FLORAL BIOLOGY, SEX EXPRESSION, SEX RATIO AND FRUIT DEVELOPMENT IN CUCUMBER (*CUCUMIS SATIVUS* L.)

(AS AFFECTED BY PLANT REGULATOR SPRAYS)

By

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A THESIS

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Certified that the results presented in this thesis entitled "Floral biology, sex expression, sex ratio and fruit development in cucumber (*Cucumis sativus* L.) (as affected by plant regulator sprays)" is the genuine record of the bonafide research work carried out by Mr. A.V. Patil, under my guidance and supervision.

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INTRODUCTION

The family Cucurbitaceae is characterised by its various forms of sex expressions. These expressions vary from strict gynoecious forms to hermaphrodite form. Dioecious species like Trichosanthes dioica are also found in this group. But monoecious expression is most common, dioecious next and hermaphroditism rare.

The family Cucurbitaceae includes many important and popular vegetable crops like cucumber, gourds, pumpkins, squashes etc. These vine crops thrive in hot weather and are affected by frost. Cucumber (Cucumis sativus L.) is one of the important and popular vegetable belonging to this family. It is one of the oldest cultivated vegetable crops and has been found in cultivation since 3000 to 4000 years. It is a native of Asia and Africa. Some authorities claim that it originated from India and from there it spread to Asia, Africa and Europe.

Cucumber is one of the quickest maturing of vine crops. The seeds do not germinate below the soil temperature 11.0°C (51.8°F) (Kotowaski 1926). The favourable temperature range for cucumber is 80°F to 85°F. In India cucumber is grown in rainy and summer seasons.

Cucumber belongs to genus Cucumis which includes 30 species from Asia and Africa. Out of these only two species are of economic importance i.e. Cucumis Melo and Cucumis sativus. Cucumber is characterised by monoecious sex expression but

andromonoecious and trimonoecious forms are also found. In India it is grown in all parts of the country including hilly tracts of Northern India.

Very little improvement work has been done in cucumber in our country. Most of the recommended varieties are introductions from other countries. These varieties are of very little use under our conditions, because though promising, these are bred at cooler regions and produce more male flowers under our conditions of high temperature and long days.

It is a common knowledge that yield of cucumber depends upon the number of female flowers produced on the vine. So the grower is naturally interested in a variety which gives more female flowers or in a practice which will increase the number of female flowers on the vines. The grower should, either be given a variety having a high female sex tendency or he should be given a method by which he can induce more female flowers on the vine. Apart from the factors like heredity, environment and plant hormone concentrations play important role in changing the sex tendency in these plants.

In recent years plant regulators have been increasingly used in horticulture. These hormone type organic compounds induce various changes in the plant. Auxin is a relatively new arrival on the scenes of sex determination in flowers. Attention to this fact was first drawn by Laibach (1952) in explanation to his works conducted in association with Kribben (1950, 1952) on cucumber and squash. He contented that during

flowering, the female flower production is associated with a higher auxin level than male flower production. The distribution of sexes between flowers, and between individual plants is usually determined by strict hereditary laws, but there are a number of well founded observations that other factors such as, the state of nutrition, light, temperature and moisture etc. may greatly influence sexual expression in these plants. Besides this the idea of a hormonic control of sex expression has also gained importance in recent years.

Plant regulator sprays have been found to modify effectively the sex in cucurbits. These regulators when sprayed on plants increase the number of female flowers and at the same time suppress the number of male flowers.

The previous work in the Division of Horticulture at I.A.R.I. (Phatak 1959) has shown that different plant regulator sprays significantly increase the number of female flowers in cucumber and suppress the number of male flowers. The question still remains whether high number of female flowers are expected to give higher yield of the fruit. The present investigation was undertaken with a view to confirm the previous findings and further study whether the plant regulator sprays can also have any effect on the pollen fertility, anthesis, setting, development and maturity of fruit and ultimate yield in cucumber. These studies were carried during the rainy season of 1959 and summer season of 1960 in the Division of Horticulture of Indian Agricultural Research Institute, New Delhi.

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REVIEW OF LITERATURE

Floral biology

The floral biology of cucurbits has been reported by number of workers. Filov (1935) observed the floral biology of different cucurbits. Millan (1951) reported observations on the floral structure of *Cucurbita* species.

Judson (1929) first studied the morphology and vascular anotomy of the pistillate flower of cucumber. Jakimovic (1935) reported the floral biology of cucumber (*Cucumis sativus*).

The corolla of the genus *Cucurbita* opens regularly at day break on account of the darkness of certain hours and partly to the decline of temperature at night. (Tamura 1954). Sun light apparently exerts little influence on the opening of corolla of this genus. (Seaton & Kremar 1938).

Seaton and Kremar (1938) observed in different cucurbits including cucumber that temperature controlled the time of flower and pollen sac opening and that humidity, rain, wind and light intensity influenced anthesis only in so far as they affected the flower temperature. Singh (1950) reported in *Trichosanthes* species that minimum temperature greatly influences the time of anthesis; while maximum temperature has effect on anther dehiscence. Agarwal *et al.* (1957) reported in *Mimordica charantia*, the time of opening and closing of flowers, and time of anther dehiscence and receptivity of stigma. Hayase (1958) observed that in cucurbit species high temperature to

flower bud can accelerate the anther dehiscence. Phatak (1959) studied the anthesis, anther dehiscence, pollen size and shape and pollen fertility in 5 varieties of cucumber. He observed that light and time of the day had more effect on the anthesis than temperature. He found temperature to be a controlling factor for anther dehiscence. He also found that pollen fertility was affected by temperature.

Sisa (1932) reported germination tests of pollens in Cucurbita species. Poole & Porter (1933) studied the effect of temperature on the growth of pollen tube within the style of Citrullus vulgaris. Hayase (1955) observed the effect of temperature before and after anthesis on pollen viability in cucumber. He found that in a agar medium a pollen becomes viable before anther dehisce. In cucumber viability was little changed when the male flowers were stored at 15°C to 30°C for 21 hours, prior to anther dehiscence. But with storage for 29 hours it was prolonged by the lower temperature and curtailed by the higher temperature. He found maximum viability at 20°C - 25°C. Knys (1958) found that cucumber pollen carried by a bee over a distance exceeding 500 meters become viable.

Filov (1935) found in water melon the receptivity of stigma about 6 days. Singh (1950) observed in Trichosanthes species receptivity 7 hours before and 51 hours after opening of flowers. Phatak (1959) observed in cucumber the receptivity 12 hours before to almost 24 hours after anthesis in April, under Delhi condition, when temperature conditions were not very

high. In May and June he found that receptivity was 12 hours before to 6 to 7 hours after anthesis.

Very little information is available about the effects of different plant growth regulator sprays on different aspects of floral biology in cucurbits. The growth regulator sprays are used to get more number of female flowers. It will be interesting to see if these sprays have any effect on anthesis, pollen fertility, and dehiscence of anthers. Choudhury and Phatak (1959) studied the effect of different growth regulator sprays on the fertility of pollens of cucumber. The growth regulator sprays were given at the two true leaf stage and four leaf stage. They observed maximum sterile pollens in plants sprayed with MH 800 ppm. in February crop. They also found that the adverse effect on pollen fertility gradually decreased and 30 days after spray no difference was observed in the fertility of pollens of the plants which were sprayed with different regulators.

Whitakar & Pryor (1946) studied the effect of growth regulator sprays on the set of fruit from hand pollinated flowers in Cucumis Melo. They found 22% increase in fruit set when they used substituted phenoxy-compounds, 4-chloro phenoxyacetic acid at the time of hand pollination. Wittwer and Hillyer (1954) studied the effect of MH at early stages of growth in cucumber. They gave repeated (4 to 5) applications at 5-7 days intervals, of MH - 100 ppm., beginning at the time of cotyledon expansion and continuing until 4 to 5 true leaf stage. This treatment effectively suppressed male flower buds and induced male sterility. They also observed that pistillate flowers were

quite normal and fertile. Use of male sterility for hybrid seed production is now well-known. Brian et al. (1959) observed the effect of Gibberellic acid treatment on the flowers of Cupid sweet peas. They found that there was a tendency of GA treated plants to delay opening of flowers. They also observed that GA treatment influenced the length of flower stalk. Choudhury & Phatak (1959) observed the production of giant ovary in the Gibberellin treated cucumber plants. Hillyer & Wittwer (1959) while studying the effect of MH on Acorn squash under green house and field conditions observed that staminate flower buds from treated plants had elongated, widened, leaf like sepals, undeveloped androecia and contained non-viable pollen grains in which protoplasm appeared shrunken. MH treated pistillate flowers possessed elongated ovaries and twisted shrunken corollas but after pollination normal fruiting was observed.

Teratology

Teratology in cucurbits has been reported by many workers like Sawhney (1919); Singh & Sinha (1928), Bose (1934), Ljascenko (1934), Pangalo (1936), Seaton & Kremer (1938a), Schanack and Cavia (1941), Pathak & Singh (1953), Singh (1953) and Phatak (1959).

Sex expression and sex-ratio

Correns (1928) forwarded a mechanism of sex determination

in monoecious plants and represented it by a formula in which 'A' and 'B' denoted the gene complexes for androecium and gynoecium respectively, and 'Z' gene which determines the sequence in which A & B are activated. Monoecious plants do not appear to have any morphologically recognised sex chromosomes, but they undoubtedly possess both male and female tendencies. Here sex is largely a developmental process, but this development is controlled by genes.

