber plants were sprayed with four concentrations of MH (200, 400, 600 and 800 ppm) and two concentrations of NAA (100 and 200 ppm) and 2,4-D (5 and 10 ppm) the first female flowers were noticed on much lower nodes when compared with the control. Satyanarayana and Rangaswami (1959) noticed delayed flowering in ribbed gourd when sprayed with NAA and 2,4-D at two levels (0.05 and 25 ppm).

YIELD

Percentage of fruit set and total yield:

Growth regulators are found to be useful in supplementing or substituting normal pollination in the setting of fruits. An attempt was made by Johnson (1956) to find out the causes of unfruitfulness in some vegetable plants, and suggested how application of growth substance was able to reverse these effects and thus to increase the fruit set.

Vanicek (1951) reported that in tomatoes, spray application of TIBA at a concentration of 25 to 100 ppm increased the total yield of the plant.

Josephson (1951) found that in corn, MH sprays reduced the yield. Guyer and Kramer (1951) found a retarding effect on pod development in snap beans, when MH was applied at concentrations of 0.04, 0.02 and 1.0%. Choudhury and Bhatnagar (1959) recommended MH sprays for the production of good quality raddishes. Maini and Sandhu (1959) while working on <u>Eruca sativa</u> found that MH decreased the fruit set while NAA increased it. Choudhury and Ramphal (1960) reported that MH sprays (50, 100 and 200 ppm) significantly increased the yield in cow pea. But higher concentrations (400, 600 and 800 ppm) proved to be toxic and reduced the yield.

Ueno (1957) working in strawberries observed that NAA applied at higher concentrations before flower formation inhibited fruiting considerably, but was not so effective when applied after flower formation. Gibson (1959) obtained increased flower formation and fruit setting of tomatoes when treated with 10% NOA. Satyanarayana and

Rangaswami (1959) obtained increased fruit set in ribbed gourd treated with NAA and 2,4-D at 25 ppm concentration. The effect of 2,4-D was more prominent than NAA. But in apple, Marsh et al (1961) found a reduction in fruit set when sprayed with NAA.

Krishnamurthy and Subramaniah (1954) obtained increased fruit set when sprayed with 2,4-D in Solanum melangonum. The same authors again (1954) reported an increased percentage of fruit set (50 to 60) by the application of 2,4-D at a concentration of 0.0005% in the same crop. Muthukrishnan (1957) found that the application of 2,4-D (5 ppm) in brinjal resulted in 37% fruit set while only 12% was recorded in the control. Krjackov (1959) got a marked increase in fruit production by 2,4-D sprays (0.001%) in two varieties of tomato. Randhawa et al (1959) while studying the effect of various growth regulators on sweet lime reported that slight increase in number of fruits was obtained when 2,4-D, 15 ppm was applied. Ravoof (1962) observed increased fruit set in sapota when treated with 2,4-D and NAA.

Size and weight of fruit:

White (1950) reported no increase in size of the fruit in raspberries, when treated with MH. Studies of Erickson et al (1952) on the response of orange plants to MH treatment showed that, in Naval orange trees, spray applications of MH reduced fruit size and in Valencia orange the mean diameter of the fruit was reduced.

Ueno (1957) reported that NAA at higher concentration had an adverse effect in the fruit size of straberries. But an increase of fruit size in peaches by NAA sprays was reported by Lombalp et al (1959).

Stewart et al (1952) showed a considerable increase in the average fruit size in Valencia orange when sprayed with 2,4-D, 8 to 16 ppm. Krjackov (1959) found an increased fruit size in tomato when sprayed with 2,4-D, 0.001%. Randhawa et al (1961) noticed that 2,4-D 10 and 15 ppm improved the size and weight of fruits in sweet oranges.

Number of seeds per fruit:

Guyer and Karmer (1951) noticed a retarding effect on seed development in snap beans, when treated with MH, 0.04, 0.2 and 1.0%.

Singh and Kacker (1962) observed about 65% seedless fruits in tomato by NAA application. But Takashima et al (1957) had reported an increase in seed production in cucurbits and tomatoes by spraying the stigmas with NAA at flowering time. Maini and Sandhu (1959) pointed out that NAA sprays at 10, 20 and 40 ppm increased the total number of seeds. Lopez (1959) got seedless fruits in cucurbits when sprayed with NAA. Alonso (1955) reported that 2,4-D treatment resulted in completely seedless mature fruits. The treated fruits were irregular in shape the growth being greatest, around the few fertilized seeds. Taguchi and Nishiiri (1955) showed an improved seed set, in varietal crosses of potatoes by the application of 0.0005 to 0.007% 2,4-D. Krjackov (1959) obtained seedless fruits in two tomato varieties by the application of 2,4-D at 0.001%.

Work done by Santhakumari (1963) in the Division of Agricultural Botany, Agricultural College and Research Institute, Vellayani, revealed that NAA at 15 and 30 ppm and 2,4-D at 2 and 5 ppm concentrations enhanced flowering, fruit and seed setting in *Sesamum indicum*.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was carried out during 1963-64 in the Division of Agricultural Botany, Agricultural College and Research Institute, Vellayani.

A. MATERIAL

1. Seed material:

An early maturing variety of *Momordica charantia* was selected for this experiment.

The seeds were collected from two plants of the same variety in September 1963. From the two plants twenty eight healthy full grown fruits were selected and labelled. They were harvested when completely ripe and the seeds collected and sun dried for two days, and then kept safely in the laboratory.

2. Growth substances:

The following four growth regulators, each at four levels were used for the present investigation.

1. 2, 3, 5-tri-indo-benzoic acid (TIBA) supplied by L.Light and Co., Ltd., Colnbrook, England.
2. Maleic hydrazide (MH) - supplied by B.D.H.
3. Naphthalene acetic acid (NAA) - Supplied by Eastman Organic Chemicals, Rochester, U.S.A.
4. 2,4-Dichloro phenoxy acetic acid (2,4-D) supplied by B.D.H. (Horticultural variety)

Preliminary studies were conducted to fix the different concentrations of all the four growth substances. The chemicals at different concentrations were sprayed on plants raised from the above seeds. TIBA and MH, at 800 ppm, NAA at 600 ppm and 2,4-D at 15 ppm were found to cause abnormalities and detrimental to the normal growth of the plants. Therefore the following concentrations were considered suitable for the experiment.

1. <u>TIBA</u>		2. <u>MH</u>	
(i)	300 ppm.	(i)	100 ppm
(ii)	400 ,,	(ii)	300 ,,
(iii)	500 ,,	(iii)	500 ,,
(iv)	600 ,,	(iv)	700 ,,
3. <u>NAA</u>		4. <u>2,4-D</u>	
(i)	200 ,,	(i)	4 ,,
(ii)	300 ,,	(ii)	6 ,,
(iii)	400 ,,	(iii)	8 ,,
(iv)	500 ,,	(iv)	10 ,,

The solutions of all chemicals except TIBA were prepared by dissolving the required quantity of the chemical in 10 m.l. of 95% alcohol and then diluting by adding distilled water to obtain the required concentration. But in the case of TIBA it was first dissolved in 10 m.l. of isopropyle alcohol and then distilled water was added to get solutions of different concentration.

B. METHOD

1. Experimental design:

A proper statistical layout was adopted with a view to minimise the environmental variations.

Layout - Randomised Block Design

Treatments - 18 (Four chemicals, TIBA, MH, NAA and 2,4-D each at 4 levels and 2 controls)

Replication - 4

Spacing - 8' x 8'

Block size - 48' x 24'

Total number of plants - 72

Site - Botany Garden, Agricultural College and Research Institute, Vellayani.

Treatments:

1.	TIBA	300 ppm
2.	,,	400 ,,
3	,,	500 ,,
4	,,	600 ,,
5	MH	100 ,,
6	,,	300 ,,
7	,,	500 ,,
8	,,	700 ,,
9	NAA	200 ,,
10	,,	300 ,,
11	,,	400 ,,
12	,,	500 ,,

13	2,4-D	4 ppm
14	,,	6 ,,
15	,,	8 ,,
16	,,	10 ,,
17	Control	
18	,,	

2. Preparation of pots and sowing:

Seventy two earthen pots of uniform size (18" diameter) were selected for the purpose. The pots were filled uniformily with well mixed red soil, river sand and dried cow dung in the proportion of 1:1:1. Three seeds were dibbled in each pot at a distance of three inches apart and at a depth of one inch.

After seven days the seeds began to germinate. On the 10th day a thinning was carried out retaining only one healthy plant in each pot. Basal dressingswere given thrice, at the rate of five gms. of garden mixture per plant. Four protective sprays of folidol were given against pests during its growth for all the plants.

Seeds were sown on 11-11-1963 and the harvest was completed on 7-2-1964.

3. Application of growth regulators:

The chemicals were applied on the seed-lings as water sprays on the 14th day after sowing, when the plant was 2 to 3 leaf staged. A second spraying was done four days after the first spray, that is at 3 to 4 leaf stage. The quantity of solution needed for the first spray was 4 to 5 ml and 6 to 7 ml for the second spray. The control plants were sprayed with distilled water in the same manner as the treated plants were sprayed with chemicals.

4. Characters studied:

The following aspects of all the seventy two plants were studied separately.

GROWTH

1. Height of the main stem
2. Total height of the plant
3. Leaf deformities
4. Number of branches
5. Fresh weight of the plant
6. Root formation

SEX EXPRESSION AND SEX RATIO

1. Number of male flowers
2. Number of female flowers
3. Sex ratio
4. Time of flowering and acceleration of female phase

YIELD

1. Number of fruit
2. Percentage of fruit-set
3. Fresh weight of the fruits
4. Number of seeds per fruit

GROWTH

1. Height of the main stem:

The length of the main stem was first measured one week after the second spray and after that once in every two weeks, till the time of harvest.

2. Height of the plants:

Immediately after the harvest of fruits, the plants were cut down at the soil level and the vines removed carefully from the supports without breaking any of the smaller branches. The total height of the plant was recorded.

3. Leaf deformities:

Abnormalities found in the leaf size, shape, colour, texture etc. were noted.

4. Number of branches:

The number of branches was recorded once in two weeks and also at the time of harvest.

5. Fresh weight:

After the harvest the fresh weight of the whole plant was recorded.

6. Root formation:

The adventitious roots produced on the callus tissue were counted and recorded.

SEX EXPRESSION AND SEX RATIO

1 & 2. Number of male and female flowers:

The fully developed male and female flowers were counted daily from the first date of flowering to the date of harvest. The procedure adopted was as recommended by Whitaker (1931), Choudhury and Phatak (1959) and Venketram (1963). One petal from each flower counted was removed with a pair of scissors without causing injury to the essential organs, to mark out the flowers already counted.

3. Sex ratio:

The sex ratio of female flower to male flower was ascertained from the average number of flowers per treatment.

4. Acceleration of female phase:

The number of the node which produced the first female flower was recorded.

YIELD

1. Number of fruits:

Fully developed fruits from individual plants were counted and recorded.

2. Percentage of fruit-set:

Percentage of fruit-set was calculated by compa ring the number of fruits with total number of flowers per treatment.

3. Fruit weight:

The weight of the first five fully matured frui from each plant was recorded and the average weight per tre ment calculated.

4. Number of seeds per fruit:

The mean number of seeds from first five fruits were calculated.

The data regarding all the important characters such as height of the plant, number of male and female flowers, number of nodes, branches, fruits, and seeds per fruit, fresh weight of the plant and fruit were statistically analysed.

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

In the course of this study the seedlings were sprayed twice with aqueous solution of four growth regulators TIBA, MH, NAA and 2,4-D each at four different levels. All the morphological characters of the treated plants were studied in comparison with the controls. A few hours after spraying, drooping of the leaves was noticed in all treatments with NAA and the lower concentrations of all the other three chemicals. Higher concentrations of TIBA, MH and 2,4-D caused the seedlings as a whole to droop. However, after twenty four hours all of them became normal.

GROWTH

1. Height of the main stem:

Height of the main stem was measured just before the spray application and then once in two weeks and at the time of harvest. The mean height of all the treated plants and the controls are given in the Table I.

A general inhibitory effect on the growth of the main stem was found in all concentrations of TIBA and in the two higher concentrations of MH. The suppression of the growth of the main stem in treatments 1 to 4, 7 and 8 is shown in Plate V fig.6.

Although the higher concentrations of MH (500 and 700 ppm) were found to retard the height of the main stem, the

TABLE I

Height of the main stem - TIBA

Treatment No.	Treatment	Mean height in cms
1	TIBA 300 ppm	97.25
2	,, 400 ,,	54.75
3	,, 500 ,,	8.25
4	,, 600 ,,	9.25
5	MH 100 ,,	295.00
6	,, 300 ,,	347.50
7	,, 500 ,,	111.00
8	,, 700 ,,	118.25
9	NAA 200 ,,	305.00
10	,, 300 ,,	298.75
11	,, 400 ,,	279.75
12	,, 500 ,,	272.50
13	2,4-D 4 ,,	290.00
14	,, 6 ,,	330.00
15	,, 8 ,,	302.50
16	,, 10 ,,	302.50
17) 18)	Control	294.38

lower concentrations tried were found to promote the growth of the main stem, the greatest height being obtained in MH 300 ppm. In NAA treatments the lower concentrations 200 and 300 ppm were found to increase the height of the main stem, while higher concentrations had reduced the final height. 2,4-D also increased the length of the main stem except the lowest concentration tried, 4 ppm.

The growth curves of TIBA, MH, NAA and 2,4-D treated plants in comparision with control are given in graph Nos.I, II, III and IV respectively.

2. Total height of the plants:

The total height of the plants including branches for all the treatments was measured separately and the data statistically analysed. The analysis of variance is given in Table II.

In the analysis of variance, the treatment effect is found to be significant. The mean height of the plants corresponding to different chemicals is given in Table III in order of merit.

TABLE II

Analysis of variance table - Height of plants

Source	S.S.	d.f.	Var.	F.
Total	174311.11	71		
Block	28016.67	3	9338.89	5.71 *
Treatments	61298.61	16	3831.16	2.34 *
Between chemicals	21892.19	3	7297.40	4.46 *
Chemical vs. control	0.17	1	0.17	⊀ 1
Between levels of TIBA	5942.19	3	1980.73	1.21
MH	26904.69	3	8968.23	5.49 *
NAA	2854.69	3	951.56	⊀ 1
2,4-D	3704.69	3	1234.90	⊀ 1
TIBA vs. Control	1813.02	1	1813.02	1.11
MH vs. Control	1054.69	1	1054.69	⊀ 1
NAA vs. Control	117.19	1	117.19	⊀ 1
2,4-D vs. Control	4313.02	1	4313.02	2.64 *
Error	84995.83	52	1634.54	

*Significant at 5% level.
⊀less than 1

TABLE III

Mean Height of the plant

Rank	Chemical	Height in cms
1	2,4-D	322.19
2	NAA	298.44
3	MH	279.70
4	TIBA	275.31

Control - 293.75   C.D. - 29.68

2,4-D   NAA   MH   TIBA

The effect of 2,4-D alone was found to differ significantly from MH and TIBA. The difference in effect between 2,4-D and NAA, and NAA, MH and TIBA are not significant. Plants treated with 2,4-D and NAA grew to greater heights. The height of the plants treated with TIBA and MH was found to be less than that of the control. But the difference was not significant.

Comparing the different levels of chemicals, difference between the levels of MH alone is found to be significant. Mean height of the plants corresponding to different levels of MH is given in Table IV.

TABLE IV

Mean height - levels of MH

Rank	Treatment No.	Levels of MH	Height in cms.
1	6	300 ppm	325.00
2	5	100 ,,	315.00
3	8	700 ,,	248.75
4	7	500 ,,	230.00

Control - 293.75   C.D. - 57.405

6 5   8 7

The greatest height of the plant was obtained in treatment with MH 300 ppm closely followed by MH 100 ppm. Though in general MH treatments decreased the height of the plant, the lower concentrations (100 and 300 ppm) are far better than the control (Plate VI, figs 4, 5 and 7).

Mean height of the plants corresponding to different levels of TIBA is given in Table V.

TABLE V

Mean height - TIBA ,

Rank	Treatment No.	Levels of TIBA	Height in cms.
1	1	TIBA 300 ppm	298.75
2	2	,, 400 ,,	287.50
3	3	,, 500 ,,	266.25
4	4	,, 600 ,,	248.75

Control - 293.75 C.D. - 57.405

1 2 3 4

The difference between the different levels of TIBA is not significant. The lowest concentration of TIBA, 300 ppm alone increased the height of the plant than the control. In TIBA treatments the least effect was noticed in 600 ppm (Plate VI, fig.6).

The effect of different levels of NAA is given in Table VI.

TABLE VI

Mean height - NAA

Rank	Treatment No.	Levels of NAA	Height in cms
1	9	NAA 200 ppm	312.50
2	10	,, 300 ,,	308.75
3	11	,, 400 ,,	293.75
4	12	,, 500 ,,	278.75

Control - 293.75 C.D. - 57.505

9 10 11 12

Table shows that there is no significant difference between the levels of NAA. The lower concentrations had slightly increased the height of the plants when compared with the control.

Mean height of the plants in respect of different levels of 2,4-D is given in Table VII.

TABLE VII

Mean height - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Height in cms
1	15	2,4-D 8 ppm	335.00
2	14	,, 6 ,,	330.00
3	16	,, 10 ,,	327.60
4	13	,, 4 ,,	296.25

Control - 293.75 C.D. - 57.405

15 14 16 13

Table shows that the effect of different levels of 2,4-D is not significantly different. All the levels of 2,4-D had increased the height of the plants when compared with control. There was a general tendency for 2,4-D to increase the height of the plants, 2,4-D 8 ppm, 6 ppm and 10 ppm gave the highest recorded heights in the experiment - 335 cms, 330 cms and 327.6cms respectively (Plate VI figs.1-3).