Considerable evidence exists which show that sex inheritance can be modified through change in environmental conditions. Basing on such instances the adherents of the environmental hypothesis take the other extreme view point and believe that sexes are not fundamentally distinct characters and these characters are amenable to change by variation in the environment. The experimental biologist takes the middle course which is also very reasonable. According to them sex is influenced by genetic factors, the manifestation of which are influenced by environmental conditions. Tiedjens (1928) isolated different strains of cucumber from commercial cucumber varieties. He isolated these strains under similar conditions, showing thereby that heredity control flower formation. He also demonstrated that sex ratio of cucumber can be changed by different light and soil conditions. The sex ratio of Cucurbita pepo var. Table queen was worked out by Erwin and Haber (1929). They found 7.5% of total flowers were pistillate and 92.5% staminate. Whitakar (1931) studied the sex expression in different varieties of cultivated Cucurbitaceae. He reported that each species is characterised

by a specific type of sex expression. He expressed the quantitative difference into a staminate/pistillate ratio. Scott (1933) reported sex ratio in Cucurbita pepo. Currence (1932) reported the nodal sequence of flowering in cucumber. He observed a gradual change from staminate to pistillate condition in the development of cucumber plant. Nitsch (1950, 52) and Nitsch et al. (1952) observed developmental pattern in Cucurbita pepo. They observed the following sequence in flowering: underdeveloped male, normal male, normal female, inhibited male, elongated female and parthenocarpic female flower. Erwin & Haber (1929) in Cucurbita pepo var. Table queen observed that staminate flowers appeared earlier than pistillate flowers. Singh (1953) reported in Trichosanthes species that staminate flowers were produced earlier than pistillate flowers. He also reported sex ratio in these species. Shifriss and Galun (1956) reported that in cucumber whole plant is a complex inflorescence with staminate flowers at the base and pistillate flowers at the upper portion. They also suggested that node number of first female flower is a good indicator of sex tendency than the male/female ratio used previously by other workers to denote sex expression. They recognised 3 phases of sex in cucurbits. First is strict male, then monoecism and third strict femaleness. Pangalo (1943) with his experiments with various external agencies affecting sex expression in cucurbits has shown that development of male and female flower is independent.

J. Heslop-Harrison (1957) has very excellently summarised the evidence concerning the modification of sex expression in

flowering plants, excluding those which act through genetical path. He listed, mineral nutrition, light, temperature, chemicals and hormones, mutilation and grafting as some of the factors affecting the sex expression in flowering plants.

Heyer (1884) reported change in sex expression through environmental conditions in cucumber and pumpkins. Tapley (1923) observed in squash that additional supply of nitrogen increased the number of female flowers. Tiedjens (1928) showed the clear effect of nutrition on the sex expression in cucumber. Whitakar (1931) while studying the sex ratio in different cultivated species of cucurbits forecasted the possibility of change in sex expression through changes in environment. Dearborn (1936) showed that high nitrogen supply produces more pistillate flowers and few staminate flowers. Sabnin (1937) observed in water melon that increased dose of nitrogen increases the number of female flowers. Minina (1938) reported similar trend in cucumber. Rodenikov (1945) observed that correct mineral nutrition influences the sex of the flower and produces large number of female flowers. Hall (1949) studied the clear effect of nitrogen on the male/female ratio in gherkin (C. anguria). Ito & Saito (1953) reported that female flower production was promoted by low nitrogen and heavy watering. Funamato and Masuda (1955) reported the effect of fractional doses of nitrogen in cucumber. They obtained high yield by 5 applications of nitrogen fertilizers as against one dose at the beginning. Brantley & Warren (1958) observed the effect of nitrogen, photoperiod and auxin on sex expression in musk melon. They reported, high N, long days and NAA were found to promote female sex expression. Miller & Ries (1958) reported that at high N level

plants produced 3 times as many fruits as low N plants.

The influence of light regime upon flowering plant sexuality has long been known. The yield of cucurbitaceous crop which is dependent on number of female flowers, changes considerably from season to season. Tiedjens (1928) reported that there was a decreasing tendency with male to female ratio with short days. Edmond (1930) observed similar variation in sex-expression in cucumber when it was grown under different photoperiods. Danielson (1944) observed in small gherkin (Cucumis anguria) that there was a quantitative difference in flowering. Short days (8 hrs.) gave maximum staminate flowers and long days (16 hrs.) lowest staminate flowers. Hwang (1944) found that in pumpkin the number of pistillate flowers increased with short photoperiod and this inhibited the development of staminate flowers. Pal & Singh (1946) reported variation in male female proportion in bitter gourd (Mimordica charantia L.) Hall (1949) studied the ratio of male and female in small gherkin (Cucumis anguria) under 8 hour and 16 hour photoperiod and found no difference in ratio under both the photoperiods. Nitsch et al. (1952) reported in small gherkin (Cucumis anguria) that day length and temperature affect the sex expression. In an experiment with Cucurbita pepo var. Table queen under phytotron conditions, no female flowers were produced under long day conditions (16 hour) and high temperature (30°C day and night) but short days (8 hour) and the same temperature produced female flowers. In cucumber var. Boston pickling short day treatment produced femaleness. Ito & Kato (1953) from Japan

reported in Japanese cucumber that different photoperiods affect the sex expression. Fujii et al. (1954) also observed a change in sex expression by change in photoperiod. Shifriss & Galun (1956) found a variation in sex expression in cucumber in two different seasons. Ito & Saito (1957b) studied the effect of day length and night temperature on cucumber seedlings in nursery beds. Short days with low night temperature promoted pistillate flowers, and long days and high night temperatures produced male flowers. Ito & Saito (1957c, 1958) reported that 15 hour day and high night temperature (30°C) for 2 to 4 days resulted in production of high number of male flowers in cucumber. Sekia (1957) reported a marked effect of short photoperiod (8 hour) and low temperature (10 - 20°C) at the early stages of cucumber. Choudhri (1957) reported possible significance of photoperiod and hormones in sex expression in plants. He conceived of a set of two hormones named as Y and Z, stamen and carpel inducers respectively. These above said hormones are activated by different photoperiods. Miller and Ries (1958) studied the effect of environment on fruit development of pickling cucumber. 70°F night temperature produced more fruits in 11 hour days than 15 hour days whereas at 60°F night temperature more fruit was produced under long day conditions. Phatak (1959) observed the sex ratio of 6 varieties of cucumber in two different seasons. He found seasonal difference in the pattern of the pistillate flower distribution.

Knight (quoted by Geddes & Thomson, 1889) found that water melon plants in green house with day temperature 43.5°C

produced only male flowers; while cucumbers raised under cold conditions gave only female flowers. Nitsch et al. (1952) carried out experiments with various cucurbits under phytotron conditions. These experiments clearly demonstrated the effect of temperature on sexuality of cucurbits. In Cucurbita pepo var. Acorn squash grown under short photoperiod and range of controlled temperatures. The results indicate clearly that in both photoperiods lower temperature during growth accelerates the trend from maleness to femaleness. The results of the experiment suggest that in both photoperiods lower temperature during growth accelerates the trend from maleness to femaleness. They also observed that night temperatures were of significance for this effect since day and night temperatures were not interchangeable. Nitsch et al. (1952) reported that climatic factors (day length and temperature) exert a profound influence upon the developmental sequence of the flowers. High temperature and long days tend to keep the vines in the male phase whereas low temperature and short days favour the development of female flowers. Ito & Kato (1953) found that temperature was one of the factors influencing sex expression in cucumber. Fujii et al. (1954) reported that temperature affected female flower production in cucumber. Ito & Saito (1957b, c, 1958) observed in cucumber that low night temperature and short days promoted pistillate flower formation and high temperature and long days favoured staminate flower formation. Sekia (1957) recorded similar results in cucumber.

There is a recorded evidence of modification of sex

expression in new offshoots following severe prunning. Tiedjens (1928) observed change in sex expression in cucumber by removing female flowers. Ito & others (1954) studied the effect of pinching in Japanese cucumber. The application of growth substances and stem pinching induced transformation of staminate flower buds into bisexual flowers, pistillate flowers. Galun (1958, 1959) reported that sex expression of the cucumber can be changed by means of chemical vernilization, removing young and adult leaves and by grafting.

Considerable research work has been done to study the effect of auxins and auxin like substances on sex expression in Cucurbitaceous crop. Russian workers were the first to observe such effect in green house cucumbers. In green house heating, gases issued had profound effect on sex of cucumber. Minina (1938) subjected the cucumber plants at seedling stages (3 to 4 leaf) in green house for 11 to 12 hours to carbon monoxide gas. Marked morphological effects like epinasty and partial loss of green colour was marked in treated plants. Non treated (control) plants gave 25:1 male/female ratio after 16 days. After 30 days these plants gave 12.5 male : 1 female. Gas treated plants showed the ratio of 2.17 male : 1 female after 16 days; and 4.34 male : 1 female after 30 days. In treated plants female flowers appeared first. Minina & Tylkina (1947) showed the clear effect of carbon monoxide on young cucumber plants. 20 - 22 days old plants were kept under bel jars containing gas mixtures for 15 - 20 hours. The average ratio of flower sexes increased from 4 male :

1 female to 6.5 males : 1 female. In 1% carbon monoxide the ratio decreased from 4 male : 1 female to 1.5 male : 1 female. In higher concentrations of carbon monoxide (0.3 to 0.5%) the sex ratio was 1:1. Minina et al. (1949) dismussed the action of carbon monoxide on monoecious cucumber. He was able to increase the number of pistillate flowers by using 2% carbon monoxide. Dubrovina (1950) did not get any effect on sex expression in cucumber by presowing treatment with carbon monoxide. Mehanik (1958) studied the effect of acetylene upon the development of female flowers in cucumber. Plants were grown under celophene bags containing acetylene bore more pistillate flowers and fewer staminate flowers. Rogalev (1953) studied the effect of Co_2 gas under glass house conditions on cucumber. He reported better quality fruits as a result of Co_2 treatment but no effect on the yield, whereas Smirnov (1954) recommended the use of Co_2 gas for green house cucumber for increasing yield and improving quality of fruits.