3. Leaf deformities:

In plants sprayed with different concentrations of TIBA, the new formed leaves became crinkled, leathery and dark green, especially the veins (Pl.VII, figs-1-3). Later on the young leaves dried up from the periphery and apical growth was also stopped.

In MH treated plants leaf deformities appeared only at the later stage, especially at the highest concentration (Pl.VII, fig.4). Here also the leaves showed the tendency to become crinkled, but the colour of the leaves turned to pale green.

All concentrations of NAA and 2,4-D induced epinastic leaves in early stages (Pl.VII, figs.5-7). In the case of 2,4-D treatment the leaves were "stingy" with etiolated veins and dark green intervenal areas (Pl.VII, fig.8).

The morphological changes such as epinasty, crinkling etc. were very conspicuous in the leaves formed soon after spraying. These changes were not so pronounced in the later formed leaves and the normal shape of the leaves was gradually regained in all treatments.

4. Number of branches:

The number of branches in all the treatments were counted, and the data were statistically analysed. The analysis of variance table is given in Table VIII.

TABLE VIII

Analysis of variance table - Number of branches

Source	S.S.	d.f.	Var.	F.
Total	5683.87	71		
Block	88.82	3	29.61	1.34
Treatment	4451.12	16	78.19	12.64 *
Between chemicals	3406.43	3	1135.48	51.61 *
Chemicals vs. Control	11.39	1	11.39	≮ 1
Between levels of TIBA	54.25	3	18.08	≮ 1
MH	892.19	3	297.06	13.50 *
NAA	110.56	3	36.85	1.68
2,4-D	8.19	3	2.73	≮ 1
TIBA vs. Control	884.08	1	884.08	40.10 *
MH vs. Control	20.02	1	20.02	≮ 1
NAA vs. Control	45.65	1	45.65	≮ 1
2,4-D vs. Control	188.02	1	188.02	8.55 *
Error	1143.93	52	21.99	

* Significant at 5% level

≮ Less than 1

In the analysis of variance the treatment was found to be significant. The mean number of branches corresponding to different growth regulators were given in Table IX.

TABLE IX

Mean number of branches

Rank	Chemical	Number of branches
1	2,4-D	23.19
2	NAA	21.06
3	MH	15.31
4	TIBA	4.37

Control - 17.25 C.D. - 2.341

2,4-D NAA MH TIBA

When compared the effect of different chemicals, 2,4-D and NAA were found to increase the number of branches. Though 2,4-D produced better results than NAA, but difference between them was not significant. The difference between all other comparisions were significantly different from one another. Comparing the effect of the different chemicals with control the effect of 2,4-D and TIBA were found to be significant.

When the levels of the different chemicals were compared, only the levels of MH alone was found to be significant. In the other three chemicals the different levels were not significantly different. The mean number of branches for different levels of MH is given in Table X.

TABLE X

Mean number of branches - MH

Rank	Treatment No.	Levels of MH	Number of branches
1	6	300 ppm	29.75
2	5	100 ,,	20.50
3	7	500 ,,	8.25
4	8	700 ,,	7.75

Control - 17.25 C.D. - 6.66

6 5 7 8

Among the different levels of MH tried 300 ppm had increased the number of branches closely followed by 100 ppm. The higher concentrations 500 and 700 ppm had decreased significantly the number of branches.

Mean number of branches corresponding to different levels of TIBA is given in Table XI.

TABLE XI

Mean number of branches - TIBA

Rank	Treatment No.	Levels of TIBA	Number of branches
1	1	300 ppm	7.50
2	4	600 ,,	3.75
3	2	400 ,,	3.50
4	3	500 ,,	2.50

Control - 17.25 C.D. - 6.66

1 4 2 3

All the levels had considerably decreased the number of branches, when compared with the control, but the difference between levels was not significant.

Comparing the different levels of NAA, it was found that their effect also was not significantly different. The mean number of branches corresponding to different levels of NAA is given in Table XII.

TABLE XII.

Mean number of branches - NAA

Rank	Treatment No.	Levels of NAA	Number of branches
1	12	500 ppm	24.25
2	9	200 ,,	21.50
3	10	300 ,,	20.75
4	11	400 ,,	18.00

Control - 17.25 C.D. - 6.66

12 9 10 11

Though all the four levels of NAA individually contributed better effect than the control, the effect between the different lewels was not significant.

There was no significant difference between the levels of 2,4-D. The mean number of branches corresponding to different levels is given in Table XIII.

TABLE XIII

Mean number of branches - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Number of branches
1	16	10 ppm	24.25
2	13	4 ,,	23.25
3	15	8 ,,	23.00
4	14	6 ,,	22.25

Control - 17.25 C.D. - 6.66

16 13 15 14

From the table it is evident that all the four levels of 2,4-D increased the number of branches. But the effect between the four levels of 2,4-D tried was found to be more or less similar.

In TIBA treated plants the branches were produced from all the leaf axils in the early stages. But later due to the drying up of the main stem from the top, most of the branches except a few from the lower nodes were lost. An interesting phenomenon noted in this treatment was that the branches were produced even from the axils of the cotyledons. (Pl. VIII, figs 1-4).

In NAA treated plants not even a single branch was produced for about 2 weeks after the spray application (Pl.VIII, fig.5) while in controls and in all other treated plants branches were produced at very early stages of growth. The mean number of branches recorded during the first observation (two weeks after the 1st spray) is given in Table XIV.

5. Fresh weight of the plant:

The fresh weight of the plant was taken separately and the data analysed statistically. The analysis of variance table is given in Table XV.

TABLE XIV

Mean number of branches

Treatment No.	Treatment			Number of branches
1	TIBA	300	ppm	9.50
2	,,	400	,,	8.70
3	,,	500	,,	9.00
4	,,	600	,,	9.25
5	MH	100	,,	4.25
6	,,	300	,,	4.25
7	,,	500	,,	3.75
8	,,	700	,,	4.00
9	NAA	200	,,	0
10	,,	300	,,	0
11	,,	400	,,	0
12	,,	500	,,	0
13	2,4-D	4	,,	1.50
14	,,	6	,,	1.00
15	,,	8	,,	1.00
16	,,	10	,,	2.50
17, 18	Control			3.50

TABLE XV

Analysis of variance - Fresh weight of the plant

Source	S.S.	d.f.	Var.	F.
Total	974376.00	71		
Block	104949.00	3	34983.00	5.68 *
Treatment	549081.00	16	34317.56	5.57 *
Between chemicals	113396.88	3	37798.96	6.14 *
Chemicals vs. Control	25281.00	1	25281.00	4.10 *
Between levels of TIBA	13779.69	3	4593.23	≮ 1
MH	388779.69	3	125993.23	21.04 *
NAA	7125.00	3	2375.00	≮ 1
2,4-D	3218.75	3	1072.92	≮ 1
TIBA vs. Control	462.52	1	462.52	≮ 1
MH vs. Control	84085.02	1	84085.02	13.65 *
NAA vs. Control	10920.34	1	10920.34	1.77
2,4-D vs. Control	18174.09	1	18174.09	2.95
Error	320346.00	52	6160.50	

* Significant at 5% level.

≮ less than 1.

The treatments are found to be significant.

Comparing the effect of different growth regulators it was found that MH alone got significantly higher fresh weight than the three other chemicals. The mean fresh weight corresponding to different chemicals are given in Table XVI.

TABLE XVI.

Mean fresh weight of plants

Rank	Chemicals	Mean weight in gms
1	MH	399.06
2	2,4-D	331.87
3	NAA	318.75
4	TIBA	282.81

Control - 273.50 C.D. - 55.722

MH <u>2,4-D NAA TIBA</u>

MH treatment gave the highest fresh weight closely followed by 2,4-D and NAA, TIBA gave the least fresh weight. But even that was found to be greater than that of the control. The difference in effect between 2,4-D, NAA and TIBA are not significant, but all the three are significantly different from that of MH. When compared with control all the four chemicals produced better result, the effects of MH only being significant.

The effect of different levels of MH alone was found to differ significantly. The mean of the fresh weight for different levels of MH is given in Table XVII.

TABLE XVII

Mean fresh weight of the plant - MH

Rank	Treatment No.	Levels of MH	Weight in gms
1	6	300 ppm	663.75
2	5	100 ,,	356.25
3	8	700 ,,	293.75
4	7	500 ,,	282.50

Control - 273.50 C.D. - 111.44

6 $\overline{5 \quad 8 \quad 7}$

The second concentration of MH (300 ppm) increased the fresh weight of the plant to the maximum. The other three concentrations also increased the fresh weight when compared with the control but they were not significantly different from each other. But their difference with the effect of MH 300 ppm alone was significant.

The effect of different levels of TIBA was not found to differ significantly from each other. While 300 ppm and 500 ppm produced better result than control the fresh weight of the plants in the other concentrations decreased. The mean values are given in Table XVIII.

TABLE XVIII

Mean fresh weight of plants - TIBA

Rank	Treatment No.	Levels of TIBA	Weight in gms
1	3	500 ppm	310.00
2	1	300 ,,	307.50
3	2	400 ,,	251.25
4	4	600 ,,	237.50

Control - 273.50 C.D. - 111.44

3 1 2 4

Comparison between the different levels of NAA showed that they were not significantly different from each other. The mean values of fresh weight corresponding to different levels of NAA are given in Table XIX.

TABLE XIX

Mean fresh weight of plants - NAA

Rank	Treatment No.	Levels of NAA	Weight in gms
1	9	200 ppm	355.00
2	11	400 ,,	310.00
3	10	300 ,,	307.50
4	12	500 ,,	302.50

Control - 273.50 C.D. - 111.44

9 11 10 12

In this chemical all the four levels have individually promoted the fresh weight, even though these effects were not significantly different from one another.

In the case of 2,4-D also, all the four levels increased the fresh weight when compared with the control. Here also the difference in effect among the four levels of 2,4-D was not significant. The values corresponding to different levels of 2,4-D is given in Table XX.

TABLE XX

Mean fresh weight of plants - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Weight in gms
1	13	4 ppm	352.50
2	14	6 ,,	332.50
3	15	8 ,,	330.00
4	16	10 ,,	312.50

Control - 273.50 C.D. - 111.44

13 14 15 16

6. Root formation:

In the course of the investigation, an interesting morphological effect was noticed in NAA and 2,4-D treated plants, one week after the spray application. In the above treatments, the stem region just below the cotyledons split opened to form a callus. Numerous small adventitious roots were produced from this callus (Pl.VIII, fig.7). The number of the roots were greater and well marked in NAA treatments than in 2,4-D treatments (Table No.XXI).

TABLE XXI

Mean number of adventitious roots

Treatment No.	Treatment	Number of roots
9	NAA 200 ppm	15.70
10	,, 300 ,,	31.00
11	,, 400 ,,	45.00
12	,, 500 ,,	32.50
13	2,4-D 4 ,,	8.25
14	,, 6 ,,	28.00
15	,, 8 ,,	13.50
16	,, 10 ,,	15.25

The maximum number of roots were produced by NAA 400 ppm followed by NAA 500 ppm NAA 300 ppm and then by 2,4-D 6 ppm

SEX EXPRESSION AND SEX RATIO

1. Number of male flowers:

The total number of the male flowers in individual plants was counted and the data were statistically analysed to compare the effect of different chemicals on male sex expression. The analysis of variance is given in Table XXII.

TABLE XXII

Analysis of variance table - Number of male flowers

Source	S.S.	d.f.	Var.	F.
Total	538206.87	71		
Block	10700.15	3	3566.72	1.31
Treatment	385462.62	16	24091.41	8.82 *
Between chemicals	162442.05	3	54147.35	19.82 *
Chemicals vs. Control	1489.88	1	1489.88	≮ 1
Between levels of TIBA	327.50	3	109.16	≮ 1
MH	215995.69	3	71998.56	26.36 *
NAA	2572.25	3	857.42	≮ 1
2,4-D	2635.25	3	878.42	≮ 1
TIBA VS. Control	41301.34	1	41301.34	15.12 *
MH vs. Control	2537.52	1	2537.52	≮ 1
NAA vs. Control	5764.09	1	5764.09	2.11
2,4-D vs. Control	9020.09	1	9020.09	3.30
Error	142044.10	52	2731.62	

* Significant at 5% level

≮ less than 1.

In the analysis of variance the treatment was found to be significant.

When the growth regulators were compared separately with the control, the effect of TIBA alone was found to be significantly different. Between chemicals 2,4-D showed the maximum response, followed by MH. The chemical used and the mean number of male flowers produced are given below:

TABLE XXIII

Mean number of male flowers

Rank	Chemicals	Number of flowers
1	2,4-D	377.62
2	MH	358.31
3	NAA	303.62
4	TIBA	248.50

Control - 336.50 C.D. - 37.104

$\overline{\text{2,4-D} \quad \text{MH}}$ NAA TIBA

It was found that 2,4-D and MH increased the number of male flowers while the other two chemical had an adverse effect on male flower production. The difference between 2,4-D and MH was not significant.

The effect of different levels of MH alone was found to differ significantly. The mean number of male flowers produced by treating with different levels of MH is given in Table XXIV.

TABLE XXIV

Mean number of male flowers - MH

Rank	Treatment No.	Levels of MH	Number of male flowers
1	5	100 ppm	493.75
2	6	300 ,,	452.50
3	7	500 ,,	258.00
4	8	700 ,,	229.00

Control - 336.50 C.D. - 74.21

5 6 7 8

The maximum number of male flowers was produced by the lowest concentration (100 ppm). As the concentration increased there was a corresponding decrease in the number of male flowers. The lowest concentrations viz. 100 and 300 ppm increased the number of male flowers over the control while the higher two concentrations (500 and 700 ppm) decreased them considerably. The difference in effect between treatments 5 and 6 and 7 and 8 was not significant. But the two lower concentrations significantly differed from the higher concentrations.

It was further noticed that among all the eighteen treatments the highest number of male flowers was recorded in the lowest concentration of MH and the least number of male flowers in the highest concentration of MH.

Mean number of male flowers corresponsing to different levels of TIBA is given in Table XXV.

TABLE XXV

Mean number of male flowers - TIBA

Rank	Treatment No.	Levels of TIBA	Number of male flowers
1	2	400 ppm	254.50
2	1	300 ,,	251.25
3	4	600 ,,	244.25
4	3	500 ,,	244.00

Control - 336.50 C.D. - 74.209

2 1 4 3

In TIBA all the four levels decreased the number of male flowers when compared with the control. The difference between each treatment was not significant.

Similar results were obtained in treatments with NAA also. All the four levels of NAA tried decreased the number of male flowers when compared with the control, and there was no significant difference between the different levels. The mean number of the male flowers for different levels of NAA is given below.

TABLE XXVI

Mean number of male flowers - NAA

Rank	Treatment No.	Levels of NAA	Number of male flowers
1	12	500 ppm	316.00
2	9	200 ,,	315.75
3	10	300 ,,	296.00
4	11	400 ,,	286.75

Control - 336.50 C.D. - 74.209

12 9 10 11

Mean number of male flowers corresponding to different levels of 2,4-D is given in Table XXVII

TABLE XXVII

Mean number of male flowers - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Number of male flowers
1	13	4 ppm	399.75
2	16	10 ,,	371.50
3	14	6 ,,	371.00
4	15	8 ,,	368.25

Control - 336.50 C.D. - 74.209

13 16 14 15

All the four levels of 2,4-D increased the number of male flowers over the control but the four levels are not significantly different from each other.

In some of the treatments variation in the size of the male flowers was also noticed. The first three concentrations of TIBA (300, 400 and 500 ppm) and two concentrations of MH (100 and 300 ppm), NAA (400 and 500 ppm) and 2,4-D 6 and 8 ppm increased the size of the male flowers. But the highest concentration of TIBA (600 ppm) and the two higher concentrations of MH (500 and 700 ppm) decreased the flower size while the rest have no effect at all. The comparative size of male flowers in all the eighteen treatments is shown in Pl.VI, fig.8.

2. Number of female flowers:

The analysis of variance is given in Table XXVIII.

TABLE XXVIII

Analysis of variance table - Number of female flowers

Sources	S.S.	d.f.	Var.	F.
Total	677.11	71		
Block	55.00	3	18.33	3.54 *
Treatment	353.11	16	22.07	4.27 *
Between chemicals	46.50	3	15.50	3.00 *
Chemicals vs. Control	51.36	1	51.36	9.93 *
Between levels of TIBA	28.69	3	9.56	1.85
MH	97.69	3	32.56	6.29 *
NAA	48.19	3	16.06	3.10 *
2,4-D	80.69	3	26.90	5.20 *
TIBA vs. Control	35.02	1	35.02	6.77 *
MH vs. Control	77.52	1	77.52	14.99 *
NAA vs. Control	11.02	1	11.02	2.13
2,4-D vs. Control	46.02	1	46.02	8.90 *
Error	269.00	52	5.17	

* Significant at 5% level.

The treatment was found to be significant.

The mean number of female flowers corresponding to different growth regulators used are given in Table XXIX.

TABLE XXIX

Mean number of female flowers

Rank	Chemical	Number of female flowers
1	MH	12.31
2	2,4-D	11.44
3	TIBA	11.06
4	NAA	9.44

Control - 8.50 C.D. - 1.614

MH 2,4-D TIBA NAA

The maximum number of female flowers was produced by MH treated plants. The other three chemicals also increased the production of female flowers when compared with the control. Between the four chemicals, the differences in effect between MH and NAA and 2,4-D and NAA were only significant. When the chemicals were separately compared with the control, only MH and 2,4-D were found to be significantly different from the control.