A direct effect of auxin treatment on sex expression in Cucurbitaceae has been reported by Laibach & Kribben (1950a, b,c, 1951), Laibach (1951). In one experiment (Laibach & Kribben 1950b) summer cucumber plants were treated at an early age of 16 - 18 days. The auxins used were, NAA, IAA and 2,4-D applied in lanolin paste to the stumps of petioles and in aqueous solution as a spray. NAA promoted number of female flowers and suppressed the number of male flowers. Nitsch et al. (1952) in Cucurbita pepo observed that NAA (100 ppm.) treated plants at young stage (two leaf stage) formed first

female bud at comparative earlier node than the non-treated plants. These results correspond to the results obtained by Laibach & Kribben. Wittwer and Hillyer (1954) with cucumber varieties, National pickling and Burpee hybrid and Table queen squash observed, when sprayed with NAA (100 ppm.), that the treatment decreased the proportion of male flowers. Ito & Saito (1956a, b, 1957, a,d) and Ito et al. (1954) conducted series of experiments on Japanese cucumber under green house conditions. They observed that auxin treatments influence the sex expression in Japanese cucumber. Branteley et al. (1958) studied the effect of nitrogen, photoperiod and auxin on sex expression in musk melon (C. Melo). They concluded that, high N, long days and NAA were found to promote the female sex expression. Maheswari (1957) conducted trials at Delhi to see the effect of auxins on 4 members of family Cucurbitaceae. He did not get any results. He reasoned that high temperature and long day conditions tended the plants in male phase. G. Satyanarayan et al. (1958) studied the effect of plant growth regulators on sex expression on ribbed gourd (Luffa acutangula Roxbg.). They observed that these growth regulators affect the sex expression in cucurbitaceous flowers. They found that due to spray there was a reduction in total number of flowers and increase in number of female flowers. Hillyer (1958) with Acorn squash and Caserta squash with NAA - 100 ppm. spray observed greatest suppression of staminate flowers. Galun (1959) observed marked change in sex expression in cucumber when sprayed with NAA at young stage.

Choudhury & Phatak (1959) used different concentrations of NAA, MH, IAA and 2,4-D on cucumber var. Straight '8'. They reported that NAA-100 ppm. increased the number of female flowers significantly. NAA-100 ppm., IAA-100, 200 ppm. suppressed effectively the number of male flowers. All treatments increased female to male flower ratio. Brian, P.W. et al.(1959) observed that Gibberellic acid has certain similarities to the auxins but there are also differences. They studied the effect of GA on flowering of Cupid sweet pea when sprayed at an early stage of growth. Weekly applications of GA increased the number of flower buds. Galun (1959) studied the effect of Gibberellic acid and NAA on sex expression in cucumber plants. He observed that the repeated applications of GA treatments retarded the appearance of female flower at lower node. This shift indicates the trend towards the maleness. More male flowers were produced preceding the first female flower. Wittwer and Buckovac (1957) gave foliar sprays of Gibberellins of 10 to 100 ppm. during early stages of growth of cucumber. They observed a marked but temporary stimulation in vegetative growth. They reported that flowering and fruit production was delayed. Both staminate and pistillate flowers developed only after more than normal number of nodes had formed. Choudhury & Phatak (1959) reported the effect of Gibberellin treatment on sex ratio in cucumber. They observed that GI treated plants were more vigorous in growth and female flowers appeared earlier. There was a marked suppression of male flowers and increase in number of female flowers.

Maleic hydrazide is regarded as a growth inhibitor (Schoene & Hoffman, 1949, Nylor & Davis 1950).

It has been found to affect the male fertility in a number of flowering plants. Wittwer & Hillyer (1954) observed the effect of MH on Table queen squash at seedling stage. The treatment delayed the appearance of staminate flowers and only pistillate flowers appeared prior to opening of any staminate flower following NAA 100 ppm. sprays. MH 100 ppm. sprays effectively suppressed staminate flower buds. Hillyer (1958) sprayed MH 350 ppm. on Acorn squash and Caserta squash under green house conditions at early stages of growth. The concentration of MH 350 ppm. was not effective in field conditions in late spring and early summer; but later in the season, short days favoured chemical suppression. In the green house condition greatest suppression of staminate flowers by MH was observed when the concentration was 350 ppm. under 60°F and short days. Hillyer et al. (1959) while studying the chemical and environmental relationship in flowering of Acorn squash reported that complete suppression of staminate flowers grown in green house condition was obtained by foliar sprays of MH (250 ppm. and 350 ppm.) during 2nd and 4th leaf stage. In the field, however, 750 ppm. to 1000 ppm. was needed for comparable results. These results were obtained only under short days (13 hour) and low (60°F or below) temperatures. Choudhury and Phatak (1959) studied the effect of different concentrations of MH on cucumber at early stages of growth. (2 & 4 leaf stage). They concluded that MH 200 ppm. increased the number of female

flowers significantly. MH 600 & 800 ppm. suppressed the number of female flowers effectively. MH in all concentrations suppressed the apical growth but the effect was temporary in all concentrations except 800 ppm. They also concluded that even under long days and high temperature conditions it was possible to modify sex expression and sex ratio in cucumber by spraying certain plant regulators.

Besides the above different main factors affecting sex expression in plants there are some minor factors which also affect sex expression in cucumber. Ermolav (1941) studied the effect of drying seeds on growth and development of cucumber. He observed that yield of cucumber can be increased if seeds after being dried, have not lost more than 40 to 50% of their moisture and during drying are not exposed to a temperature of more than 70°C. Minina et al.(1944) observed in cucumber the sexual development of plants affected by the moisture condition of the medium. Rise in air humidity accelerated the appearance and increased the proportion of female flowers as compared with plants kept under dry condition. Holman (1954) treated the cucumber seeds with iodine and he obtained early yield. Namgoljnyh (1955) reported the change in sex characters by treating the seeds with 0.03% solution of Meythelene blue for 24 hours at 22 - 25°C. The treatment resulted in 62% more pistillate flowers. Sun (1957) reported in cucumber that seeds from middle portion of cucumber fruit produced higher percentage of female flowers. Van Koot et al. (1958) reported the influence of viruses on flower formation in cucumber. They

observed that infection with Cucumis virus I resulted in a approximately doubling the number of male flowers when plants were affected at an early stage of growth.

Fruit set, development and maturity:

The role of hormones in the initiation of ovary primordium in cucurbits has been thoroughly discussed in above paragraphs. The role of different factors on the differentiation of ovary primordia has also been discussed. Now it has been established beyond doubt that hormones can change the developmental pattern in monoecious plants like cucurbits. Now it will be interesting to see if these plant growth regulators further exert their influence in the fruit set and development. J. van. Overbeek (1959) has stated that most of the synthetic chemicals showing auxin activity do show their influence at low level. A few, however, surpass native auxins in their activity and nearly all persists in the plant much longer than native auxin. Gustafson (1926) first studied the development of cucumber fruit. He observed that growth curve shows slow beginning followed by rapid increase and final cessation of growth. Sinnott (1939, 1945a, b) reported from his studies in cucurbit fruits that growth proceeds at exponential rate before, as well as after, full bloom, slowing down only when fruits approach maturity. He found that the increase in ovary size is accompanied by active cell multiplication before the opening of the flower, but after pollination growth of the ovary proceeds

without appreciable cell division. Finally he was able to correlate the difference in fruit size observed in different varieties of cucurbits with duration of cell multiplication, this process continuing longer after full bloom in large fruited variety than in small fruited ones. Thus in most of the cases two processes regulate the growth of ovary: cell division and cell enlargement. Cell enlargement can reach enormous proportion in fruits, and any person who has eaten a piece of water melon (Citrullus vulgaris) can have noticed that, when mature, the cells of this fruits are so large that they can be seen individually with naked eye. The striking fact about the ovary development is that it grows regularly until the flower opens and then abruptly ceases to enlarge unless it is fertilised or a fruit is developed parthenocarpically. Nitsch (1950b) and Nitsch et al. (1952) have shown that at least in cucurbits it is possible to obtain continued growth of ovary from its initiation until it has completely developed into a mature fruit by controlling adequately the climatic environment. It is a common observation in most of the fruiting plants that if flowers are not pollinated they drop off. A abscission layer is formed and the flower drops off. This eliminates the possibility of fruit development. But in some cases like small gherkin (Cucumis anguria) no abscission layer is formed if the flowers are not pollinated. The flower remains attached to the plant for long periods after bloom (which lasts one day). Nitsch (1950b) made comparison between pollinated and unpollinated ovaries of small gherkin (Cucumis anguria). The results showed

that pollinated ovaries grew regularly into full sized fruits and unpollinated ovary started turning yellow and shrinking. This clearly shows that ovary needs more than merely to remain connected with the whole plant. Nitsch (1949b,c) planted the detached flowers of tomato into medium containing no auxins. The detached flowers which were pollinated previously developed into fruits and those not pollinated, the detached flowers in the same medium did not develop into fruits. It can be concluded from this that maintenance of ovary on the plant is only a prerequisite for fruit set and not the cause. Went (1928) first suggested "without growth substance no growth". Since then hundreds of experiments have suggested that auxin is responsible for cell enlargement. It is a known fact that young stamens are very rich in auxin. (Wittwer, 1943; Hatcher, 1946). Using flowers without stamens i.e. female flowers of Cucumis sativus, Gustafson (1939b) found also a drop in the auxin content of the flower at the time of the flower opening.

Pollination and fruit development :

Nitsch (1950b) has traced the growth curve of gherkin ovary, the increase in diameter proceeds at constant exponential rate and it is difficult to detect any sudden change in the shape of the curve at the time of pollination. If pollination does not take place growth soon ceases. Pollination not only supplies a male nuclei to its female counterpart but stimulates growth of fruit. Yasuda in Japan (1934) first produced a fully formed parthenocarpic fruit in cucumber by the injection of

pollen extracts into the ovary. Winkler (1908) termed this as "parthenocarpic stimulus". This stimulus of pollens after pollination is definitely of hormonal nature. Massart (1902) showed that dead pollen grains could stimulate the swelling of ovary in orchid. Fitting (1909) obtained same response by water extracts of pollens. These facts demonstrate the existence of hormones in pollen grains. Laibach in Germany established that pollens contain substance identical with auxins. Gustafson (1936) did pioneering work in this field.

Although the initial set of the fruit may be due to the auxin liberated into the ovary tissue from the pollen, yet the quantity involved seems completely inadequate to account for subsequent continued fruit growth.(Muir 1947 and Lund). The question remained as to which was the other source of auxins for developing fruits. Developing seeds have been found as the sources of fruit growth hormones.

The effects of seeds on fruit development :

Heinicke (1917) had shown that young apples containing low percentage of developing seeds were the ones which drop more readily. This is the first indication of a correlation between seed and fruit development. It is common knowledge that the size of fruit is proportional to the number of well developed ovules. Nitsch (1949a) has demonstrated in straw berry that growth of a straw berry receptacle can be completely stopped by the removal of all the achenes.

Gustafson (1939b) extracted various parts of squash

fruits and found that the seeds and the tissues immediately surrounding them were from 6 to 30 times richer in auxin than were other fruit parts. Wittwer (1943), Luckwill (1948), Redemann, Wittwer and Bell (1951) were able to obtain tomato fruit set with extracts of corn or apple seeds. That synthetic auxins can set fruits has been demonstrated by Gustafson (1936). He used 1% solution in lanolin of IAA to the stigma of squash and he was able to induce fruit development. He was not successful with water melon, winter squash and pumpkins. Gardener and Marth (1937a) obtained similar results with cucumber by spraying flowers with NAA, IBA, IPA.

It can thus be considered as well established that seeds control fruit growth by releasing a chemical stimulus of the auxin type.

Fruits are rich in water. Heinicke (1917) had shown that seeds in the apple are important in its water metabolism. Since the studies of Reinders (1938) it has been well known that auxins promote water uptake in plant tissues. It is very probable that one of the effects of the auxin produced by the pollen and the seeds is to regulate an active water uptake by the fruit.

Crafts et al. (1950) studied the response of several crop plants and weeds to MH. They sprayed MH on 20 days old crop plants and observed its effect on fruiting. In cucumber, they sprayed MH from 0.1% to 0.4% and they found stunted and badly shaped fruits in higher concentrations. Stewart et al. (1951) applied 2,4-D to Washington naval orange prior to bloom

and they observed increase in fruit size. Wittwer et al. (1957) reported in foliar sprays of 10 to 100 ppm. Gibberellins to cucumber seedlings, a marked but temporary stimulation in vegetative growth. The treatment resulted in delayed flowering and fruiting in slicing type of cucumber. G. Satyanarayan et al. (1959) observed that plant regulator sprays when sprayed at young stage to ribbed gourd (Luffa acutangula) resulted into inducing in more number of female flowers. They observed increased fruit set in higher concentrations of NAA and 2,4-D. Choudhury & Phatak (1959) studied the development of fruits by spraying the cucumber plants with GIB at seedling stages. The development of fruits of sprayed plants was rapid. The fruits matured 3 to 4 days earlier than the control.

MATERIALS AND METHODS

MATERIALS

Plant Material:

The variety Straight '8' of cucumber (*Cucumis sativus*) which is recommended as a standard variety by I.A.R.I., New Delhi was used for the present studies. This variety is a exotic collection released by Ferry-Morse Seed Company of Detroit, U.S.A. The data were collected from the statistically layed out experiment in two seasons i.e. July - October 1959, February - May 1960.

Chemicals Used:

Maleic hydrazide (MH), alpha-Napthaleneacetic acid (NAA), beta-Indoleacetic acid (IAA), 2,4-Dichlorophenoxy-acetic acid (2,4-D) and Gibberellic acid (GA) were used.

MH was obtained from United States Rubber Company, Naugatack, U.S.A. as MH-40 (a water soluble powder of the sodium salt of MH with wetting agent and sticker containing 40.0% MH acid). Stock solution of 10,000 ppm. was prepared from which various lower concentrations were made, just before use. Stock solution of 1000 ppm. were used for NAA, IAA and 2,4-D by dissolving the weighed amount of each chemical separately in a small quantity of alcohol and then adding a required quantity of distilled water slowly with constant stirring. NAA and 2,4-D and IAA used were the products of British Drug House, U.K. Stock solution of 1000 ppm. was

prepared for GA in dissolving the required quantity in distilled water from which various lower concentrations were made just before use. Gibberellic acid was obtained from Merck and Co. Inc. Chemical Division, Rahway. N.G.

METHODS.

Stages of anthesis, dehiscence, pollen fertility were studied in the plants which were sprayed with different concentrations of plant growth regulator sprays. Floral abnormalities were also recorded. The seeds of variety, Straight '8' cucumber was sown in the month of July 1959 in the field. The seeds were presoaked in water for 24 hours before sowing in the field. Then the seeds were sown on ridges at 3 ft. apart. At each hill 3 to 4 seeds were sown. The distance between two rows or ridges was 8 ft. The plants were thinned to one to each hill. The plants were given similar treatments as regards manuring, watering and plant protection. Second sowing was done in a similar way in the month of March 1960.

Stages of anthesis and dehiscence was studied in second week of May 1960. The pollen fertility study was undertaken in both the seasons. For anthesis and dehiscence study, temperature and relative humidity during observations were also recorded.

For studying the effect of different plant regulator sprays on fertility of pollens, the acetocarmine preparations were made of pollens. Minimum of 200 pollens from each treatment

were taken. Before collection of pollens, the flowers were covered with cotton plug the previous day to avoid contamination. The pollens were studied under the microscope after 15 minutes when th grains were properly stained. Several random fields all over the slide were counted making a total of about 200 pollens. Care was taken to include various fields lying in both peripheral and central regions of the cover slip.

Sex expression and sex ratio as affected by plant regulator sprays:

The experiment was undertaken to find out the effects of 5 different plant regulator sprays on the sex expression and sex ratio in cucumber. Cucumber (Cucumis sativus L. var. Straight '8') was taken up for the studies. The seeds were sown (presoaked in water for 24 hours) in the second week of July 1959. The young seedlings were first sprayed after 16 days at 1 to 2 true leaf stage and again after 10 days at 3 to 4 true leaf stage. The quantity of solution needed to spray each plant was 1.5 to 2 ml. for the first spray and 2 to 3 ml. for the second spray. The plant regulators used were, Maleic hydrazide (MH), 25, 50, 100, 200, 400, 600 ppm. alpha-Napthaleneacetic acid (NAA), 50, 100, 150, 200 ppm. beta-Indoleacetic acid (IAA) 50 & 100 ppm. and 2,4-Dichlorophenoxyacetic acid (2,4-D), 2.5 ppm. and 5 ppm. One set of plants were sprayed with distilled water and the plants were used as control plants. One treatment consisted of removal of male flower buds till the first female flower appeared. All the above sixteen treatments

in rainy season crop were replicated four times to eliminate the effect of the soil variation factors. There were 3 plants under each treatment in each replication. The number and sex of the flowers at each node on the main shoot and side shoots were recorded. The observations were recorded till the second week of October 1959 when the crop was practically over. Care was taken not to disturb the normal condition of the plant while recording the sex of the flower. Only one petal from the recorded flower was removed to distinguish it from the uncounted one.

The experiment was repeated and the seeds for the purpose were sown on first March 1960. In addition to above sixteen treatments four additional treatments of Gibberellic acid were taken up. The concentrations used were 10, 25, 50, 100 ppm. of Gibberellic acid. The observations on the lines mentioned above were continued till the third week of May 1960 when the crop was practically over because of rising temperature.

Fruit set, development and maturity as affected by plant regulator sprays.

Complete record of fruit set on each vine was taken to observe the effect of different regulator sprays on the fruit set on vines. The date of opening of female flowers was recorded and size of ovary was also recorded. To record the fruit set the plants were examined 5 or 6 days after opening of female flowers.

After harvest of each fruit its measurements were

recorded regarding its individual weight, length and diameter. The date of harvesting was also noted to calculate the days required for maturity of fruits. The number of days required for maturity of fruits were calculated from the day of opening of female flower till the harvesting of fruit. While harvesting the fruit, it was seen that the fruit has attained a tender and edible maturity. This was recognised by a slight change in colour from the stalk end of the fruit.

Statistical Methods:

The method of analysis of variance which is commonly used for randomised block design was used for finding out the test of significance between different treatment means.

The correlation coefficient was worked out on treatment and error level for number of female flowers and fruit set. The method of analysis of covariance was adopted to test the effect of plant regulators on fruit set, by eliminating the effect of initial number of female flowers. This method of analysis enabled to find out the effect of plant regulator sprays on fruit set.