In comparing the different levels of each chemical, the levels of MH, NAA and 2,4-D were found to be significant while there was no difference between levels of TIBA.

The mean number of female flowers corresponding to different levels of MH is given in Table XXX.

TABLE XXX

Mean number of female flowers - MH

Rank	Treatment No.	Levels of MH	Number of female flowers
1	5	100 ppm	15.75
2	6	300 ,,	13.50
3	8	700 ,,	10.50
4	7	500 ,,	9.50

Control - 8.50 C.D. - 3.22

5 6 8 7

The lowest concentration of MH, 100 ppm produced the best result which is closely followed by the next higher level 300 ppm. The higher concentrations 500 and 700 ppm decreased the number of female flowers when compared with the lower concentrations, but they were found to produce more female flowers than the control. The comparison between 100 ppm and 300 ppm, 300 ppm and 700 ppm and 700 ppm and 500 ppm were not significant.

The four levels of NAA were also found to be significantly different from each other. The mean number of female flowers pertaining to different levels of NAA were given in Table XXXI.

TABLE XXXI

Mean number of female flowers - NAA

Rank	Treatment No.	Levels of NAA	Number of female flowers
1	10	300 ppm	12.75
2	11	400 ,,	10.00
3	9) 12)	200) 500) ,,	8.50

Control - 8.50 C.D. - 3.228

10 11 (9 & 12)

NAA 300 ppm produced better results which is followed by 400 ppm. The lowest (200 ppm) and the highest (500 ppm) concentrations are same as that of the control. Here only the differences between 300 ppm and 200 ppm and 300 ppm and 500 ppm were significant.

The mean number of female flowers belonging to the different levels of 2,4-D is given in Table XXXII.

TABLE XXXII

Mean number of female flower - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Number of female flower
1	13	4 ppm	15.75
2	14) 15)	6) 8) ,,	10.75
3	16	10 ,,	9.50

Control - 8.50 C.D. - 3.228

13 $\overline{(14 \& 15) \quad 16}$

This table reveals that all the four concentrations increase the number of female flowers, over the control. The lowest concentration (4 ppm) was proved to be the best followed by the second and third concentrations (6 and 8 ppm). The highest concentration (10 ppm) produced the least number of female flowers. Thus, as the concentration increased there was a gradual decrease in the number of female flowers. The difference in effect of 4 ppm with all other concentrations was significant.

The different levels of TIBA tried did not significantly differ from each other though all of them increased the number of flowers considerably over the control. The mean number of female flowers corresponding to different levels of TIBA is given in Table XXXIII.

TABLE XXXIII

Mean number of female flowers - TIBA

Rank	Treatment No.	Levels of TIBA	Number of female flowers
1	1	300 ppm	13.00
2	2	400 ,,	11.25
3	3	500 ,,	10.75
4	4	600 ,,	10.25

Control - 8.50 C.D. - 3.228

1 2 3 4

In this case also the lowest concentration was the best and the number of flowers decreased when the concentration was increased.

3. Sex ratio:

The total number of female and male flowers was counted, and the sex ratio was arrived at. It is expressed as so many male flowers per female flower (Pl.II)

The results are furnished in Table XXXIV.

From this table it is evident that all the sixteen treatments have contributed to the better results in the sex ratio of female to male flowers when compared with the control. MH 300 ppm has given the highest female to male sex ratio of 1:19.11 closely followed by TIBA 300 ppm with 1:19.31 and thereafter by MH 700 ppm with 1:21.80 and so on as against 1:39.50 of the control. The higher concentrations of 2,4-D (6, 8 and 10 ppm) and NAA 200 and 500 ppm are rather weak agents in promoting the sex ratio of female to male.

4. Time of flowering and acceleration of female phase:

All the treatments showed a delay in flowering when compared with the control. 2,4-D, NAA and TIBA treatments delayed flowering for 5, 7 and 10 days respectively.

TABLE XXXIV

Sex Ratio

Treatment in order of merit

Rank	Treatment No.	Treatments			Sex ratio
1	6	MH	300	ppm	1:19.11
2	1	TIBA	300	,,	1:19.31
3	8	MH	700	,,	1:21.80
4	2	TIBA	400	,,	1:22.62
5	3	,,	500	,,	1:22.88
6	10	NAA	300	,,	1:23.21
7	7	MH	500	,,	1:24.10
8	13	2,4-D	4	,,	1:26.21
9	4	TIBA	600	,,	1:26.40
10	11	NAA	400	,,	1:28.68
11	5	MH	100	,,	1:31.35
12	15	2,4-D	8	,,	1:34.24
13	14	,,	6	,,	1:36.18
14	9	NAA	200	,,	1:37.14
15	12	,,	500	,,	1:37.17
16	16	2,4-D	10	,,	1:39.06
17	17 & 18	Control			1:39.50

In cucurbits usually the staminate flowers appear about a week before the emergence of the first pistillate flower. But an interesting feature was noticed during the course of this study in certain treatments viz. MH and TIBA 300 ppm which produced the highest female to male flower ratio. In the above treatments the female flower emerged three to four days before the first male flower appeared. In treatments with MH 700 ppm, TIBA 400 ppm, NAA 300 ppm and 2,4-D4 ppmfemale and male flowers appeared on the same day.

There is a relationship between the node of emergence of the first female flower and female sex expression. Lower the node, more favourable was the female sex expression. This trend was more predominant in treatments with MH 100 and 300, NAA 300 and 2,4-D 4 and 8 ppm.

Appearance of pistillate flowers on continuous nodes was also found to promote the female phase. Pistillate flowers were seen appearing continuously on seven to eight nodes on treatments with MH 300 and TIBA 300 ppm (Pl. IX, figs 1 and 2), which ranked first and second in Table XXXIV expressing the female to male sex ratio. In treatments TIBA 400 and 500 ppm, MH 500 and 700 ppm and 2,4-D 4 ppm also, female flowers were found to appear continuously on more than four nodes (Pl.IX, figs.3-7), whereas, in control, female flowers were not seen on more than two continuous nodes.

YIELD

1. Number of fruits:

The total number of well developed fruits in different treatments was recorded separately and the data analysed statistically. The analysis of variance is given in Table XXXV.

In the analysis of variance, the treatment effect is found to be significant.

TABLE XXXV

Analysis of variance

Number of fruits

Source	S.S.	d.f.	Var.	F.
Total	584.99	71	.	--
Block	58.26	3	19.42	4.08 *
Treatment	279.74	16	17.48	3.67 *
Between chemicals	78.67	3	26.22	5.52 *
Chemical vs. Control	56.88	1	56.88	11.97 *
Between levels of TIBA	12.75	3	4.25	≁ 1
MH	71.69	3	23.89	5.02 *
NAA	19.50	3	6.50	1.36
2,4-D	54.25	3	18.08	3.80 *
TIBA vs. Control	30.09	1	30.09	6.33 *
MH vs. Control	67.69	1	67.69	14.25 *
NAA vs. Control	8.34	1	8.34	1.75
2,4-D vs. Control	90.75	1	90.75	19.10 *
Error	246.99	52	4.75	

* Significant at 5% level.

≁ less than 1

The comparision between the growth regulators was found to be significant. The mean number of fruits for different chemicals was given in Table XXXVI.

TABLE XXXVI

Mean number of fruits.

Rank	Treatment	No. of fruits
1	2,4-D	10.63
2	MH	10.06
3	TIBA	8.88
4	NAA	7.75

Control - 6.5 C.D. - 1.57

2,4-D MH TIBA NAA

The difference in effect between 2,4-D and TIBA, 2,4-D and NAA and MH and NAA were significant. 2,4-D had significantly increased the number of fruits than TIBA and NAA, but MH was significantly superior only to NAA. When compared with the control the effect of all chemicals except NAA was found to be significantly superior.

Among the chemicals tried, the different levels of MH and 2,4-D only were found to be significantly different The mean number of fruits for each levels of MH is given in Table XXXVII.

TABLE XXXVII

Mean number of fruits - MH

Rank	Treatment No.	Levels of MH	Number of fruits
1	5	100 ppm	12.75
2	6	300 ,,	10.75
3	8	700 ,,	9.00
4	7	500 ,,	7.75

Control - 6.5 C.D. - 3.094

5 6 8 7

The lowest concentration of MH (100 ppm) was found to be significantly better than the higher concentrations tried (500 & 700 ppm), but its difference with 300 ppm was not significant.

Different levels of 2,4-D were also found to be significantly different. The mean number of fruits and level of 2,4-D are given in table below:

TABLE XXXVIII

Mean number of fruits - 2,4-D.

Rank	Treatment No.	Levels	Number of fruits
1	13	4 ppm	13.75
2	15	8 ,,	10.00
3	14	6 ,,	9.75
4	16	10 ,,	9.00

Control - 6.5 C.D. - 3.094

13 15 14 16

As in MH, in 2,4-D also the lowest concentration tried (4 ppm) was found significantly superior to the other concentrations.

The comparison between the effect of different levels of TIBA and NAA were not significant.

The mean number of fruits produced by different levels of TIBA are given in Table XXXIX

TABLE XXXIX

Mean number of fruits - TIBA

Rank	Treatment No.	Levels	Number of fruits
1	1	300 ppm	10.0
2	2	400 ,,	9.5
3	3 & 4	500 & 600 ,,	8.0

Control - 6.65 C.D. - 3.094

1 2 (3 & 4)

All the four levels of TIBA produced more fruits than the control. The difference between themselves was not significant.

In the case of NAA even though the effect of different levels was not significant, the higher three concentrations produced greater number of fruits than the control. The details are given in Table XL.

TABLE XL

Mean number of fruits - NAA

Rank	Treatment No.	Levels	Number of fruits
1	11	400 ppm	9.00
2	10	300 ,,	8.75
3	12	500 ,,	6.75
4	9	200 ,,	6.50

Control - 6.5 C.D. - 3.094

$\overline{11 \quad 10 \quad 12 \quad 9}$

2. Percentage of fruit-set:

The percentage of fruit-set corresponding to different treatments are furnished in Table XLI (Pl.III).

All the treatments except the lowest concentrations of TIBA and NAA increased the percentage of fruit-set when compared with control. All the four concentrations of 2,4-D proved to be the best treatments among those tried. The maximum result was produced by 2,4-D 6 ppm (95.12%), while the percentage of fruit-set in control was only 78.00. The 2,4-D treatments were followed by NAA 400 and 300 ppm. Though the lowest level of TIBA decreased the percentage of fruit-set slightly, all the other concentrations were proved to be better than the control. When the concentration was increased the percentage of fruit-set also increased. The two lower concentrations of MH viz. 100 and 300 ppm and the highest

TABLE XLI

Percentage of fruit-set

Treatment No.	Treatment		% of fruit-set
1	TIBA	300 ppm	76.92
2	,,	400 ,,	84.44
3	,,	500 ,,	86.00
4	,,	600 ,,	86.49
5	MH	100 ,,	80.94
6	,,	300 ,,	79.63
7	,,	500 ,,	81.58
8	,,	700 ,,	85.71
9	NAA	200 ,,	76.59
10	,,	300 ,,	88.22
11	,,	400 ,,	90.00
12	,,	500 ,,	79.41
13	2,4-D	4 ,,	90.24
14	,,	6 ,,	95.12
15	,,	8 ,,	93.02
16	,,	10 ,,	94.73
17 & 18	Control		78.00

concentration of NAA 500 ppm proved to be rather weak agents in increasing the percentage of fruit-set.

3. Fresh weight of the fruits:

The weight of the first five fully matured fruits harvested from each plant was recorded (Pl. IV). The mean weight per treatment was calculated and the data statistically analysed. The analysis of variance is given in TABLE XLII.

TABLE XLII

Analysis of variance

Fruit weight

Source	S.S.	d.f.	Var.	F.
Total	42703.74	71		
Block	1373.13	3	457.71	1.22
Treatment	21751.25	16	1359.45	3.61 *
Between Chemicals	3324.19	3	1108.06	2.94 *
Chemicals vs. Control	950.17	1	950.17	2.52
Between levels of TIBA	931.35	3	310.45	≮ 1
MH	5522.86	3	1874.29	4.98 *
NAA	1803.23	3	601.08	1.60
2,4-D	9219.45	3	3073.15	8.16 *
TIBA vs. Control	2422.52	1	2422.52	6.43 *
MH vs. Control	1019.36	1	1019.36	2.71
NAA vs. Control	507.00	1	507.00	1.35
2,4-D vs. Control	9.72	1	9.72	≮ 1
Error	19579.36	52	376.53	

* Significant at 5% level.

≮ less than 1

In the analysis of variance, the treatment is found to be significant. The effect of different chemicals was also found to be significantly different.

Table XLIII shows the mean weight of the fruits obtained in treatments with different chemicals.

TABLE XLIII

Mean weight of fruits

Rank	Chemicals	Fruit weight in gms
1	TIBA	114.59
2	MH	107.10
3	NAA	103.02
4	2,4-D	94.62

Control - 93.55 C.D. - 13.77

TIBA MH NAA 2,4-D

All the four chemicals gave higher fruit weights than the control. But the effect of TIBA alone was significantly higher than control. Among the chemicals tried 2,4-D had the least effect.

The comparison between the different levels of each chemicals showed that the levels of MH and 2,4-D were significantly different from one another, but the difference in effect between the levels of TIBA and NAA was not significant.

The mean weight of fruits corresponding to different levels of MH is given in the table below:

TABLE XLIV

Mean weight of fruits - MH

Rank	Treatment No.	Levels of MH	Weight of fruits in gms
1	5	100 ppm	123.55
2	6	300 ,,	117.70
3	7	500 ,,	111.35
4	8	700 ,,	75.80

Control - 93.55 C.D. - 27.552

$\overline{5 \quad 6 \quad 7}$ 8

This table shows that the first three levels of MH viz. 100, 300 and 500 ppm produced more fruit weight while the highest concentration, 700 ppm decreased the weight of fruits. The first three concentrations were not significantly different from each other, but all of them were significantly different from 700 ppm. There was a steady decrease in fruit weight as the concentration of MH was raised from 100 to 700 ppm

The mean weight of fruits corresponding to different levels of 2,4-D is given below:

TABLE XLV

Mean weight of fruits - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Weight of fruit in gms
1	16	10 ppm	112.45
2	15	8 ,,	107.65
3	14	6 ,,	105.10
4	13	4 ,,	53.00

Control - 93.55 C.D. - 27.552

16 15 14 13

The highest concentrations of 2,4-D, 10 ppm produced best result which was closely followed by the next lower concentrations of 8 ppm and 6 ppm. The respective fruit weights of these 3 treatments were 112.45, 107.65 and 105.10 gms. They were not significantly different from each other. But the lowest concentration of 4 ppm gave the least fruit weight, 53.00 gms which was significantly lower than the other three levels and the control. Here as the concentration of 2,4-D decreased from 10 ppm to 4 ppm there was also a steady decrease in the fruit weight.

The effect of different levels of TIBA and NAA were not significantly different. The mean weight of fruits corresponding to different levels of TIBA is given in Table XLVI.

TABLE XLVI.

Mean weight of fruits - TIBA

Rank	Treatment No.	Levels of TIBA	Weight of fruits in gms
1	2	400 ppm	125.50
2	1	300 ,,	117.85
3	3	500 ,,	108.65
4	4	600 ,,	106.35

Control - 93.55 C.D. - 27.552

2 1 3 4

In TIBA though all the four concentrations increased the weight of fruits from that of the control they were not significantly different from each other. Only the effect of TIBA 400 ppm could be considered significantly better than that of control.

The average weight of fruits pertaining to different levels of NAA is given in Table XLVII.

TABLE XLVII

Mean weight of fruits - NAA

Rank	Treatment No.	Levels of NAA	Weight of fruit in gms
1	9	200 ppm	115.20
2	10	300 ,,	111.80
3	11	400 ,,	94.30
4	12	500 ,,	90.80

Control - 93.55 C.D. - 27.552

9 10 11 12

When the different levels of NAA were compared, it was found that they were not significantly different from each other though all the levels except the highest concentration, 500 ppm increased the fruit weight from that of the control. In this case also just as in MH treatment the fruit weight decreased as the concentration of the growth regulator increased.

4. Number of seeds per fruit:

The total number of seeds in the first five fruits harvested from each plant was recorded and the mean number of seeds per fruit corresponding to different treatments was determined. The final data were subjected to statistical analysis. The analysis of variance is given in Table XLVIII.

TABLE XLVIII

Analysis of variance
Number of seeds

Source	S.S.	d.f.	Var.	F.
Total	2366.65	71		
Block	24.13	3	8.04	≮ 1
Treatment	1794.58	16	112.16	10.76 *
Between Chemicals	907.12	3	302.39	29.02 *
Chemicals vs. Control	107.82	1	107.82	10.35 *
Between levels of TIBA	129.68	3	43.23	4.15 *
MH	153.71	3	51.24	4.72 *
NAA	13.75	3	4.58	≮ 1
2,4-D	482.51	3	160.84	15.44 *
TIBA vs. Control	358.06	1	358.06	34.36 *
MH vs. Control	98.61	1	98.61	9.46 *
NAA vs. Control	149.90	1	149.90	14.39 *
2,4-D vs. Control	24.24	1	24.24	2.33
Error	541.94	52	10.42	

* Significant at 5% level

≮ less than 1

The treatment effect is found to be significant. The effect of the four chemicals, were also found to be significantly different. The mean number of seeds per fruit corresponding to different chemicals is given in Table XLIX.

TABLE XLIX

Mean number of seeds

Rank	Chemicals	Number of seeds
1	TIBA	26.52
2	NAA	23.54
3	MH	22.62
4	2,4-D	16.20

Control - 18.325 C.D. - 2.29

TIBA NAA MH 2,4-D

The seed production was increased by TIBA, NAA and MH, but 2,4-D had an adverse effect on the production of seeds. TIBA produced the maximum response, followed by NAA and MH, the difference between these two chemicals being not significant. The effect of these three chemicals was significantly better than that of control. The number of seeds produced in the treatment with 2,4-D, was less than that of control but the difference between them was not significant.

The comparison between different levels of the chemicals had shown that only the effects between the levels of TIBA and MH were significantly different, whereas there was not significant difference between different levels of 2,4-D and NAA.

Mean number of seeds corresponding to different levels of TIBA is given in Table L.

TABLE L

Mean number of seeds - TIBA

Rank	Treatment No.	Levels of TIBA	Number of seeds
1	2	400 ppm	29.95
2	1	300 ,,	28.35
3	3	500 ,,	25.20
4	4	600 ,,	22.575

Control - 18.325 C.D. - 4.583

2 1 3 4

All the four concentrations of TIBA had increased the number of seeds when compared with the control. The maximum number of seeds was obtained in the treatment with TIBA 400 ppm. This was closely followed by the concentration 300 ppm. The effect of these two concentrations was not significantly different from each other. This was further followed by concentrations 500 and 600 ppm. Eventhough they did not significantly differ between themselves the effect of the concentration 600 ppm was alone definitely inferior to that of 300 ppm.

TABLE LI

Mean number of seeds - MH

Rank	Treatment No.	Levels of MH	Number of seeds
1	5	100 ppm	25.30
2	6	300 ,,	24.50
3	7	500 ,,	23.30
4	8	700 ,,	17.40

Control - 18.325 C.D. - 4.583

$\overline{5 \quad 6 \quad 7} \quad 8$

The maximum number of seeds was obtained by the treatment MH 100 ppm followed by 300 and 500 ppm. The difference between these three levels was not significant.

MH 700 ppm had decreased considerably the number of seeds when compared with the control. A steady decrease in the number of seeds was noticed as the concentration of MH was increased from 100 to 700 ppm.

The mean number of seeds obtained for different levels of 2,4-D is given in the table below.

TABLE LII

Mean number of seeds - 2,4-D

Rank	Treatment No.	Levels of 2,4-D	Number of seeds
1	16	10 ppm	22.05
2	15	8 ,,	20.525
3	14	6 ,,	13.90
4	13	4 ,,	8.30

Control - 18.325 C.D. - 4.58

16 15 14 13

2,4-D 10 ppm had produced the maximum number of seeds. This was followed by concentrations, 8, 6 and 4 ppm respectively. Thus there was a steady decrease in the number of seeds produced as the concentration of 2,4-D decreased. The higher concentrations 10 and 8 ppm did not differ significantly between themselves but their response was significantly higher than that of the lower two concentrations, 6 and 4 ppm.

The different levels of NAA and the mean number of seeds obtained are given in Table LIII.

TABLE LIII

Mean number of seeds - NAA

Rank	Treatment No.	Levels of NAA	Number of seeds
1	9	200 ppm	24.625
2	10	300 ,,	23.65
3	12	500 ,,	23.50
4	11	400 ,,	22.10

Control - 18.325 C.D. - 4.583

9 10 12 11

The number of seeds was increased by all the levels of NAA when compared with control, the greatest increase being caused by NAA 200 ppm, followed in order by 300, 500 and 400 ppm. The difference between the last three concentrations was not significant.

D I S C U S S I O N

D I S C U S S I O N

Studies on the effect of growth regulators in various plants, carried out in different parts of the world had not yielded uniform results. The effect of the growth substance may be harmful as well as beneficial. Growth regulators enter into the plant and come in contact with the living cells, before they alter the plant growth. The action of a given chemical on the plant parts may depend upon the rate and amount of penetration of the material concerned. The response to growth regulators also depends partly on the age of the plant treated.

GROWTH

Height of the main stem:

In the present investigation a general retardation of the growth of the main stem was noticed in all the four concentrations of TIBA and in the two higher concentrations of MH 500 and 700 ppm. This effect was more predominant in plants treated with TIBA 500 and 600 ppm. As early as 1950, Fillmore and Erickson and Price had reported that different concentrations of MH had caused inhibition of growth in sugar beets. McIlrath (1950) and Ergle and McIlrath (1952) in cotton and Klein and Leopold (1953) in Peas had also noted the inhibitory effect of MH. The inhibitory effect of MH was also reported by Choudhury and Phatak (1959, 1960) in Cucumis sativus, in all the concentrations tried, viz. 200, 400, 600 and 800 ppm. But in the present study, the lower concentrations of MH was found to promote the main stem growth and the maximum height of the main stem in all treatments was obtained by MH 300 ppm. This is more or less supported by the work of Mikkelsen et al (1952). They found that foliar spray of MH in sugar beets had promoted the apical growth.

A general inhibitory effect of TIBA was noticed in the present study. Stambera (1960) also found that TIBA treatment had definitely suppressed the growth of the main axis of cucumber plants. Here in Momordica, all the concentrations of TIBA tried had definitely suppressed the growth of the main stem. Eventhough the apical growth was thus suppressed numerous lateral branches were produced and their growth was also promoted at a much quicker rate. Similar results were also obtained by Victor (1950) in tomato and wheat and Kiermayer (1959) in tomato.

The inhibition of the growth of the main stem may be due to the general toxicity caused by the treatments in the tender tissues of the plant, leading to the destruction of the terminal bud and adjacent tissues. According to Andreae and Andreae (1953) the inhibition of the growth of the main stem may also be caused by the high oxidation of IAA produced by the plant.

In NAA treatments the height of the main stem was increased slightly, but the concentration of 500 ppm had a retarding effect. This is comparable with the results of Kiermayer (1959).

Treatments with all concentrations of 2,4-D, except the lowest one (4 ppm) also increased the height of the main stem.

Total height of the plant including branches:

In the present study height of the plants including branches was promoted by spray application of 2,4-D, NAA and lower concentrations of MH. All concentrations of TIBA except the lowest one (300 ppm) and higher concentrations of MH decreased the total height of the plants.

Esther and Beck (1952) obtained increased height of the plants by lower concentrations of MH (0.5%) and a retardation of growth by higher concentrations (1.0%) which confirm the present results.

According to Audus (1959) the stimulation of growth brought about in plants by growth regulators reaches a maximum point at a certain concentration and above that level the growth is found to be retarded. The inhibitory effect becomes more intensive as the concentration of the chemical is further increased. In the present work also a steady reduction in height corresponding to the increased concentrations of the chemicals, in the case of NAA and TIBA, is observed.

Leaf deformities:

Various morphological abnormalities were noticed in the leaves soon after the spray application of the growth regulators. In TIBA treated plants leaves became crinkled, leathery and more deeply pigmented. Similar results were reported by Moor (1950) and Choudhury and Phatak (1959). Denffer (1952) observed expansion of leaf lamina by TIBA treatments while in this investigation of TIBA had reduced considerably the leaf lamina. Joseph and Applegate (1962) noticed that TIBA at lower concentrations caused hyponasty and higher concentrations epinasty of the leaves of the treated plants. No such abnormalities were produced by TIBA treatment in the present work. But both epinastic and hyponastic leaves were found in plants treated with NAA and 2,4-D. Such abnormalities in the leaves were also reported by George and Olson (1953) in barley, Walrand and Sironual (1953-54) in Gossypium herbaceum and Krishnamurthy and Bhandari (1957) in Capsicum.

The MH treated plants were found to produce crinkled and pale green leaves. Similar leaf deformities were also noticed by Esther and Beck (1952) in Easter lilies by treating with MH. In support of the present results, alteration of leaf colour and texture was also noticed by Srinivasan and Hamner (1962) in Lycopersicum esculentum with spray application of MH. Another striking malformation found in 2,4-D treated plants was the "stingy" leaves. This was found only in a few leaves soon after the application of the growth substance. The later formed leaves were quite normal. According to Naylor et al this malformation was caused due to the slower growth of the veins than the growth of intervenal areas.

Number of branches:

The maximum number of branches was produced by 2,4-D treatment and next by NAA. The number of branches produced by both these chemicals was greater than the control. But MH and TIBA treatments decreased the number of branches. TIBA produced the minimum number of branches, the mean value being 4.37 against 17.25 of the control. Eventhough the number of branches produced by TIBA treatment was found to be the lowest, at early stages of growth, just after the treatment of the plants treated with all the four concentrations of TIBA produced numerous branches. Branches were found produced from the axils of the cotyledons also. (Plate VIII. fig.1-4). But the ultimate reduction in the number of branches was probably due to the drying up of the first formed branches along with the main stem during the later stages of the plants's growth.

In the present study NAA treatment was also found to produce a higher number of branches than the control, the mean number of branches being 21.06 and 17.25 respectively. As against the effect of TIBA, NAA treated plants produced no branches at the early stages of the plant's growth (Pl.VIII. fig.5). Only two to three weeks after the treatment the formation of branches was noticed.

Walther (1952) in conformity with the results obtained in the present study observed promotion of more axillary buds by 2,4-D treatments in flax plants. But Appalanaidu (1959) reported an inhibition in the development of branches in Hibiscus esculentus and Helianthus annus when treated with 100 ppm, 2,4-D. It may be due to the higher concentration of the chemical used.

The results obtained in the present work with MH is not in accordance with previous reports on the effect of MH in producing branches. Promotion of lateral branches was noticed by Schoene and Hoffmann (1949) in tomato, Victor (1950) in tomato, lime tree and wheat with 2000 ppm of MH. Choudhury and Ramphal (1960) also found development of a number of lateral branches in cow pea when sprayed with MH 50, 100, 200, 400 and 600 ppm. The different concentrations of MH, 50 to 2000 ppm were thus found to promote the production of lateral branches while in the present investigation MH in general inhibited to a certain extent the formation of secondary branches. This, perhaps, may be due to the difference in the nature of response of <u>Momordica</u> and the plants studied by other authors to this particulab growth substance, MH.

<u>Fresh weight of the plant</u>:

All the four growth regulators were found to increase the fresh weight of the plants.

MH treated plants gave the maximum weight followed by 2,4-D, NAA and TIBA in order of merit. Mikkelsen <u>et al</u> (1952) also got similar increase in fresh weight in sugar beet plants treated with MH. But contradictory to this, Currier <u>et al</u> (1951) reported a decrease in fresh weight when young barley plants were treated with MH.

It is revealed in the present study that the fresh weight of the plant does not depend upon the total height of plant or on the increased number of branches produced. MH treatment was definitely inferior to 2,4-D and NAA in respect of promoting height of the plant and formation of branches. But when fresh weight of the plant was considered it ranked above the other two chemicals. This clearly proves that factors other than height of the plant and the number of branches, may account for an increase in the weight of the whole plant.

Root formation:

In NAA and 2,4-D treated plants, one week after the spray application, numerous small adventitious roots were produced from the region just below the cotyledons (Pl.VIII, figs. 7 and 8). Appalanaidu (1959) reported such adventitious root formation in *Hibiscus* and *Helianthus* treated with 2,4-D. Adventitious root formation was also reported by Stoutemyer (1954) in certain species of *Taxus*, *Ligustrum* and *Elaeagnus* treated with NAA and 2,4-D. The abnormal root formation in the NAA and 2,4-D treated plants in the present study confirms Stoutemyer's view that root primordia which may some time be present within the stem of normally growing plants, require only favourable conditions to grow out as roots.

SEX EXPRESSION AND SEX RATIO

Number of male flowers:

The number of male flowers was increased by 2,4-D and MH, whereas TIBA and NAA reduced them, but the effect of 2,4-D and TIBA is only significant. Among the four chemicals tried, only the effect of different levels of MH is found to be significantly different. The greatest number of male flower was produced by the lowest concentration of MH (100 ppm) and the least number by the highest concentration, viz. 700 ppm. As the concentration was raised from 100 to 700, a corresponding decrease in the number of male flowers was noticed. Another feature noticed was that the highest concentration of all the chemicals had an adverse effect in producing the male flowers.

In the present study it was found that eventhough MH 100 ppm produced the maximum number of male flowers, 2,4-D on the whole, ranked first in promoting the male flower formation. It confirms the observations of Ito and Saito (1956) that the male flower formation in cucumber was promoted by 2,4-D and unaffected by TIBA. They also reported that NAA had enhanced the male flower formation, but here NAA treatment is not significantly different from the control. Choudhury and Phatak (1959, 1960) also observed that NAA had an inhibitory effect on the production of male flowers in Cucumis sativus. But the observation of Satyanarayana and Rangaswami (1959) was contradictory to this. The effect of 2,4-D in enhancing the male phase was further supported by the report of the Satyanarayana and Rangaswami (1959).

It was found in the present study that higher concentration of MH had suppressed the male phase. This was supported by the report of Wittwer and Hillyer (1954) and Choudhury and Phatak (1959, 1960). Thus the result obtained in the present investigation regarding the behaviour of 2,4-D in enhancing the male phase, and the higher concentration of MH and TIBA in general, in inhibiting the male phase is almost in confirmity with the observations of the previous workers. But the reports on the effect of NAA was more or less contradictory.

<u>Number of female flowers</u>:

The different concentrations of all the four chemicals tried had increased the number of female flowers. The maximum increase was noted in MH treatments, with a mean value of 12.31 followed closely by 2,4-D, TIBA and NAA with 11.44, 11.06 and 9.94 respectively as against the 8.5 of the control. Of these the effect of NAA alone was not significantly different from the control.

Various other previous workers also found that plant regulators in general had increased the production of female flowers. The reports of Laibach and Kribben (1950), Wittwer and Hillyer (1954), Ito and Saito (1956), Brantley and Warren (1959), Choudhury and Phatak (1959), and Mitchell and Wittwer (1962) are in support of this. Thus in the present work all the four chemicals tried enhanced the female phase while two of them only promoted the male phase, the other two being found to inhibit male flower production.

<u>Sex ratio</u>:

All the sixteen treatments tried were found to increase the ratio of pistillate to staminate flowers. The highest ratio obtained was 1:19.11 for MH 300 ppm. It was closely followed by TIBA 300 ppm with a ratio 1:19.31. The other treatments in order of merit are MH 700 ppm, TIBA 400, TIBA 500, NAA 300, MH 500, 2,4-D 4 ppm and so on. The lowest ratio was that of the control, 1:39.50. The higher concentrations of 2,4-D 8 and 10 ppm and NAA 200 and 500 ppm proved to be rather weak in promoting the female to male sex ratio. The ratios obtained by 2,4-D 10 ppm treatment and control were practically the same. This result confirms the reports of Wittwer and Hillyer (1954), Choudhury and Phatak (1959, 1960) and Venketram (1963). Wittwer and Hillyer (1954) obtained increased female to male ratio (from 1:23 to 1:8) in National Pickling variety of *Cucumis sativus* and in Burpee Hybrid, (from 1:14 to 1:2) by NAA sprays of 100 ppm and TIBA 250 ppm. Choudhury and Phatak (1959, 1960) also reported an increased sex ratio in *Cucumis sativus* by spraying with different concentrations of MH (200, 400, 600 and 800 ppm) of NAA (100 and 200 ppm) and 2,4-D (5 and 10 ppm). Venketram (1963) in snake gourd, also observed increased female to male ratio when sprayed with TIBA, MH and NAA. TIBA and NAA at 200 and 500 ppm and MH 500 ppm produced better results. In the present study also the highest female to male ratio was obtained in the treatment with MH 300 ppm and the next by TIBA 300 ppm. The lower concentrations of MH 100 and 300 ppm had produced an increased number of male flowers. At the same time the highest female ratio has been obtained in MH 300 ppm which may be attributed to the enhancement of female phase. On the other hand in other treatments viz. TIBA, NAA and the higher concentration of MH, the sex ratio (female to male) was increased due to the suppression of male phase. The present results are comparable with those of Whitaker (1931), Laibach and Kribben (1950, 1951), Laibach (1952), Heinze (1956), Ito and Saito (1956, 1957), Brantley and Warren (1959, 1960) and Satyanarayana and Rengaswamy (1959).

The sex ratio can thus be controlled by the use of growth regulators which may increase the production of female flowers or decrease the number of male flowers. Laibach (1952) explained that in Cucumber plants transition from vegetative to flowering state was marked by a fall in the auxin content of the plant. If this fall persisted in the period of flowering, then female flower production would be associated with a higher auxin level than male flower production. This suggestion was supported by results obtained in experiments on cucumber and pumpkins by Laibach and Kribben (1950, 1951). According to Wittwer and Hillyer (1954) some naturally occurring growth regulators reach a low level in the young active region of many plants at the time the change from vegerative to reproductive development occurs. From this it can be inferred that, if growth regulators are maintained at a high concentration by external application, a delay or inhibition of flowering may result. But Harrison (1956) suggested that although auxin level might have to fall before flowering could be initiated, yet a much higher auxin level was required for flower development. He also proposed that the auxin concentration necessary for female organ development might be much higher than those for the development of the male organ. This may be the probable reason for the increased production of female flowers in the present study.

Time of flowering and acceleration of female phase:

A general delay in flowering was noticed in treated plants. TIBA, NAA and 2,4-D treatments delayed flowering for 10, 7 and 5 days respectively. But the effect of MH was more or less similar to control. This was in confirmation with the reports of Josephson (1951) in corn, Ferres Helen (1952) in raspberries, straw berries and black current apples, Satyanarayana and Rangaswamy (1959) in ribbed gourd, and White (1960) in raspberries.