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OBSERVATIONS

The experimental data are presented in the following three parts:-

A) Floral biology as affected by plant regulator sprays.

B) Sex expression and sex ratio as affected by plant regulator sprays.

C) Fruit set, development and maturity as affected by plant regulator sprays.

A. Floral biology as affected by plant regulator sprays:

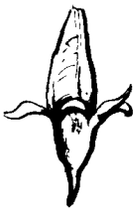
Anthesis:

The various stages of the anthesis of male flowers, beginning from the flower bud to a day before anthesis, were studied. The stages of development in anthesis of male flower in cucumber have been described by Phatak (1959). The same pattern was followed in studying the anthesis of male flowers in cucumber in present studies. The anthesis was studied in the middle of May 1960. Ten male flowers of each treatment were studied. The time and temperature at different stages during the observations in different treatments are presented in Table 1. (Plate 1).

Stage - 1:

In this stage the male flower was of distinguished yellow colour from the younger buds. In all the treatments except

STAGES OF DEVELOPMENT OF MALE FLOWER — CUCUMBER



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GA treatments, this stage was observed from 7.00 a.m. till 8.00 p.m. in the evening. This stage in GA treated plants was observed from 7.00 a.m. till 9.00 p.m. i.e. an hour later than other treatments. The temperature during this stage was ranging from 28.0°C to 39.0°C and in GA treatments it ranged from 28.0°C to 30.0°C.

Stage - 2:

The petals started opening slightly from the top. This stage was observed in all the treatments except GA treatments from 8.00 p.m. to 9.00 p.m. In GA treatments the stage was attained from 9.00 p.m. to 10.30 p.m. The temperature range for this stage was 34.0°C to 30.0°C for all the treatments except GA treatments. In GA treated plants the temperature range was from 30.0°C to 27.0°C.

Stage - 3:

The petals separated completely from the top. This stage reached in all the treatments except GA treatment from 9.00 p.m. to 10.00 p.m. with temperature range from 30.0°C to 29.0°C. In GA treated vines the stage reached from 10.30 p.m. to 12.0 p.m. with temperature range 27.0°C to 24.0°C.

Stage - 4:

In this stage there was a clear opening of petals from the top. This stage was seen in all the treatments except GA treatments from 4.45 a.m. to 5.30 a.m. with temperature range 19.50°C to 21.0°C. In GA treatment the stage was seen from 5.30 a.m. to 7.00 a.m. with a temperature range 21.5°C

Table - 1

Anthesis in cucumber (Cucumis sativus) var. Straight-8 in the middle of May, 1980 as affected by plant regulator sprays.

Treatment		STAG: 1	2	3	4	5	6	7	8	9
MH - 25 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	5.45 a.m. to 7.15 a.m.	5.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	6.30 a.m. to 7.15 a.m.
	Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.5°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C
MH - 50 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	5.45 a.m. to 7.15 a.m.	5.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	6.30 a.m. to 7.15 a.m.
	Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.5°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C
MH - 100 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	5.45 a.m. to 7.15 a.m.	5.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	6.30 a.m. to 7.15 a.m.
	Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.5°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C
MH - 200 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	5.45 a.m. to 7.15 a.m.	5.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	6.30 a.m. to 7.15 a.m.
	Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.5°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C
MH - 400 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	5.45 a.m. to 7.15 a.m.	5.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	6.30 a.m. to 7.15 a.m.
	Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.5°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C

(Contd.)

Table - 1 (Contd.)

Treatment		STAGE 1	2	3	4	5	6	7	8	9
NH - 600 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	6.45 a.m. to 7.15 a.m.	6.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	8.30 a.m. to 7.15 a.m.
	Temp.	38.0°C to 39.0°C	34.0°C to 36.0°C	30.0°C to 32.0°C	19.50°C to 21.0°C	21.3°C to 22.0°C	21.8°C to 23.0°C	31.0°C to 34.0°C	32.0°C to 31.0°C	25.0°C to 28.0°C
NAA- 50 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	6.45 a.m. to 7.15 a.m.	6.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	8.30 a.m. to 7.15 a.m.
	Temp.	38.0°C to 39.0°C	34.0°C to 36.0°C	30.0°C to 32.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.8°C to 23.0°C	31.0°C to 34.0°C	32.0°C to 31.0°C	25.0°C to 28.0°C
NAA- 100 ppm	Time	7.00 p.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	6.45 a.m. to 7.15 a.m.	6.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	8.30 a.m. to 7.15 a.m.
	Temp.	38.0°C to 39.0°C	34.0°C to 36.0°C	30.0°C to 32.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.8°C to 23.0°C	31.0°C to 34.0°C	32.0°C to 31.0°C	25.0°C to 28.0°C
NAA- 150 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	6.45 a.m. to 7.15 a.m.	6.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	8.30 a.m. to 7.15 a.m.
	Temp.	38.0°C to 39.0°C	34.0°C to 36.0°C	30.0°C to 32.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.8°C to 23.0°C	31.0°C to 34.0°C	32.0°C to 31.0°C	25.0°C to 28.0°C
NAA- 200 ppm	Time	7.00 a.m. to 8.00 p.m.	8.00 p.m. to 9.00 p.m.	9.00 p.m. to 10.00 p.m.	4.45 a.m. to 5.30 a.m.	5.30 a.m. to 6.15 a.m.	6.45 a.m. to 7.15 a.m.	6.15 p.m. to 7.15 p.m.	7.15 p.m. to 8.15 p.m.	8.30 a.m. to 7.15 a.m.
	Temp.	38.0°C to 39.0°C	34.0°C to 36.0°C	30.0°C to 32.0°C	19.5°C to 21.0°C	21.3°C to 22.0°C	21.8°C to 23.0°C	31.0°C to 34.0°C	32.0°C to 31.0°C	25.0°C to 28.0°C

Table - 1 (Contd.)

Treatment	STAGE 1	2	3	4	5	6	7	8	9
Time	7.00 a.m. to	8.00 p.m. to	9.00 p.m. to	4.45 a.m. to	5.30 a.m. to	5.45 a.m. to	5.15 a.m. to	7.15 a.m. to	6.30 a.m. to
Water(Control)	8.00 p.m.	9.00 p.m.	10.00 p.m.	5.30 a.m.	6.15 a.m.	7.15 a.m.	7.15 p.m.	8.15 p.m.	7.15 a.m.
Temp.	28.0°C to 39.0°C	34.0°C to 30.0°C	30.0°C to 29.0°C	19.5°C to 21.0°C	21.5°C to 22.0°C	21.3°C to 23.0°C	31.0°C to 32.0°C	29.0°C to 31.0°C	25.0°C to 28.0°C
Time	7.00 a.m. to	9.00 p.m. to	10.30 p.m. to	5.30 a.m. to	7.00 a.m. to	7.30 a.m. to	7.15 p.m. to	8.30 p.m to	6.45 p.m. to
GA -10 ppm	9.00 p.m.	10.30 p.m.	12.00 p.m.	7.00 a.m.	8.00 a.m.	8.30 a.m.	8.30 p.m.	9.00 p.m.	7.30 p.m.
Temp.	28.0°C to 30.0°C	30.0°C to 27.0°C	27.0°C to 24.0°C	21.5°C to 22.0°C	22.0°C to 24.0°C	23.0°C to 24.5°C	29.0°C to 32.0°C	32.0°C to 31.0°C	30.0°C to 31.0°C
Time	7.00 a.m. to	9.00 p.m. to	10.00 p.m. to	5.30 a.m. to	7.00 a.m. to	7.30 a.m. to	7.15 p.m. to	8.30 p.m. to	6.45 p.m. to
GA -25 ppm	9.00 p.m.	10.30 p.m.	12.00 p.m.	7.00 a.m.	8.00 a.m.	8.30 a.m.	8.30 p.m.	9.00 p.m.	7.30 p.m.
Temp.	28.0°C to 30.0°C	30.0°C to 27.0°C	27.0°C to 24.0°C	21.5°C to 22.0°C	22.0°C to 24.0°C	23.0°C to 24.5°C	29.0°C to 32.0°C	32.0°C to 31.0°C	30.0°C to 31.0°C
Time	7.00 a.m. to	9.00 p m. to	10.30 p.m. to	5.30 a.m. to	7.00 a.m. to	7.30 a.m. to	7.15 p.m. to	7.15 p.m. to	6.45 p.m. to
GA- 50 ppm	9.00 p.m.	10.30 p.m.	12.00 p.m.	7.00 a.m.	8.00 a.m.	8.30 a.m.	8.30 p.m.	8.30 p.m.	7.30 p.m.
Temp.	28.0°C to 30.0°C	30.0°C to 27.0°C	27.0°C to 24.0°C	21.5°C to 22.0°C	22.0°C to 24.0°C	23.0°C to 24.0°C	29.0°C to 32.0°C	29.0°C to 32.0°C	30.0°C to 31.0°C
Time	7.00 a.m. to	9.00 p.m. to	10.30 p.m. to	5.30 a.m. to	7.00 a.m. to	7.30 a.m. to	7.15 p.m. to	8.30 p.m. to	6.45 p.m. to
GA -100 ppm	9.00 p.m.	10.30 p.m.	12.00 p.m.	7.00 a.m.	8.00 a.m.	8.30 a.m.	8.30 p.m.	9.00 p.m.	7.30 p.m.
Temp.	28.0°C to 30.0°C	30.0°C to 27.0°C	27.0°C to 24.0°C	21.5°C to 22.0°C	22.0°C to 24.0°C	23.0°C to 24.0°C	29.0°C to 32.0°C	32.0°C to 31.0°C	30.0°C to 31.0°C

to 22.0°C.