There is a relationship between the number of node on which the first female flower appears and the female sex expression. In the present investigation all the treatments induced the formation of the first female flower on comparatively lower nodes when compared with the control and all of them had a higher female to male sex ratio than the control. This is in confirmation with the results of Currence (1932), Nitsch et al (1952), Leopold and Guernsey (1954) Shifriss and Galun (1956) and Choudhury and Phatak (1959).

An interesting observation made during the course of this investigation was that female flowers emerged 3 to 4 days before the appearance of male flowers, particularly in treatments with MH and TIBA 300 ppm. Generally in control plants female flowers appear one week after the appearance of male flowers. Ito et al (1956) made anatomical studies of the cucumber flowers and reported that in the primordial stage all flowers carried both sets of sex organs and the application of growth substance induced the transformation of more flower buds into pistillate flowers. This seems to be the probable explanation for the first appearance of female flowers in the treated plants.

YIELD

Number of fruits:

Total number of fruits produced by different treatments was found to be greater than that of the control. But the effect of TIBA and NAA in this respect was not significant. 2,4-D produced maximum number of fruits with a mean of 10.63 which was closely followed by MH with 10.06. The mean number of fruits for TIBA and NAA were 8.8 and 7.75. At the same time the control plants produced only a mean number 6.5 fruits. This was almost in confirmation with the findings of Vanicek (1951) in tomato, Krishnamurthy and Subramanian (1954) in *Solanum*, Muthukrishnan (1957) in brinjal, Gibson (1959) in tomato, Krjackov (1959) in tomato, Randhawa *et al* (1959) in Sweet lime, and Ravoof (1963) in Sapota. Satyanarayana and Rangaswami (1959) in ribbed gourd and Santhakumari (1963) in *Sesamum indicum* obtained greater number of fruits by 2,4-D and NAA treatments. In both cases the effect of 2,4-D was more marked than NAA. In the present study also 2,4-D produced better result than all the other chemicals. In 2,4-D treated plants the number of fruits was inversely proportional to the increasing concentrations. In MH treatments also the lower concentrations (100 and 300 ppm) produced better results than the higher concentrations viz. 500 and 700 ppm. The same results were obtained by Choudhury and Ramphal (1960) and they reported that lower concentrations of MH significantly increased the yield in cow pea while higher concentrations (400 to 800 ppm) reduced the yield. Again similar results were reported by Josephson (1951) in corn, Guyer and Karmer (1951) in Soya beans and Maini and Sandhu (1959) in Eruca sativa. In NAA treatments a reduction of yield was obtained by Ueno (1957) in Strawberries, and Marsh et al (1961) in apples. In the present study NAA produced a greater number of fruits than the control but the differente was not significant.

Percentage of fruit-set:

In the present investigation all the chemicals TIBA, MH, NAA and 2,4-D promoted the fruit-set considerably than control. 2,4-D is proved to be the best among them all the levels of which contributed better results than all other treatments. Vanicek (1951) reported that spray application of TIBA produced a greater percentage of fruit-set in tomato. Krishnamurthy and Subramanian (1954) obtained increased fruit-set in Solanum with 2,4-D Sprays. Maini and Sandhu (1959) reported that NAA promoted the percentage of fruit-setting in Eruca sativa. Satyanarayana and Rangaswami (1959) obtained an increased fruit-set in NAA and 2,4-D treated ribbed gourds. Ueno (1957) reported that higher concentration of NAA had decreased the percentage of fruit-set in Strawberries. In this investigation also the higher concentrations of NAA had an adverse effect on the setting of fruits.

Fruit weight:

All the four chemicals increased the weight of fruits. TIBA treatments produced the maximum weight of 114.59 gms,which was followed by 107.1 gms by MH and NAA 103.02 gms as against 93.55 gms of the control. Though 2,4-D resulted in greater number of fruits than all the other three growth regulators the least weight of fruits was obtained in this treatment. In the present investigation the four concentrations of 2,4-D tried were 4, 6, 8 and 10 ppm. The lowest fruit weight was recorded in the treatment with the lowest concentration of 2,4-D viz. 4 ppm,which was 53.00 gms. But when the concentration was increased the fruit weight also increased and the highest level (10 ppm) produced 112.45 gms which was far better than the control. From this we can assume that if the concentration is further increased the weight of the fruits may also increase still further. This substantiates the results of Randhawa et al (1961) who found that 2,4-D at 10 and 15 ppm considerably increased the weight of fruits in oranges.

But in the case of MH, when the concentration was increased the fruit weight decreased and in the highest concentration, 700 ppm the fruit weight was less than that of control, the other concentrations being better than control. In TIBA all the four concentrations and in NAA the lower three concentrations were found to give better results.

Number of seeds per fruit:

The number of seeds per fruit was increased in all treatments except 2,4-D. The maximum number of seeds was produced by TIBA treatments, followed by NAA and then by MH. Takashima *et al* (1952) in tomato and Maini and Sandhu (1959) in *Eruca sativa* obtained increased percentage of seed-set when sprayed with NAA. Contradictory results were obtained by various other workers. Guyer and Karmer (1951) reported that the seed development in snap beans were retarded when treated with MH. Lopez (1958) obtained seedless fruit in cucurbits when sprayed with NAA. Singh and Kacker (1952) reported that 65% seedless fruits were obtained in tomato with NAA treatment.

MH and 2,4-D treatments exhibited a kind of relationship between the fruit weight and number of seeds per fruit. In other words, the fruit weight varied in proportion to the number of seeds per fruit. The highest concentration of MH (700 ppm) reduced considerably the number of seeds per fruit. There was also a proportionate decrease in fruit weight as the concentration of MH increased. But in 2,4-D treatment there was a steady increase in fruit weight when the concentration was increased and the maximum weight was obtained in the highest concentration tried. The highest seed set was also obtained in the treatment with the highest concentration of 2,4-D and it was reduced correspondingly to the reduced levels of the growth substance. The lowest concentration of 2,4-D (4 ppm) produced among others a single seeded fruit (Pl. VI, fig.9).

Taguchi and Nishiiri (1955) showed improved seed-set in varietal crosses of potato with 2,4-D sprays. But Alonso (1955) and Krjackov (1959) had also reported that 2,4-D sprays produced seedless fruits in tomato.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

An experiment was conducted to study the effect of four growth regulators in Momordica charantia with special reference to sex expression and sex ratio. The four growth regulators tried were TIBA (300, 400, 500 and 600 ppm), MH (100, 300, 500 and 700 ppm), NAA (200, 300, 400 and 500 ppm) and 2,4-D (4, 6, 8 and 10 ppm).

The treatment was given one week after germination. The experiment was conducted as pot culture in randomised block design with four replications and eighteen treatments.

Observations on the height of the main stem and of the plant including branches, number of nodes and branches in the main stem, fresh weight of plants, leaf deformities, number of male and female flowers and fruits, weight of the fruits and number of seeds per fruit were recorded and the data collected were statistically analysed. The sex ratio was determined by comparing the number of male and female flowers produced in various treatments. The percentage of fruit-set was also studied. The time of flowering and the variation in the size of the male flower were also noticed in the course of the study.

An inhibitory effect in the growth of the main stem was noticed in all the four concentrations of TIBA and the two higher concentrations of MH. This was very strikingly conspicuous in TIBA 500 and 600 ppm, the mean height of the main stem being only 8.25 and 9.25 cms, whereas in control the height of the main stem was 294.38 cms. 2,4-D treatments in general and lower concentrations of MH and NAA increased the height of the main stem.

2,4-D and NAA treatments increased the height of the plants when compared with the control. The maximum height was obtained in treatments with 2,4-D 8 ppm.

NAA and 2,4-D at all levels, MH at the first two levels (100 and 300 ppm) were found to be equally good in increasing both the number of nodes and branches in the main stem. But TIBA treatments had significantly reduced the number of nodes.

MH treatments produced greater fresh weight than all other chemicals. The maximum weight was obtained in treatment with MH 300 ppm.

Numerous leaf deformities such as epinasty, hyponasty crinkling etc. were noticed in all the treated plants in the early stages of growth. 2,4-D and NAA treated plants also produced numerous adventitious roots from the lower portion of the main stem.

2,4-D treatments increased the number of male flowers and TIBA and NAA suppressed male flower formation. In MH treatment the lower two concentrations 100 and 300 ppm were found to increase the male flower formation while still higher concentrations were found to decrease the number of male flowers. But all the four growth regulators had produced more female flowers than the control. The highest female to male sex ratio was obtained in MH 300 ppm treated plants which was followed by TIBA 300 ppm, MH 700 ppm, TIBA 400 ppm and then by TIBA 500 ppm in order of merit.

A general delay of flowering was noticed in all the treated plants.

The number of fruits was increased by all the treatments especially 2,4-D and MH. The maximum number of fruits was produced by 2,4-D 4 ppm treated plants. The percentage of fruit-set was also greater in 2,4-D treatments. TIBA and NAA at lower concentrations were not found to be so effective in promoting production of more fruits.

The weight of fruits was increased by all treatments. The effect of TIBA was more significant in this respect. A proportionate increase in the number of seed to the increase in the fresh weight of the fruit was observed. Thus TIBA treatment which recorded the greatest fresh weight of fruit also produced the largest number of seeds. 2,4-D was not as effective as the other three growth regulators in increasing the fresh weight of the fruit and the least number of seeds per fruit was obtained in plants treated with this chemical. A single seeded fruit was also obtained from a plant treated with 2,4-D 4 ppm concentration.

R E F E R E N C E S

1. Alonso, G.M.	1955	Induction of parthenocarpy in Cucurbitaceae and particularly in Citrullus vulgaris. Farmacognosia. 15:379-95 Hort. Abstrs. 27(1):70.
2. Andreae, W.A. and S.R. Andreae.	1953	Studies on the indoleacetic acid metabolism. The effect of methyl Umbelliferome, maleic hydrazide and 2, 4-D on IAA oxidation. Can. Jour. Bot. 31(4):426-37 Biol. Abstrs. 28:923.
3. Appalanaidu, B.	1959	Studies on the effect of 2, 4-D on Brassica kaber, Hibiscus esculentus, Helianthus annus. Diss. Abstrs. 29:858. Hort. Abstrs. 30(2):208.
4. Audus, L.J.	1959	Plant growth substances. Leonard Hill (Books) Ltd., 9, Eden Street, N.W.1, London.
5. Brantley, B.B. and G.F. Warren.	1959	The effect of nitrogen, photoperiod and auxin on sex expression in musk melon. Abst. Plant Phys. 33 Hort. Abstrs. 29(1):129.
6. -----------------	1960	Sex expression and growth in musk melon. Plant Phys. 35:741-45. Hort. Abstrs. 31(2):307.
7. Bukouae, M.J. and S.H. Wittwerr.	1961	Gibberlin modification of flower sex expression in Cucumis sativus. Advances Chem. Ser. 28:80-8.
8. Choudhury, R.S. and V.B. Bhatnagar.	1959	Effect of MH on growth bolting behavious and keeping quality of Indian raddish Proc. Ind. Acad. Sci. 39(1):1-16.

9. Choudhury, R.S. and S.C. Phatak. 1959 Sex expression and sex ratio in Cucumber (Cucumis sativus) as affected by plant regulator sprays. Ind. Jour. Hort. 16(3):162

10. ------------------ 1960 Further studies in sex expression and sex ratio in Cucumber (Cucumis sativus) as affected by Plant regulator sprays. Ind. Jour. Hort. 17(3-4):210-16.

11. Choudhury, B. and Ramphal 1960 Effects of the interruption or destruction of apical dominance of plant regulator sprays on cow pea. Ind. Jour. Hort. 17:129.

12. Clark, H.E. and K.R. Kerns. 1942 Control of flowering with Phytohormones. Science, 95:536.

13. Currence, T.M. 1932 Nodel sequence of flower type in Cucumber. Proc. Amer. Soc. Hort. 29:447.

14. Currier, H.B. and A.S. Crafts. 1950 Maleic hydrazide, a selective herbicide. Science, 111:152.

15. Currier, H.B., Day, B.E. and A.S. Crafts. 1951 Some effect of MH on plants. Bot. Gazz. 112(3):272-80.

16. Denffer, D. Von. 1952 Dureh' di Behandlung mit 2, 3, 5-Tri-jodbenzoesoure hervorgerul'ere Gamophyllian. Ber. Deutsch. bot. ges. 64(9): 269-274. Biol. Abstrs. 26(11): 2870.

17. Ergle, D.R. and W.J. Mc Ilarth. 1952 Response of cotton plants to late and localized application of Maleic Hydrazide. Bot. Gazz. 114:114-22.

18. Erickson, L.C., Brannaman, B.L., Hield, Z. and D. Miller. | 1952 | Responses of organge and grape fruit trees to Maleic hydrazide. Bot. Gazz. 114(1):122-130.

19. Erickson, L.C. and C. Price. | 1950 | Some effects of MH on sugar beets. Amer. Jour. Bot. 37:657-659.

20. Esther, S.B. and G.E. Beck. | 1952 | The effects of MH on the growth and flowering of Croft Easter lilies. Proc. Amer. Soc. Hort. Sci. 59: 542-48. Biol. Abstrs. 27(5):I293.

21. Fillmore, R.H. | 1950 | The control of plant development with MH. Arnoldia 10:38.

22. Galston, A.W. | 1947 | The effects of 2, 3, 5-TIBA on the growth and flowering of Soyabeans. Amer. Jour. Bot. 34:356-360.

23. Galun, E. | 1959 | Effect of gibberllic acid and Naphathalene acetic acid on sex expression and some morphological characters in Cucumber plants. Phyton. 13:1-8. Hort. Abstrs. 30(2):285.

24. George, F. and P.J. Olson. | 1953 | The effect of 2, 4-D on the developmental process in barley and oats. Can. Jour. Agri. Sci. 33(4):315-329. Biol. Abstrs. 28: 439.

25. Gibson, W.B. | 1959 | Flower setting and fruit yield of tomato in glass houses. Res. Exp. Rec. Minist. Agric. Belfast. 9:97-105. Hort. Abstrs. 31(2):329.

26. Gorten, C.J. | 1951 | The influence of 2, 3, 5-TIBA on growing points of tomatoes II. The initiation of ring fasciations K. Nederland Akad. Wettenschapp. Amsterdam Proc. 54(2):181-190. Biol. Abstrs. 26(8):2041.

27. Guyer, R.B. and A. Karmer. | 1951 | Measurements of quality of raw and processed snap beans as affected by Maleic hydrazide Para-chloro phenoxy acetic acid. Proc. Amer. Soc. Hort. Sci. 58: 263-273.

28. Harley, C.P. *et al* | 1959 | Evidence that post bloom apple thinning sprays of Naphathalene acetic acid increase bloosom bud formation. Proc. Amer. Soc. Hort. Sci. 72:52-6. Hort. Abstrs. 29(2): 1009.

29. Harrison, H.J. | 1956 | Auxin and sexuality in Cannabis sativus. Physiol. Plant. 9:588.

30. Heinze, W. | 1956 | Experimental application of growth substances to melons. Arch. Gartenle. 4:312-19. Hort. Abstrs. 27(3):387.

31. Helen, F.M. | 1952 | The effect of MH in delaying the flowering and fruiting. Univ. Bristol Ann. Rept. Agric. and Hort. Res. Sta. 40-42.

32. Hensz, R.A. and H.C. Mohr. | 1959 | Functional male sterility in Cucubits induced by chemical treatment. Proc. Amer. Soc. Hort. Sci. 74:552-54. Hort. Abstrs. 30(3):496.

33. Ito, H. and T. Saito. | 1956 | Factors responsible for the sex expression of Japanese Cucumber. The role of auxin on plant growth and sex expression. Jour. Hort. Ass. Japan. 25:201-10. Hort. Abstrs. 27(1):70.

34. Ito, H. and T. Saito — 1957 — Factors responsible for sex expression of Japanese Cucumber causal interpretation of the effect of pinching and growth substances on the transformation of the primordia of staminato flower nodes. Jour. Hort. Ass. Japan. 25:213-20. Hort. Abstrs. 27(4):553.

35. John, M.W. — 1940 — Effect of NAA and naphthalene acetamide on nitrogenous and carbohydrate constituents of bean plants. Bot. Gazz. 101: 688-699.

36. Johnson, S.P. — 1956 — Influence of growth regulators on setting of tomato fruits. Proc. Amer. Soc. Hort. Sci. 67: 365-68. Hort. Abstrs. 27(1): 81.

37. Joseph, B. and H.G. Applegate — 1962 — The effect of injecting 2, 3, 5-TIBA into Kalanchoe diagremontiana New Phytol; 61(2):132-37. Plant Science 40(3):914.

38. Josephson, L.M. — 1951 — Effect of MH on delaying flowering in Corn. Agron. Jour. 43(8):404. Biol. Abstrs. 26(1):2121

39. Kagawa, A. — 1959 — Studies on the floral induction of slow blotting Spinach V. Effect of plant regulators on floral initiation of Spinach. Jour. Hort. Ass. Japan. 28:277-87. Hort. Abstrs. 30(4):720.

40. Kiermayer, O. — 1959 — The influence of naphathalene acetic acid on the morphological effects induced by 2,3, 5 tri-iodobenzoic acid (TIBA). Physiol. Plant. 12:841-58. Hort. Abstrs. 30(4):5612.

41. Klein, W.H. and A.C. Leopold.	1953	The effect of MH on flower initiation. Plant Physiol. 28(2):293-298.
42. Krishnamurthy, S. and B.P. Bhandari	1957	Modification of leaves in the Chilli (Capsicum frutescans-L) as a result of whole plant sprays of high concentrations of certain plant regulators. Ind. Jour. Hort. 14(4):239.
43. Krishnamurthy, S. and D. Subramanyan	1954	Effect of 2, 4-dichloph'enoxy acetic acid on Solanum melangona Curr. Sci. 23:125-26.
44. Krjackov, P.	1959	The effect of growth substances on the ripening of tomatoes at high altitudes. Hort. Abstrs. 29(2):1009.
45. Laibach', F.	1952	Wuchsstoff and Blutenbildung Beitr. Biol. Pfl. 29:129-41.
46. ------------ and F.J. Kribben	1950	The influence of growth substances on the sex of the flowers of a monoecious plant. Beitr. Biol. Pfl. 28(1):64-67. Biol. Abstrs. 26(10):2591.
47. --------------	1951	The importance of growth substances for the formation and sex determination of flowers. Beitr. Biol. Pfl. 28(2):131-144. Biol. Abstrs. 26(7):1774.
48. Leopold, A.C. and F.S. Guernsey	1954	Flower initiation in Alaska pea. Amer. Jour. Bot. 41(3):181-85.
49. Leopold, A.C. and W.H. Klein	1952	Maleic hydrazide as an anti auxin. Physiol. Plant. 5(1):91-99. Biol. Abstrs. 26(7):1374.

50. Lombalp, P.B., Mitchell, A.E. and H.A. Cardinell. 1959 Chemical thinning of peaches using Naphathalene acetic acid N-1. Naphathalmic acid and 3-chlor. IPC. Quart-Bull. Mich. Agric. Exp. Stat. 41:147-56. Hort. Abstrs. 29(1):

51. Lopez, R.M. 1958 Parthenocarpy induced in species of Cucurbita. Biol. Int. Nac. Invest. Agron. Madrid. 18:265-70. Hort. Abstrs. 29(1):

52. Maini, N.S. and S.S. Sandhu 1959 Effect of some growth substances on seed set in Eruca sativa. Sci. and Culture, 25:377-8.

53. Marsh, H.V., Southwick, F.W. and W.D. Weeks. 1961 The influence of chemical thinness on fruit set size, seed development and preharvest drop of apples. Proc. Amer. Soc. Hort. Sci. 75: 5-21. Hort. Abstrs. 31(1):45

54. Mc Ilrath, W.J. 1950 Response of cotton plants to Maleic hydrazide. Amer. Jour.. Bot. 37:816-819.

55. Mikkelsen, D.S., Griffith, R.B. and D. Ririe 1952 Sugar beat response to MH treatment. Agron. Jour. 44:533-36. Biol. Abstrst. 27(5):1305.

56. Mitchell, W.D. and S.H. Wittwerr 1962 Chemical regulation of flower sex expression and negative growth of Cucumis sativus. Science, 136:880-881.

57. Muthukrishnan, C.R. 1957 Some studies on the influence of 2, 4-D in decreasing blossom drop and increasing fruit-set in a summer Crop of Brinjal. Mad. Agr. Jour. 4:157.

58. Naylor, A.W. 1950 Observations on the effect of MH on flowering of Tobacco Maize and Cocklebur. Proc. Nat. Acad. Sci. 36:280-32.

59. Nitsoh, J.P. et al 1952 The development of sex expression in cucurbit flowers. Amer. Jour. Bot. 39:32-43.

60. Overbeek, V. 1946 Control of flower formation and fruit size in pine apples. Bot. Gazz. 108:64-78.

61. Paterson, C.E. 1960 A gynoecious inbred line of Cucumber. Quart. Bull. Mich. Agric. Exp. Stat. 43:40-42. Hort. Abstrs. 31(2)306.

62. Randhawa, G.S., Sharma, B.B. and N.D. Jain 1961 Effect of plant regulators on fruit drop size and quality in sweet oranges. Ind. Jour. Hort. 18(3)

63. Randhawa, G.S., Singh, J.P. and H.S. Dhuria. 1959 Effect of Gib. Acid, 2, 4-D and 2, 4, 5-T on fruit-set, drop, size and total yields in sweet lines. Ind. Jour. Hort. 16(4): 206.

64. Ravoof, A.A. 1962 Preliminary studies on the effect of Boric Acid, GA and growth regulators on fruit set, maturity and composition in Sapota. Mad. Agric. Jour. 50:2.

65. Santha Kumari, S. 1963 Studies on the effect of growth regulators on germination, growth and oil content in Sesame. M.Sc. Thesis. Agri. College. Univ. Kerala. 1962-'63.

66. Satyanarayana, G. and G. Rangaswami 1959 The effect of plant regulators on sex expression in ribbed gourd (Lalfa aceutangula). Curr. Sci. 28:376-77.

67. Schoene, D.L. and O.L. Hoffmann — 1949 — Maleic hydrazide a unique growth regulator. Science. 109:585.

68. Singh, S.M. and P.N. Kacker. — 1952 — Effects of some hormones and their methods of application on parthenocarpy on tomatoe fruits. Ind. Jour. Hort. 9(4):25-29.

69. Skene, M. — 1932 — The biology of flowering plants. Landen, Sidewick and Jackson. 329-38.

70. Skoog, F. Ed. — 1951 — Plant growth substances. University of Wisconsis Press.

71. Srinivasan, K.M. and C.L. Hamner. — 1962 — Significance of the modifications of some physiological responses of Lycopersicum esculentum resulting from foliar sprays of Maleic hydrazide. Mad. Agric. Jour. 49:5.

72. Stambera, J. — 1960 — Effect of spraying 2, 3, 5-triiodobenzoic acid on the development and fertility of glass house cucumber varities. Rostàinna vyroba, 6:483-8. Hort. Abstrs. 31(2):306.

73. --------------- — 1961 — An investigation of cultural methods for glass house varities of forced cucumbers. Ved. Prace. Uyzk. Ust. Zelin. CSAZY and OLOMONI, 1:29-44. Hort. Abstrs. 32:2915.

74. Stewart, W.S., Heild, H.Z. and B.L. Brannamann — 1952 — Effects of 2, 4-D and related substances on fruit drop, yield, size and quality of Valencia oranges. Hilgardia, 21:301.

75. Stoutemyer, V.T. — 1954 — Encouragements of roots by plant regulators. Plant Regulator in Agriculture. John Willy & Sons, Inc. New York.

76. Taguchi, K. and K. Nishiiri. 1955 The influence of 2, 4-D treatment on seedling in Potato varities. Rep. Tohoku. Agri. Exp. Stat. 4:27-33.

77. Takshima, S., Izuta, S. and H. Kitao. 1952 Effect of plant hormones on the seed production of fruit and vegetabls. Stud. Inst. Hort. Kyoto. 8:112-15. Hort. Abstrs. 29(2).

78. Teubner, F.G. and S.H. Wittwer. 1957 Effect of naphathalmic acid on tomato flower production. Proc. Amer. Soc. Hort. Sci. 69:343-51. Hort. Abstrs. 27(4):3567.

79. Tukey, H.B. 1954 Plant regulators in agriculture, John Wiley and Sons, Inc., New York. Chapman and Hall Limited, London.

80. Ueno, Y. 1957 Effect of fall application of IAA and NAA on straw berries. Stud. Inst. Hort. Kyoto. 8:120-25. Hort. Abstrs. 29(2):234.

81. Vanicek, V. 1951 The effect of 2, 3, 5-TIBA on fruiting and carliness in tomato. Sborink. Chesk. Akad. Zemedelske. 24(1/5):259-68. Biol. Abstrs. 27(7):1919.

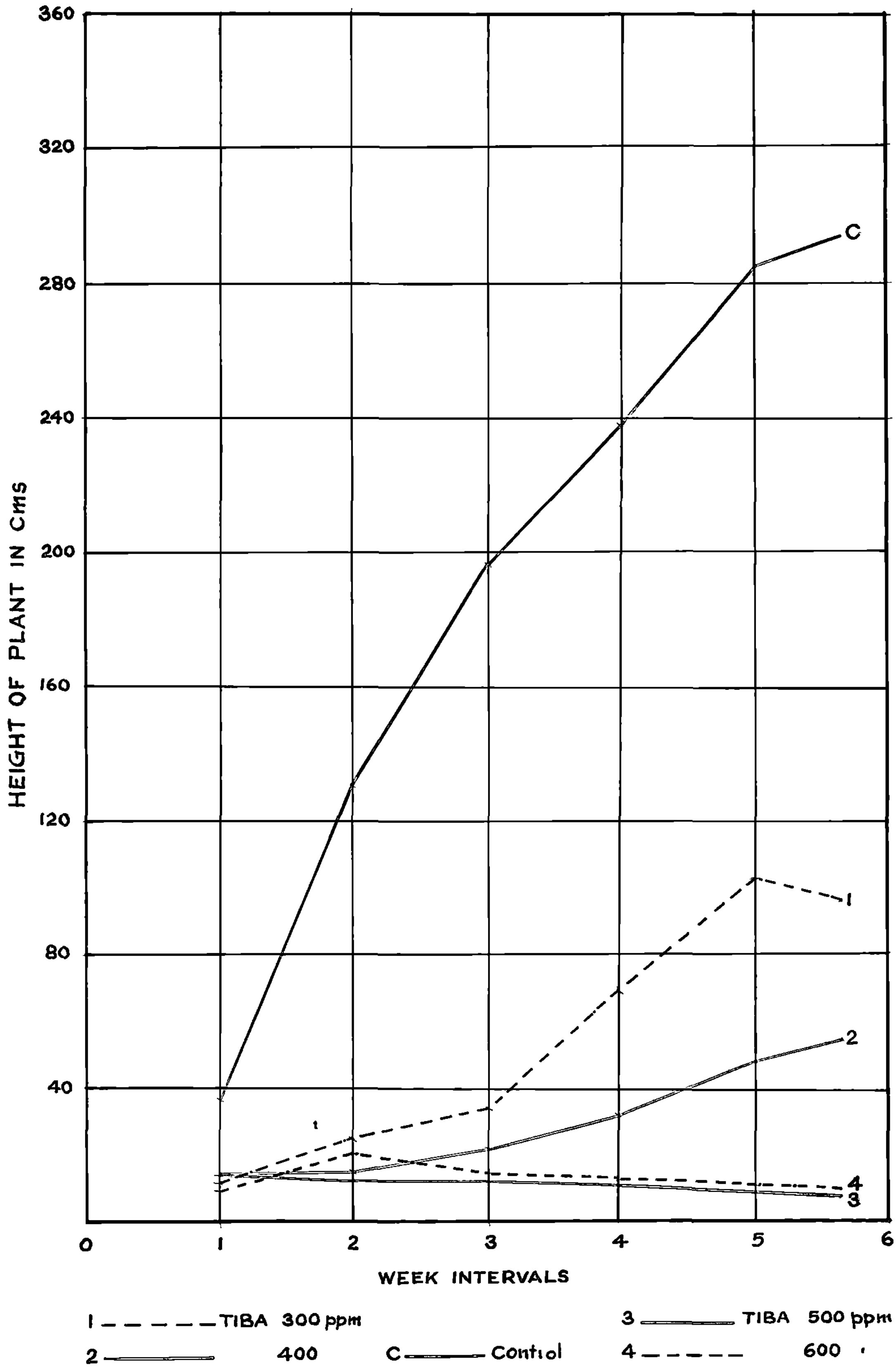
82. Venketram, T.M. 1963 Studies in the sex expression in the snake gourd with special reference to the influence of photoperiod and growth substances. M.Sc. Diss. Agri. College & R.I. Coimbatore. 1962-'63.

83. Victor, G. 1950 Growth inhibition and injury of plants by Maleic hydrazide. Texas. Jour. Sci. 2(2):219-221. Biol. Abstrs. 25(7):1962.

84. Walrand, B.M. and C. Sironual.	1953-'54	The action of 2, 4-D on morphology, anatomy and progeny of Gossypicem herbaceum. Bull. Soc. Roy. Bot. Belg. 86:227-36.
85. Walther, R.	1952	Uber die Wirkung von U46 (2, 4-D) auf Lein. Beiti. Biol. Pflanzen. 29(2):185-196. Biol. Abstrs. 28:439.
86. Whitaker, T.W.	1931	Sex ratio and sex expression in cultivated cucurbits. Amer. Jour. Bot. 18:359-66.
87. -------------- and G.S. Davis.	1962	Cucurbits Leonard Hill (Books) Ltd. London.
88. White, D.G.	1950	Blossoming of fruits delayed by MH. Science 111:303.
89. Wittwer, S.H. and I.G. Hillyer.	1954	Chemical induction of male sterility in cucurbits. Science, 120:893-4.
90. Zanardi, D.	1956	Symptamatology of charges induced by 2, 4-D in Capsicum plants. Ann. Sper. Agnar. 10:1663-75. Hort. Abstrs. 27(1):82.

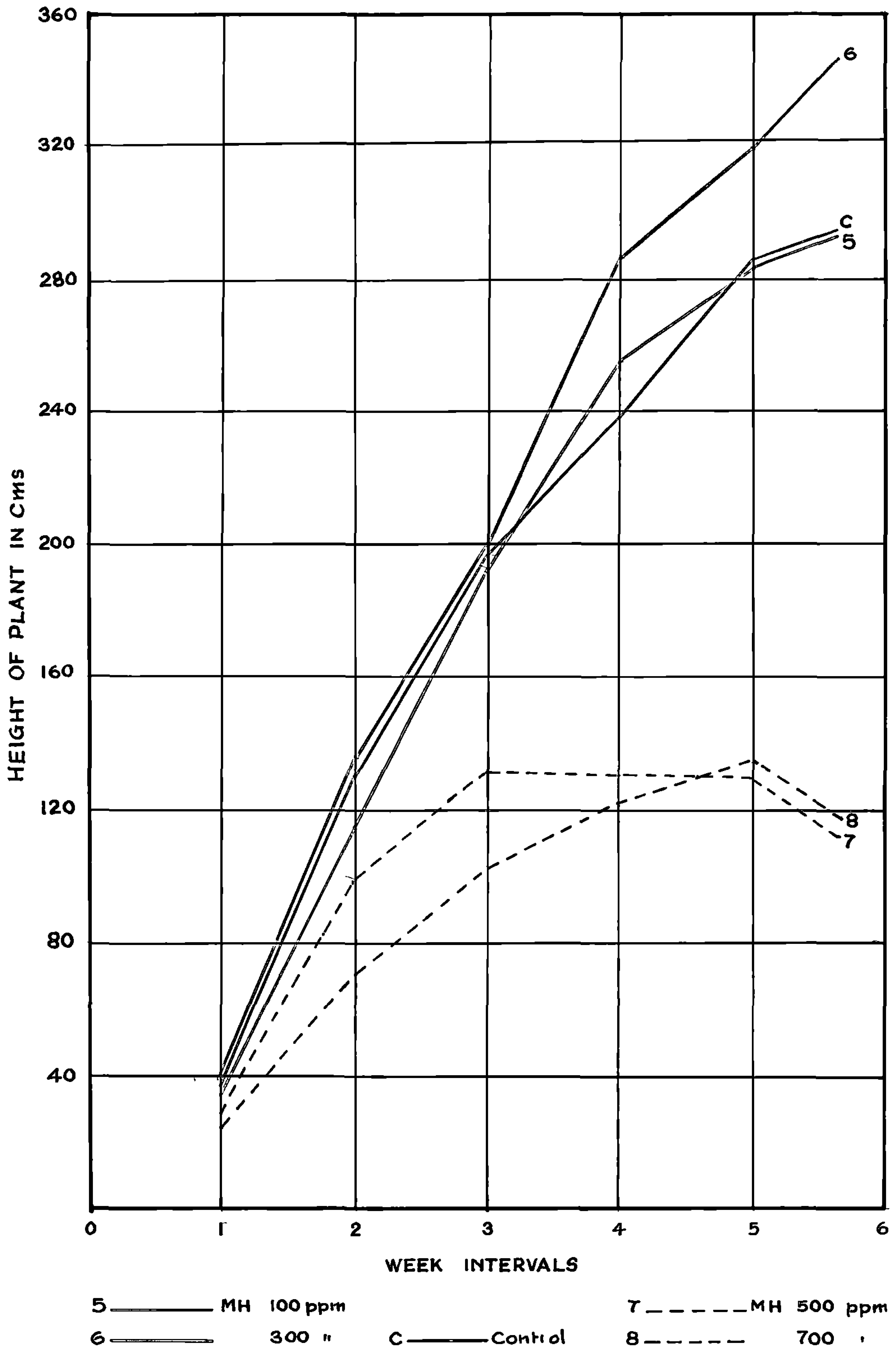
GRAPH I

Growth curve showing the height of the main stem of TIBA treated plants


360
320
280
240
200
160
120
80
40
HEIGHT OF PLANT IN Cms
0
1
2
3
4
5
6
WEEK INTERVALS
C
1
2
4
3
1 TIBA 300 ppm
2 400
C Contiol
3 TIBA 500 ppm
4 600