Stage - 5:

There was a slight downward curling of opened petals. This stage was seen in all the treatments except GA treatments, from 5.30 a.m. to 6.15 a.m. The range of temperature was from 21.3°C to 22.0°C. In GA treatments, the stage was seen from 7.00 a.m. to 8.00 a.m. with range of temperature from 22.0°C to 24.0°C. In GA treated plants anthers were visible clearly.

Stage - 6:

The expansion of petals was complete in this stage. The anthers were clearly visible in this stage. This was observed from 5.45 a.m. to 7.15 a.m. with temperature range from 21.5°C to 23.0°C in all the treatments except GA treatments. In GA treatments the stage was seen from 7.30 a.m. to 8.30 a.m. with temperature range from 23.0°C to 24.0°C. The flowers were open till evening with slight fading of yellow colour.

Stage - 7:

In this stage therewas a upward curling of flower petals. This stage was seen from 5.15 p.m. to 7.15 p.m. with temperature range from 31.0°C to 32.0°C except GA treatments. In GA treated plants this stage was seen from 7.15 p.m. to 8.30 p.m. with temperature range from 29.0°C to 32.0°C.

Stage - 8:

The petals were completely but loosely closed in this stage. This stage was reached in all the treatments except GA treatments from 7.15 p.m. to 8.15 p.m. with temperature range from 29.0°C to 31.0°C. In GA treated plants the stage was seen from 8.30 p.m. to 9.00 p.m. with temperature range from 32.0°C to 31.0°C.

Stage - 9:

Most of the closed flowers detached from pedicels in the next morning. This stage was reached from 6.30 a.m. to 7.15 a.m. from 25.0°C to 28.0°C temperature range, in all the treatments except GA treatments. In GA treated plants the stage was reached in the next day evening from 6.45 p.m. to 7.50 p.m. with temperature range from 30.0°C to 31.0°C. Some few flowers had not still dropped.

Anther dehiscence:

In all the treatments including GA treatments dehiscence occurred when the temperature was ranging from 20.5°C to 22.0°C. The temperature condition was found from the fourth stage of flower bud till the beginning of 5th stage. Dehiscence was complete when temperature reached round about 22.0°C.

In case of anther dehiscence the different plant regulators had no effect and only temperature seemed to regulate the anther dehiscence.

Pollen fertility as affected by plant regulator sprays:

This study was undertaken in both the seasons 21 days after the second spray, to observe the effect of different plant regulator sprays on fertility of pollens.

Table - 2

The percentage of sterile pollens - July crop
(Observation after 3 weeks after the 2nd spray)

S.No.	Treatments	Percentage of sterile pollen
1.	MH-25 ppm	2.57
2.	" -50 ppm	6.20
3.	" -100 ppm	6.25
4.	" -200 ppm	6.37
5.	" -400 ppm	6.37
6.	" -600 ppm	6.39
7.	NAA- 50 ppm	5.50
8.	" -100 ppm	5.52
9.	" -150 ppm	5.55
10.	" -200 ppm	5.69
11.	IAA- 50 ppm	7.35
12.	" -100 ppm	7.80
13.	2,4-D -2.5 ppm	4.64
14.	" - 5 ppm	5.32
15.	Removing male flower buds	2.16
16.	Water (Control)	2.10

From the table 2 it is seen that there was a very little effect on the fertility of pollens of the different plant regulator sprays 21 days after second spray. This shows that different plant regulator sprays have practically no adverse effect 21 days after second spray. A reading taken 30 days after second spray showed that, little effect recorded after 21 days,disappeared and all the pollens were normal.

Table - 3

The percentage of sterile pollens - February crop
(Observation 3 weeks after the 2nd spray)

S.No.	Treatments	Percentage of sterile pollen
1.	MH - 25 ppm	4.50
2.	" - 50 ppm	5.50
3.	" - 100 ppm	5.50
4.	" - 200 ppm	5.70
5.	" - 400 ppm	8.00
6.	" - 600 ppm	11.50
7.	NAA - 50 ppm	3.00
8.	" - 100 ppm	4.00
9.	" - 150 ppm	6.00
10.	" - 200 ppm	7.00
11.	IAA - 50 ppm	4.50
12.	" - 100 ppm	4.50
13.	2,4-D - 2.5 ppm	6.50
14.	" - 5 ppm	6.80
15.	Removal of male flower bud	4.00
16.	Water (Control)	4.00
17.	GA - 10 ppm	6.00
18.	" - 25 ppm	6.50
19.	" - 50 ppm	6.00
20.	" - 100 ppm	6.00

From the table 3 it is seen that the adverse effect of different plant regulator sprays on fertility of pollens remained to some extent even 21 days after the 2nd spray. The effect was more prominent in MH- 400, 600, and NAA - 200 ppm. The other treatments had no marked effect on the fertility of pollens. A study of the pollens 30 days after the 2nd spray showed no difference in fertility.

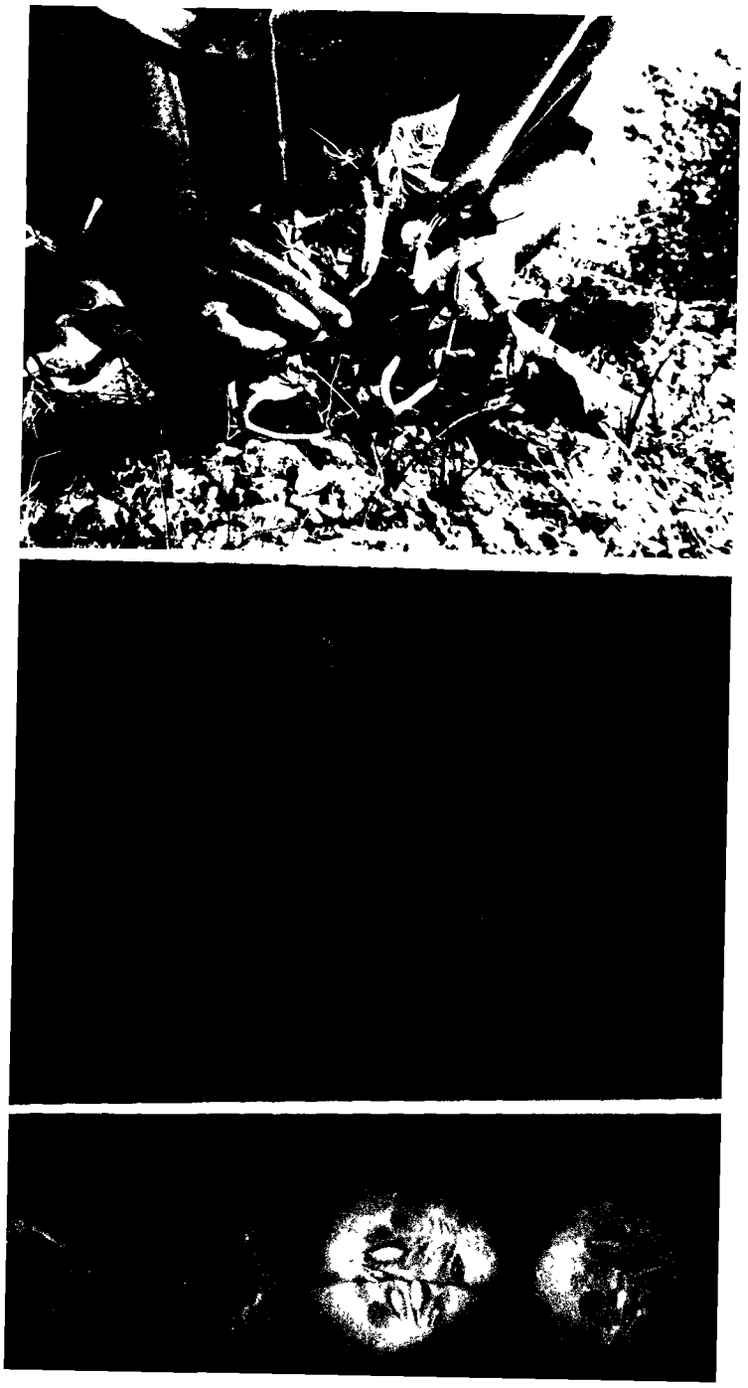
Size of the ovary:

There was marked increase in the size of ovary in GA treated plants. In other treatments the occurrence of such ovary was very rare. (Plate 2).

Table - 4

Treatments	No. of ovaries counted.	No. of giant ovaries	Percentage of giant ovaries
GA - 10 ppm	35	20	57.14
" - 25 ppm	32	8	25.00
" - 50 ppm	30	5	16.66
" -100 ppm	25	4	16.00

The lower treatment of GA (10 ppm) produced a largest number of giant ovaries, i.e. 57.14%. The term 'giant ovary' was designated to those ovaries which measured 3 cms or more than 3 cms in length.



Teratology as affected by plant regulator sprays:

Fusion:

Two male flowers were born on a single peduncle in treatment MH - 100 ppm in July crop. (Plate III(3)).

Flower:

(a) One giant male flower bud was observed in GA - 10 ppm treatment. The sepals and petals were of nearly double the size of the normal flower. There were two distinct groups of Androecia. The pollens were examined under microscope and they were found normal and fertile. (Plate III(1)).

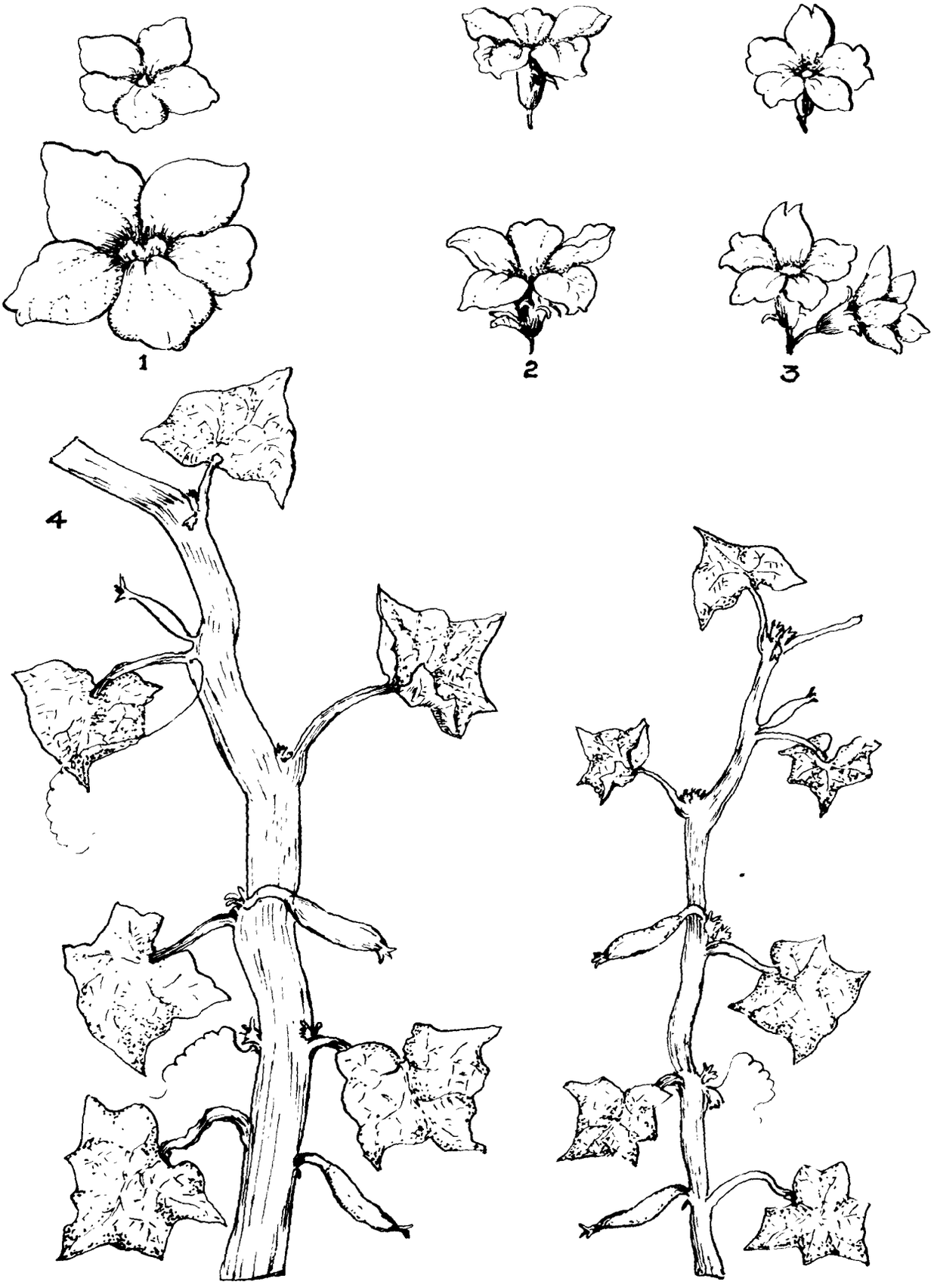
(b) In a treatment MH - 400 ppm a leaflet was found fused with the one of the sepal of male flower. This was observed in February crop. (Plate III(2)).

Fasciation:

(a) In a treatment GA - 50 ppm and 100 ppm, one plant in each treatment was found to have a fasciated like stem. The stem was completely flattened and an axillary branch had been completely fused with the main stem. The stem bore male and female flowers in the axils as usual but the flowers seemed crowded and did not develop completely. (Plate III(4)).

(b) Similar flattened stem and other symptoms of fasciation were observed in a treatment, 2,4-D - 2.5 ppm. The axillary branch was fused with the stem from 2nd to 4th node giving the stem a peculiar flattened appearance. (Plate III(4))

TERATOLOGY AS A RESULT OF PLANT REGULATOR SPRAYS



B. Sex expression and sex ratio as affected by plant regulator sprays.

In the present studies the seedlings were sprayed twice with aqueous solution of different plant regulator sprays. The different morphological effects observed on the leaves were as follows: In all the seedlings sprayed with different growth regulators, there was a marked effect on leaves. In July crop, there was a drooping of leaves in the treatment - NAA 200 ppm 5 hours after the spray. There was a slight drooping effect in the treatment - NAA 150 ppm. This effect was persistent till next day evening i.e. upto 36 hours after the spray. This was observed after the 2nd spray also. In February crop, this epinastic effect was more marked. The plants in the treatments - NAA 50, 100, 150, 200 ppm, IAA 100 ppm showed clear epinastic effect immediately after the spray and the effect persisted for nearly 48 hours. In other treatments also this effect was observed but it was not such marked as was observed in above mentioned treatments.

In plants sprayed with 2,4-D 2.5 and 5 ppm sprays, there were marked pustule like markings on the leaves. This effect lasted upto 3 weeks after the 2nd spray and the new leaves became normal afterwards. In plants sprayed with NAA and IAA the leaves were dark green and healthy looking. This effect was observed in both the seasons. In GA treated plants there was no yellowing of leaves observed as reported in other plants sprayed with GA.

In plants sprayed with NAA and IAA the terminal growth

was stimulated. In July crop growth was suppressed with some regulators in the higher concentrations like MH- 100, 200, 400 and 600 ppm, IAA - 100 ppm.

There appears some correlation between the appearance of the first female flower on the main axis, with pistillate staminate ratio. Most of the treatments induced the formation of the first female flower at lower nodes on the main axis of the plants in both the experiments, (Table 5 & 6) and they had higher female to male ratio. (Table 7 & 8) than the control.

Table - 5

Average node number and the lowest node of the first female flower appearance. (July crop)

S.No.	Treatment	Average node	Lowest node
1.	MH - 25 ppm	15.74	7
2.	" - 50 ppm	14.33	10
3.	" - 100 ppm	12.99	7
4.	" - 200 ppm	11.91	8
5.	" - 400 ppm	12.33	9
6.	" - 600 ppm	13.33	10
7.	NAA - 50 ppm	13.60	11
8.	" - 100 ppm	14.45	10
9.	" - 150 ppm	15.08	13
10.	" - 200 ppm	15.87	9
11.	IAA - 50 ppm	18.83	14
12.	" - 100 ppm	14.91	11
13.	2,4-D - 2.5 ppm	16.41	14
14.	" - 5 ppm	16.66	15
15.	Removal of male flower buds	17.58	16
16.	Water (Control)	18.99	18

Table - 6

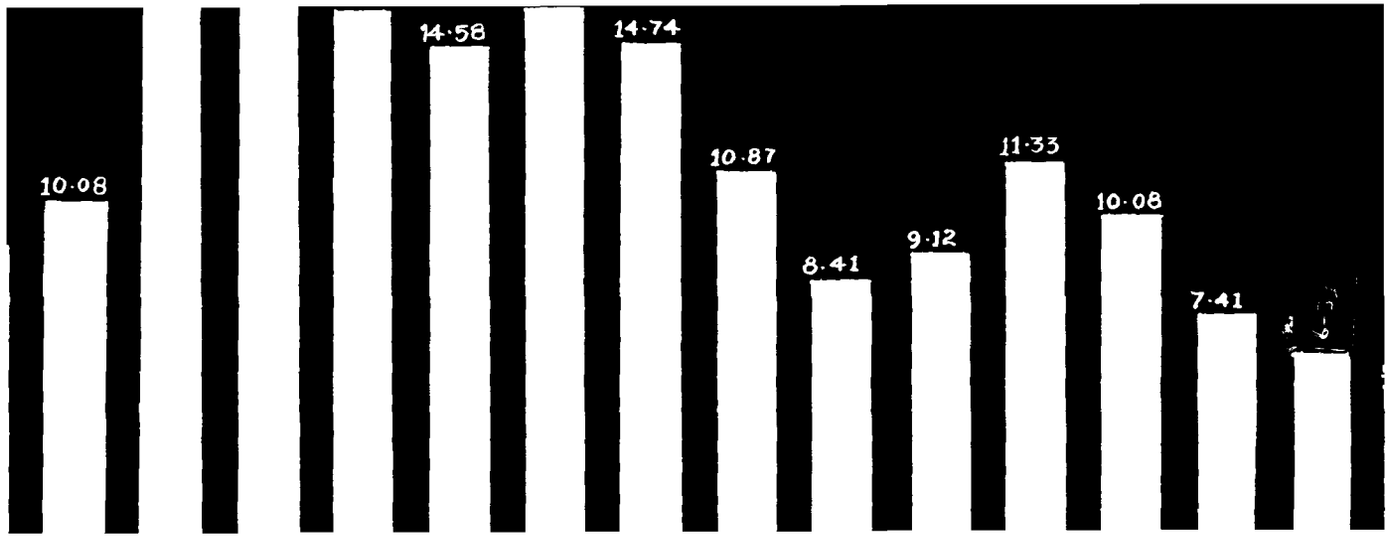
Average node number and lowest node of the first female flower appearance. (February crop)