GRAPH II

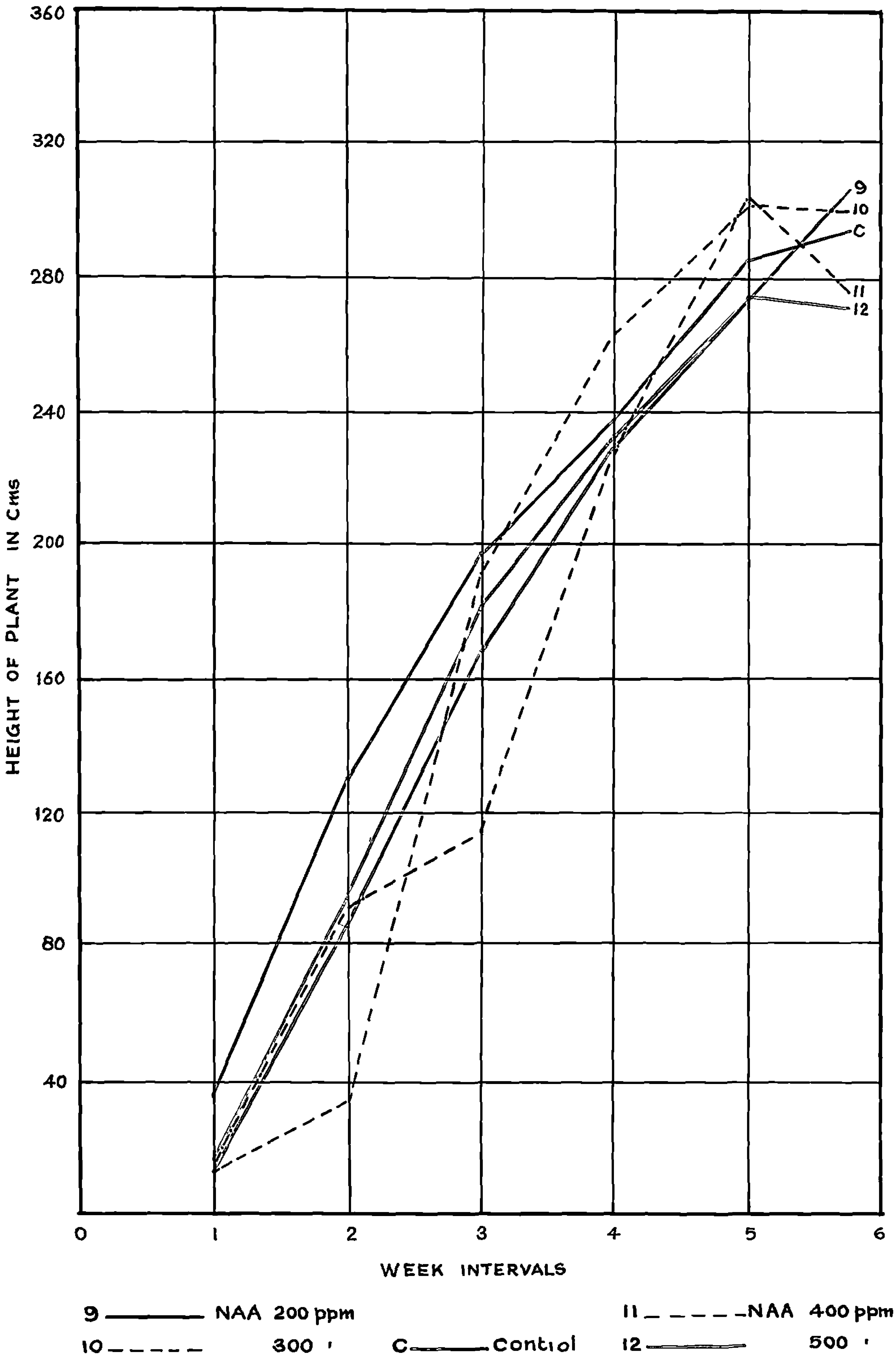
Growth curve showing the height of the main stem of MH treated plants



360
320
280
240
200
160
120
80
40
0
1
2
3
4
5
6
HEIGHT OF PLANT IN Cms
WEEK INTERVALS
6
C
5
8
7
5 MH 100 ppm
6 300 "
C Control
7 MH 500 ppm
8 700

GRAPH III

Growth curve showing the height of the main stem of NAA treated plants



360
320
280
240
200
160
120
80
40
0
1
2
3
4
5
6
9
10
C
11
12
HEIGHT OF PLANT IN Cms
WEEK INTERVALS
9 NAA 200 ppm
10 300 '
C Contiol
11 NAA 400 ppm
12 500 '

GRAPH IV

Growth curve showing the height of main stem of 2,4-D treated plants

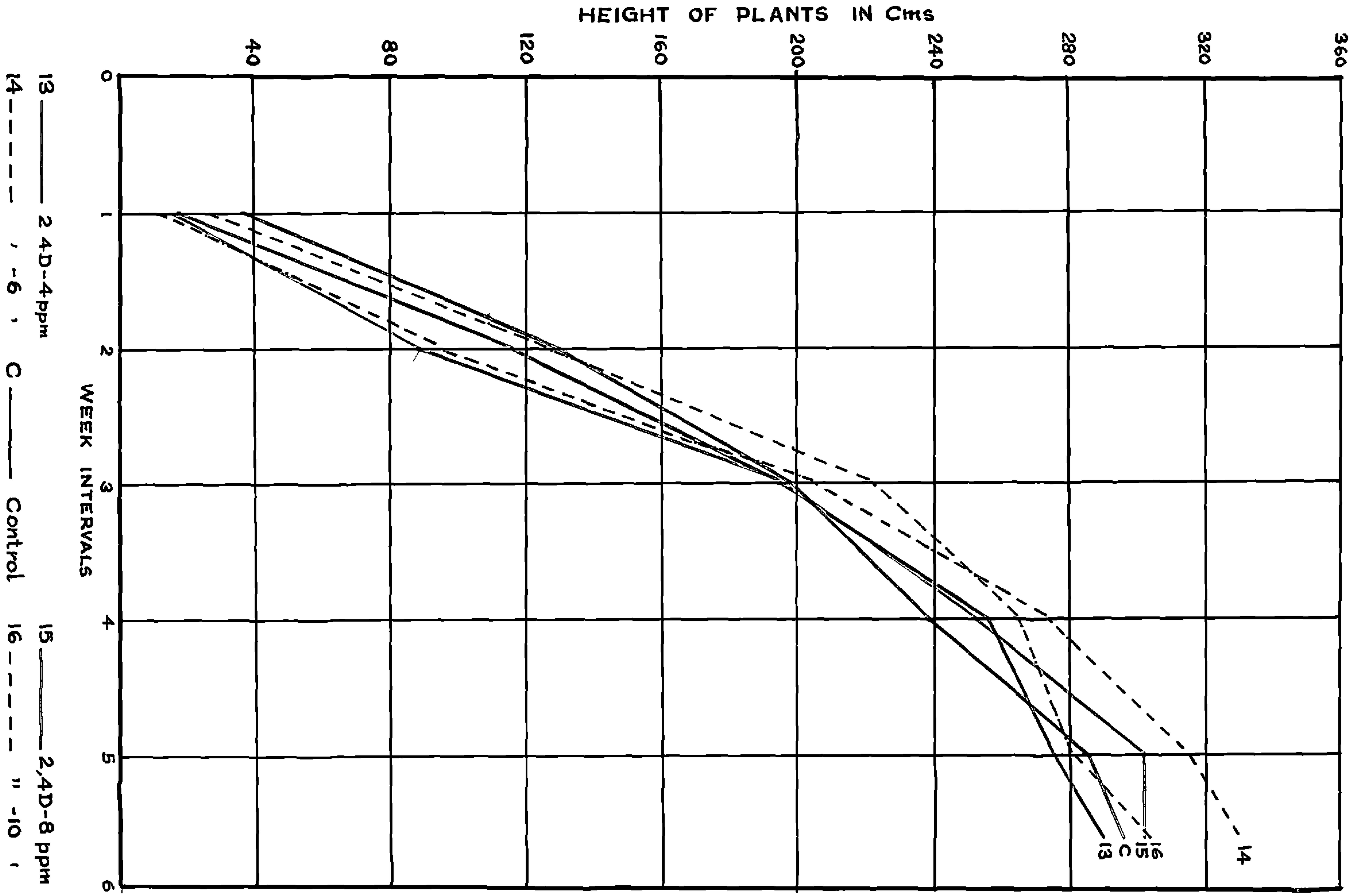
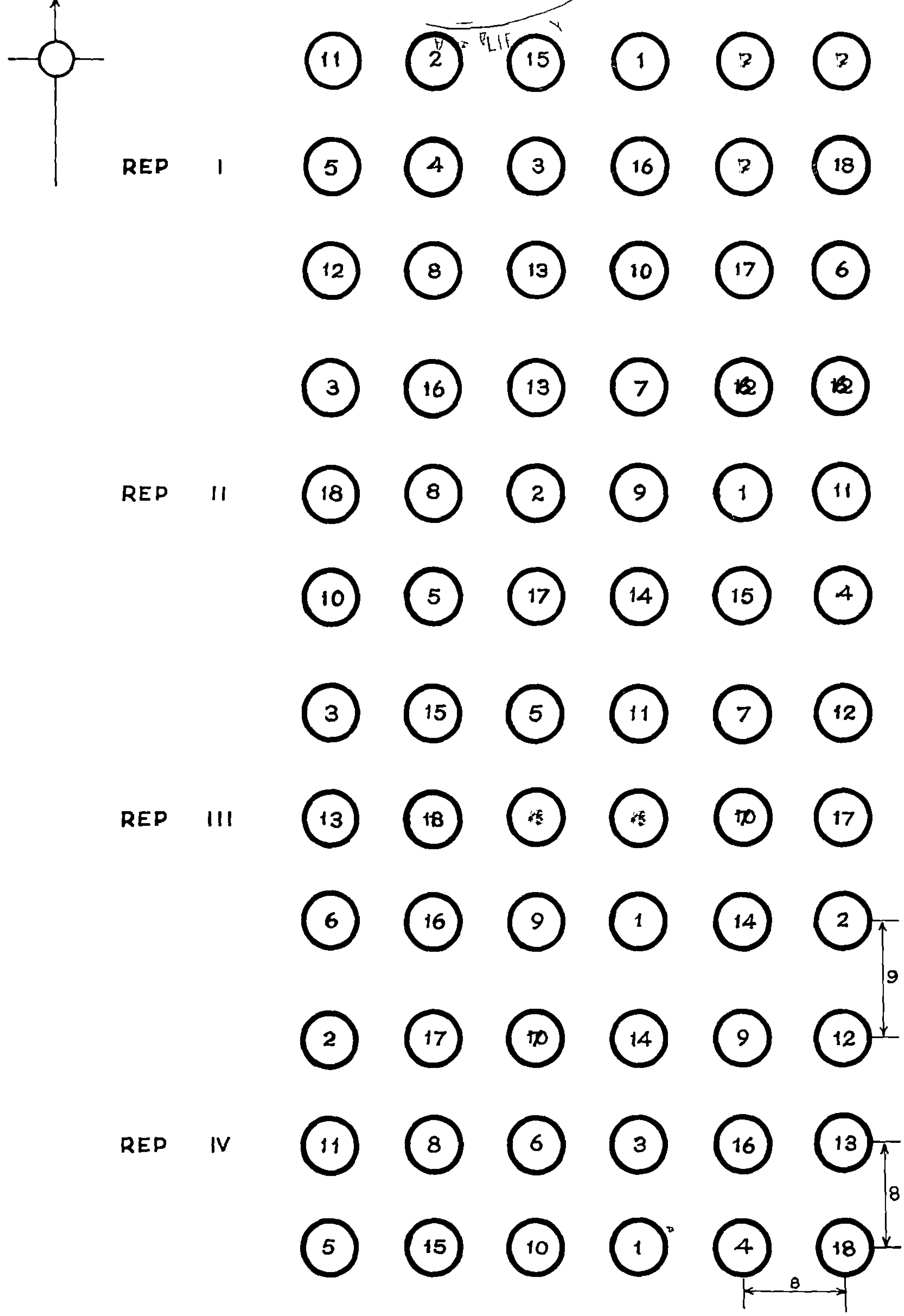

HEIGHT OF PLANTS IN Cms
40
80
120
160
200
240
280
320
360
WEEK INTERVALS
0
1
2
3
4
5
6
13 —— 2 4D-4ppm
14 - - - - " -6 "
C —— Control
15 —— 2,4D-8 ppm
16 - - - - " -10 "
13
C
15
16
14

PLATE I

Plan of Lay out of the experiment

PLATE I



LAY OUT OF THE EXPERIMENT

PLATE II

Comparison between the number of male and female flowers

PLATE II

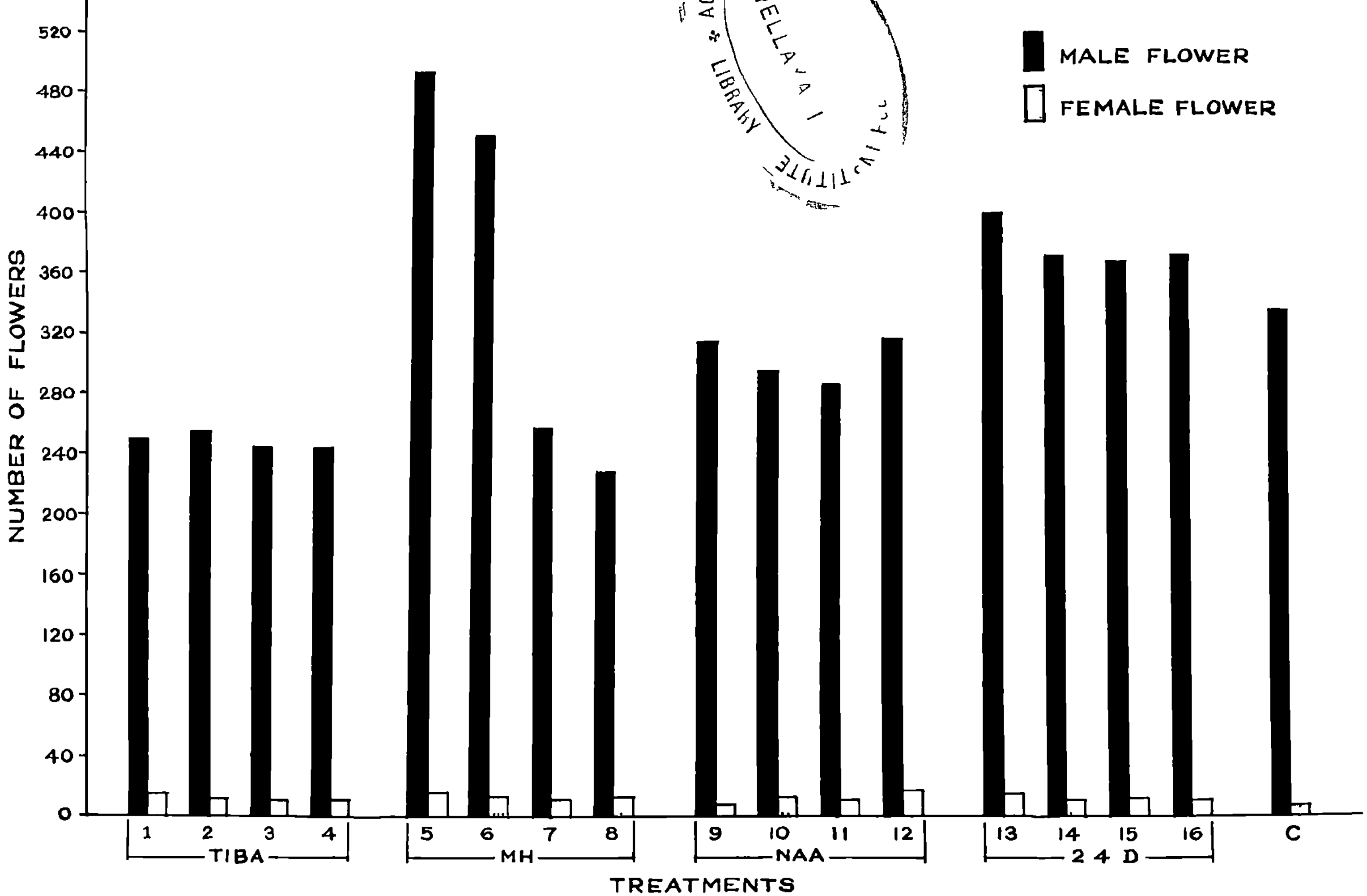

MALE FLOWER
FEMALE FLOWER
NUMBER OF FLOWERS
0
40
80
120
160
200
240
280
320
360
400
440
480
520
1
2
3
4
TIBA
5
6
7
8
MH
9
10
11
12
NAA
13
14
15
16
2 4 D
C
TREATMENTS

PLATE III

Percentage of fruit-set (Number of female flowers and fruits)

PLATE III

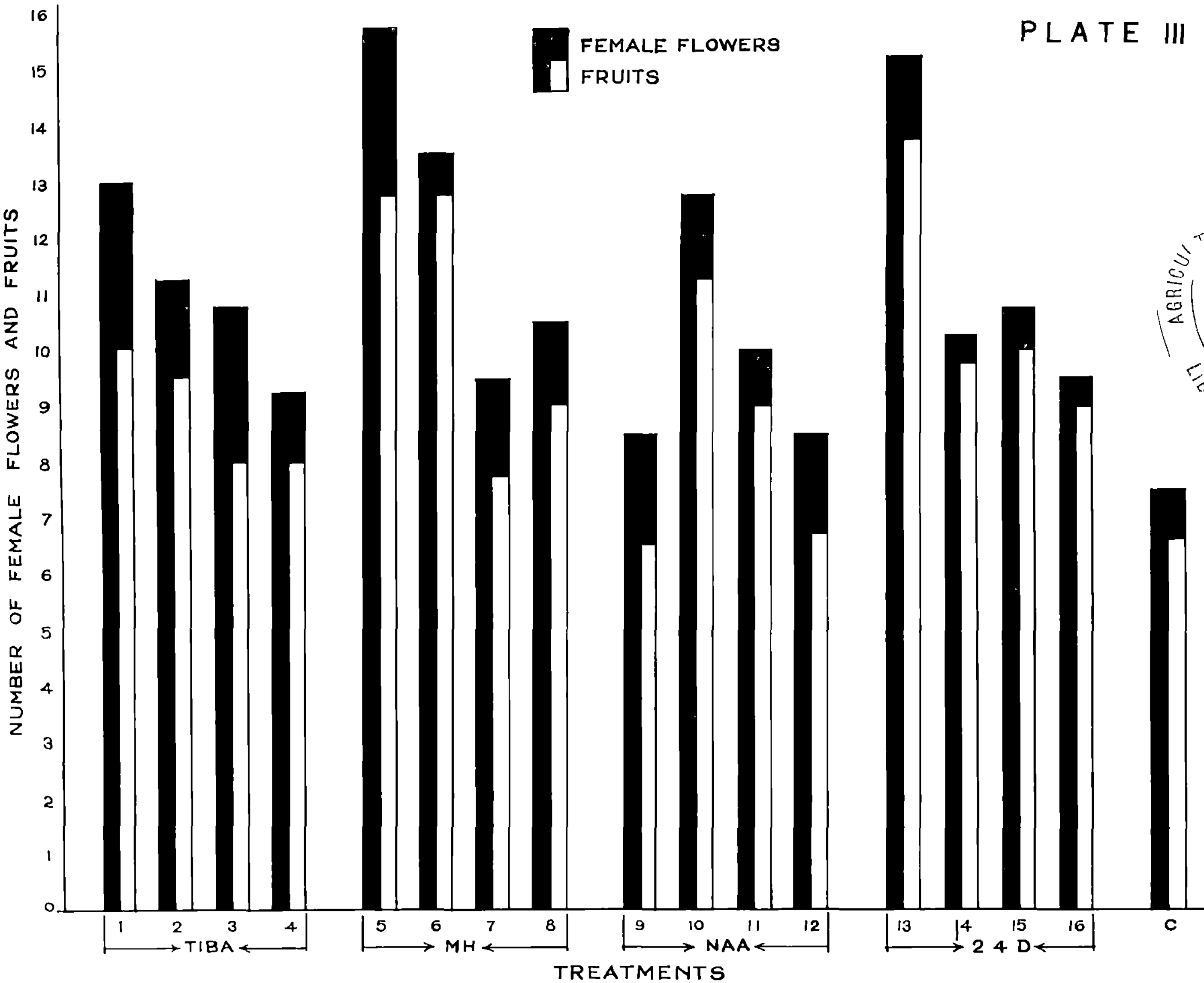

FEMALE FLOWERS
FRUITS
NUMBER OF FEMALE FLOWERS AND FRUITS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1
2
3
4
TIBA
5
6
7
8
MH
9
10
11
12
NAA
13
14
15
16
2 4 D
C
TREATMENTS

PLATE IV

Weight of fruits in gms

PLATE IV

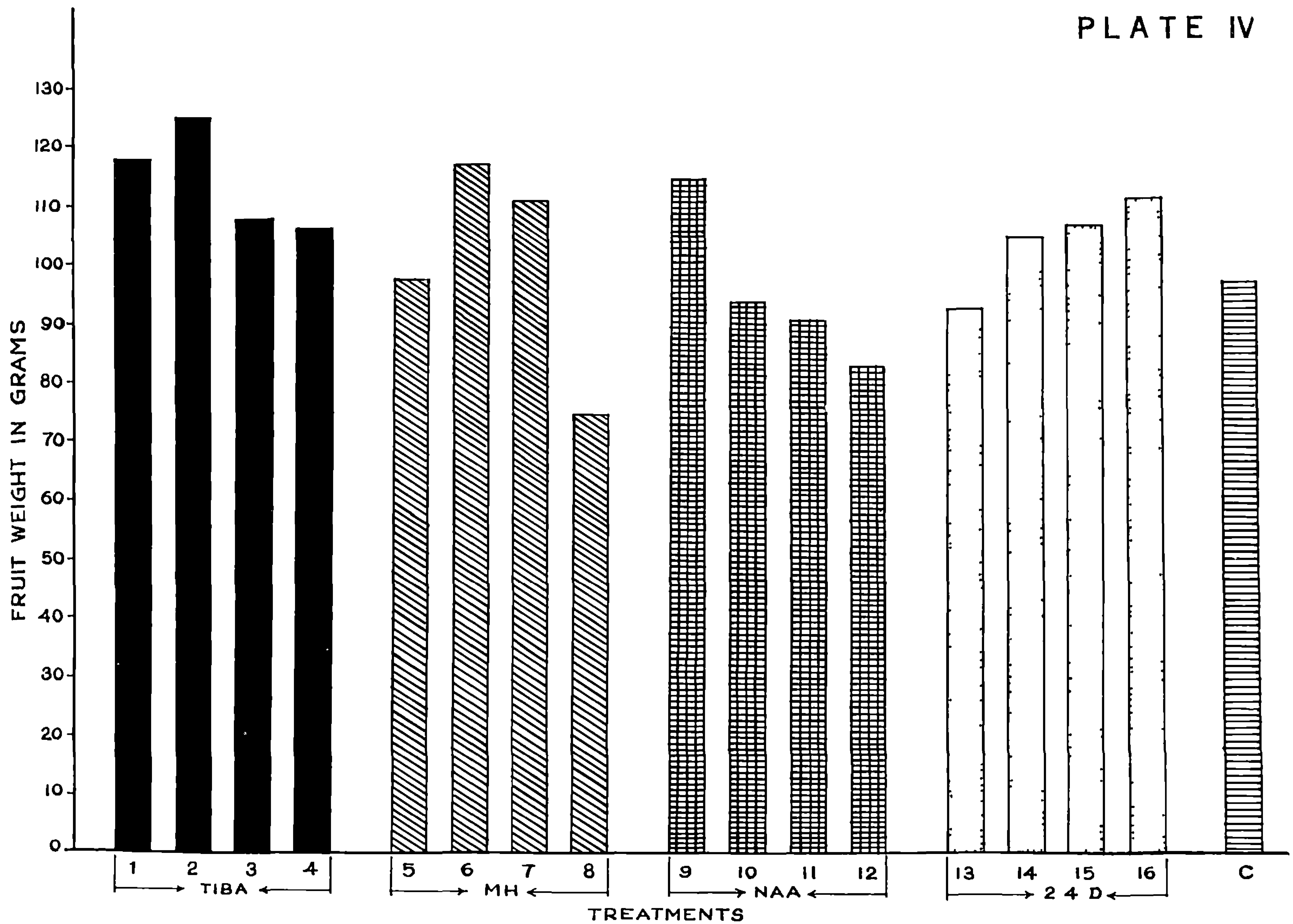

FRUIT WEIGHT IN GRAMS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
1
2
3
4
TIBA
5
6
7
8
MH
9
10
11
12
NAA
13
14
15
16
2 4 D
C
TREATMENTS

PLATE V

Suppression of the growth of the main stem in TIBA and MH treated plants

Fig. 1. TIBA 400 ppm

Fig. 2. TIBA 600 ,,

Fig. 3. MH 700 ,,

Fig. 4. Control

Fig. 5. Control (after harvest)

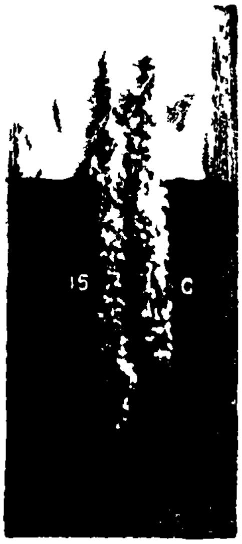
Fig. 6. TIBA 300, 400, 500 and 600 ppm and MH 500 and 700 ppm (after harvest)


2
1
2
8
3
4
5
8
7
4
3
2
1
6

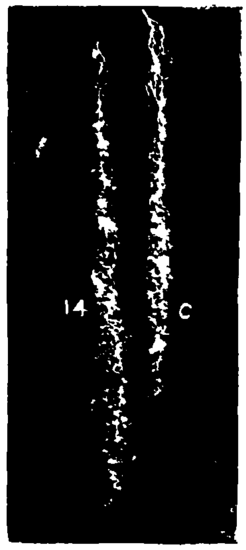
PLATE VI

Figs. 1-7.	Total height of the plant	
Fig. 1.	2,4-D 8 ppm and control	
Fig. 2.	2,4-D 6 ,, ,,	
Fig. 3.	2,4-D 10 ,, ,,	
Fig. 4.	MH 300 ,, ,,	
Fig. 5.	MH 100 ,, ,,	
Fig. 6.	TIBA 600 ,, ,,	
Fig. 7.	MH 700 ,, ,,	
Fig. 8.	Section showing the single seeded fruit in 2,4-D 4 ppm treated plants in comparison with control.	
Fig. 9.	Variation in the size of male flowers in all the treatments and control	

PLATE VI



1



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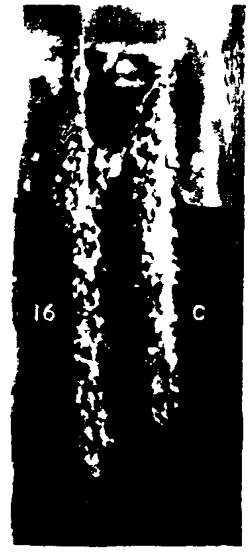

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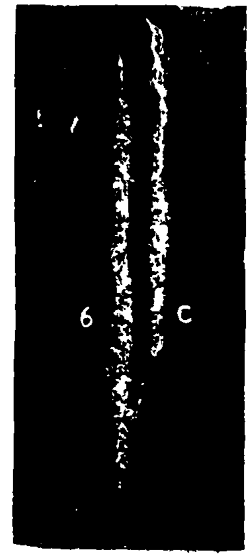

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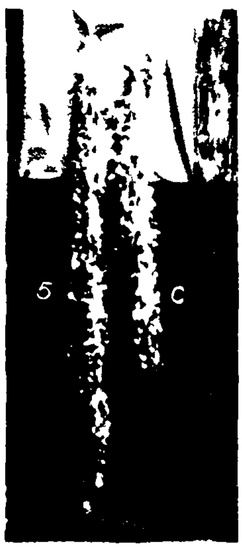

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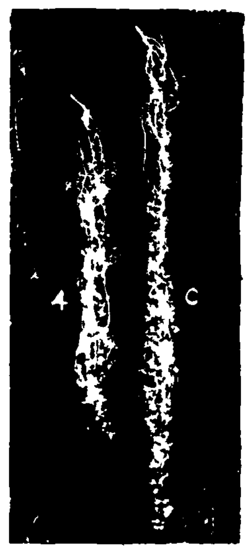

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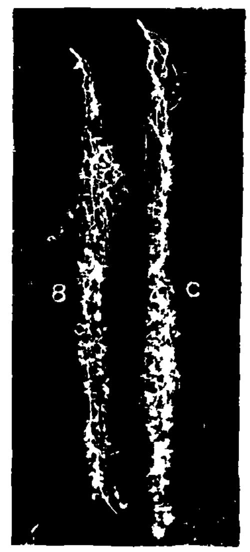

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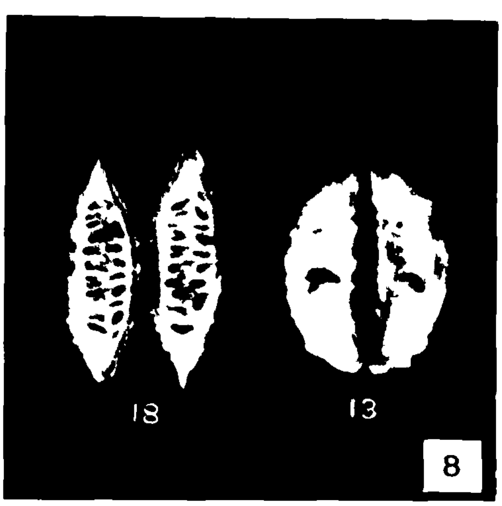

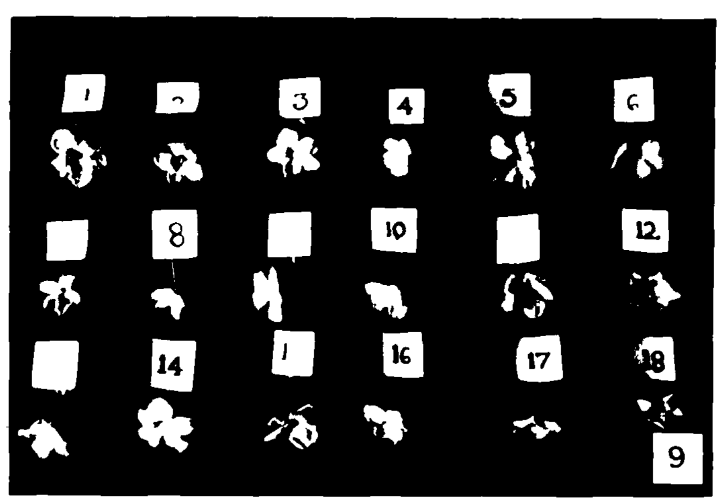

PLATE VII

Leaf deformities

Figs. 1-3. TIBA treated plants showing the crinkled leaves with dark green veins

Fig. 4. MH 700 ppm treated plants showing the crinkled leaves at the later stages in comparison with control

Fig. 5& 6. Epinastic leaves of NAA treated plants.

Fig. 7. Epinastic leaves of 2,4-D treated plants.

Fig. 8. Stingy leaves of 2,4-D treated plants.

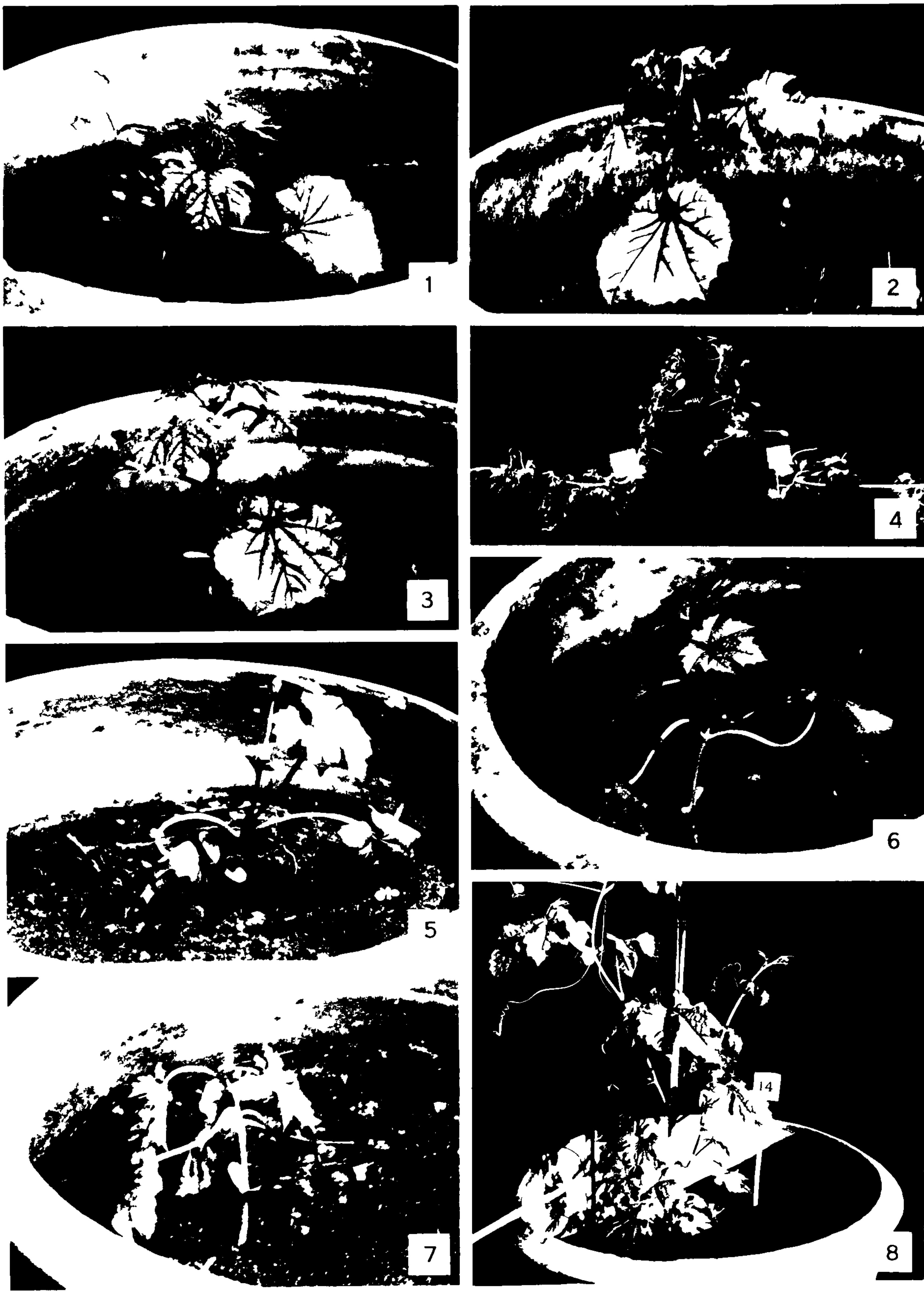
1
2
3
4
5
6
7
8
14

PLATE VIII

Figs. 1-4. TIBA treated plants showing the branches produced from the axils of the cotyledons

Fig. 5. Control

Fig. 6. NAA treated plants showing the main stem without branches at the early stages of growth.

Fig. 7. Adventitious roots in NAA treated plant

Fig. 8. Control

PLATE VII

PLATE IX

Production of female flowers in continuous nodes in TIBA, MH and 2,4-D treated plants.

Fig.	1.	MH	300	ppm
Fig.	2.	TIBA	300	,,
Fig.	3.	TIBA	400	,,
Fig.	4.	TIBA	500	,,
Fig.	5.	MH	500	,,
Fig.	6.	MH	700	,,
Fig.	7.	2,4-D	4	,,
Fig.	8.	Control		

PLATE IX