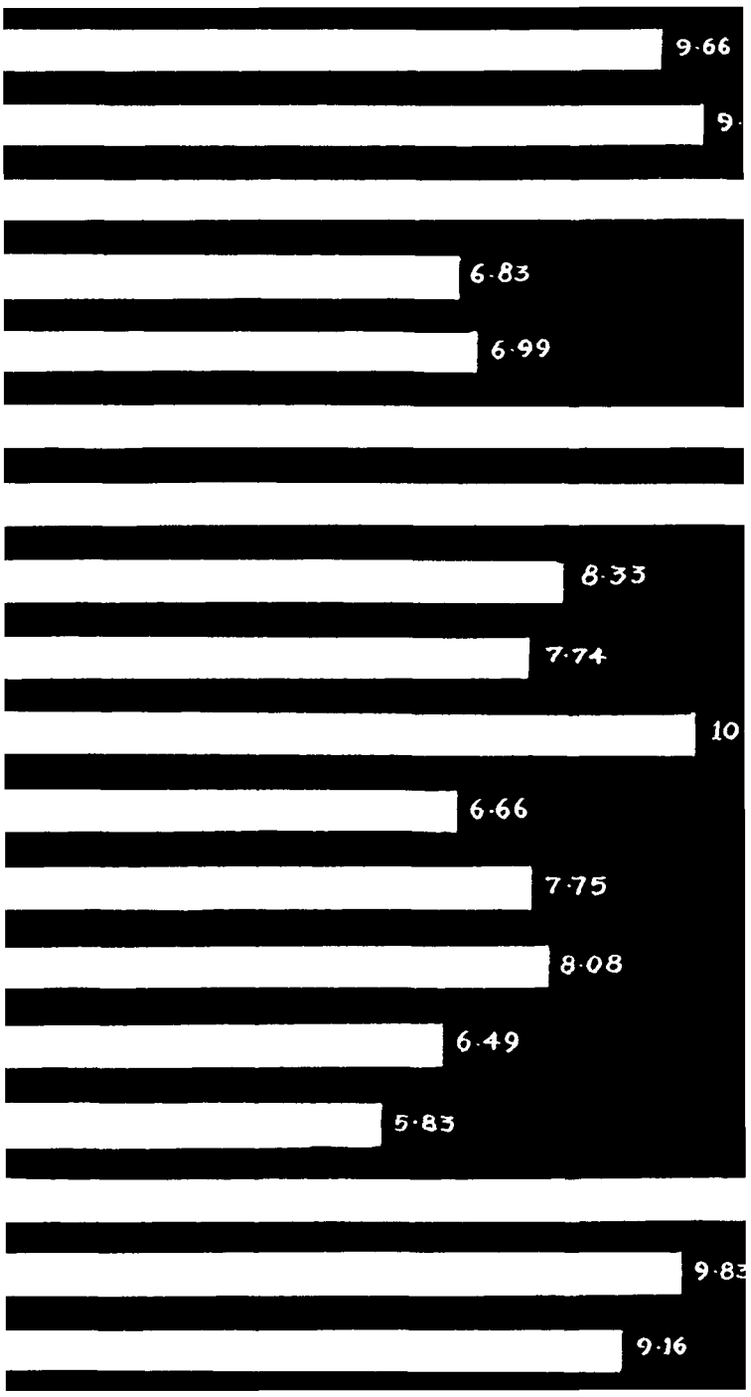
S. No.	Treatment	Average node	Lowest node
1.	MH - 25 ppm	11.00	6
2.	" - 50 ppm	10.99	5
3.	" - 100 ppm	10.74	7
4.	" - 200 ppm	10.78	7
5.	" - 400 ppm	13.45	9
6.	" - 600 ppm	11.91	10
7.	NAA - 50 ppm	11.24	7
8.	" - 100 ppm	8.41	4
9.	" - 150 ppm	12.49	5
10.	" - 200 ppm	11.24	7
11.	IAA - 50 ppm	10.33	7
12.	" - 100 ppm	12.49	6
13.	2,4-D - 2.5 ppm	11.14	4
14.	" - 5 ppm	11.49	6
15.	Removal of male flower buds	13.83	9
16.	Water (Control)	15.33	6
17.	GA - 10 ppm	11.99	6
18.	" - 25 ppm	11.16	3
19.	" - 50 ppm	11.74	9
20.	" - 100 ppm	12.41	6

There was an increase in the average number of female flowers in all the treatments over the control. (Table 7 & 8). However, the increase was statistically significant with MH - 50, 100, 200, NAA - 50, 100, IAA - 50, GA - 10 and GA - 25 ppm in February crop and in July crop, MH - 100, 200, 400, 600, NAA - 50, 100 ppm.(fig-1 & 2) 150 PPM, NAA - 100 PPM.

In July crop there were no significant differences within the MH treatments of 100, 200, 400, 600 ppm in average number of female flowers. But MH - 100, 200, 400 ppm significantly increased the number of female flowers over the treatments MH - 25 & 50 ppm. Within NAA treatments in the concentrations of 50, 100 & 150 ppm there were no significant differences in average number of female flowers. But NAA - 50, 100 ppm significantly increased the number of female flowers over the treatment NAA - 200 ppm. There was no significant difference in treatments NAA - 150 and 200 ppm. Within IAA and 2,4-D treatments there were no significant differences in number of female flowers.

In February crop, within MH treatments of 25, 50, 100, 200 ppm there were no significant differences in number of female flowers. But MH - 200 ppm significantly increased the number of female flowers over the treatments MH - 400 and 600 ppm. There were no significant differences in NAA - 50, 100, 150 ppm in number of female flowers but NAA - 50, 100 ppm significantly increased the number of female flowers over the treatment NAA - 200 ppm. There were no significant differences in the treatments NAA - 150 and 200 ppm. Within IAA and 2,4-D treatments there were no significant differences. Within GA treatments 10, 25, 50 ppm there were no significant differences. But GA - 10 ppm


10·08
14·58
14·74
10·87
8·41
9·12
11·33
10·08
7·41


9·66
9·
6·83
6·99
8·33
7·74
10
6·66
7·75
8·08
6·49
5·83
9·83
9·16

significantly increased the number of female flowers over GA 100 ppm.

Table - 7

Average number of flowers and sex ratio under different treatments (July crop).

S. No.	Treatment	Female flowers	Male flowers	Total flowers	Sex ratio, female: male
1.	MN- 25 ppm	9.75	167.66	177.41	1 : 17.19
2.	" - 50 ppm	10.08	172.33	182.41	1 : 17.09
3.	" -100 ppm	16.91	178.25	195.16	1 : 10.54
4.	" -200 ppm	17.49	204.33	221.82	1 : 11.68
5.	" -400 ppm	15.66	217.95	233.61	1 : 13.91
6.	" -600 ppm	14.58	234.16	248.74	1 : 16.06
7.	NAA- 50 ppm	15.34	174.04	189.38	1 : 11.19
8.	" -100 ppm	14.74	150.37	165.11	1 : 10.20
9.	" -150 ppm	10.87	144.33	155.20	1 : 13.27
10.	" -200 ppm	8.41	140.99	149.40	1 : 16.76
11.	IAA- 50 ppm	9.12	142.54	151.66	1 : 15.62
12.	" -100 ppm	11.33	180.66	191.99	1 : 15.94
13.	2,4-D-2.5 ppm	10.08	158.03	168.11	1 : 15.67
14.	" 5 ppm	7.41	167.91	175.32	1 : 22.65
15.	Removal of male flower buds	6.33	162.99	169.32	1 : 25.74
16.	Water (Control)	5.41	178.91	184.32	1 : 33.07
	$S.E_m$	± 1.83	± 14.78		
	L.S.D. at 5%	5.22	44.22		
	'F' test of significance	at 1%	at 1%		

Table - 8

Average number of flowers and sex ratio under different treatments (February crop)

S. No.	Treatment	Female flowers	Male flowers	Total flowers	Sex ratio
1.	MH- 25 ppm	9.25	93.33	102.58	1 : 10.08
2.	" - 50 ppm	9.66	83.41	93.07	1 : 8.63
3.	" - 100 ppm	9.99	71.74	81.73	1 : 7.18
4.	" - 200 ppm	11.22	72.24	83.46	1 : 6.43
5.	" - 400 ppm	6.83	63.66	70.49	1 : 9.32
6.	" - 600 ppm	6.99	62.58	69.57	1 : 8.95
7.	NAA- 50 ppm	11.74	84.66	96.40	1 : 7.21
8.	" - 100 ppm	11.35	64.58	75.93	1 : 5.68
9.	" - 150 ppm	8.33	62.41	70.74	1 : 7.49
10.	" - 200 ppm	7.44	53.41	60.85	1 : 7.17
11.	IAA- 50 ppm	10.08	68.24	78.32	1 : 6.76
12.	" - 100 ppm	6.66	56.08	62.74	1 : 8.42
13.	2,4-D- 2.5 ppm	7.75	81.16	88.91	1 : 10.47
14.	" - 5 ppm	8.08	76.49	84.57	1 : 9.46
15.	Removal of male flower buds	6.49	77.91	84.40	1 : 12.00
16.	Water (Control)	5.83	110.66	116.49	1 : 18.98
17.	GA- 10 ppm	10.66	97.41	108.07	1 : 9.13
18.	" - 25 ppm	9.83	107.33	117.16	1 : 10.91
19.	" - 50 ppm	9.16	108.74	117.90	1 : 11.87
20.	" - 100 ppm	6.08	114.82	120.90	1 : 18.88
	$S.E_m$ ±	1.35	± 11.68		
	L.S.D. at 5%	3.80	32.96		
	'F' test of significance	1%	1%		

Table - 9

Analysis of variance for female flowers. July crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	28.33	
Treatments	15	59.22	4.38**
Error	45	13.49	

** 'F' test of significance at 1% level.

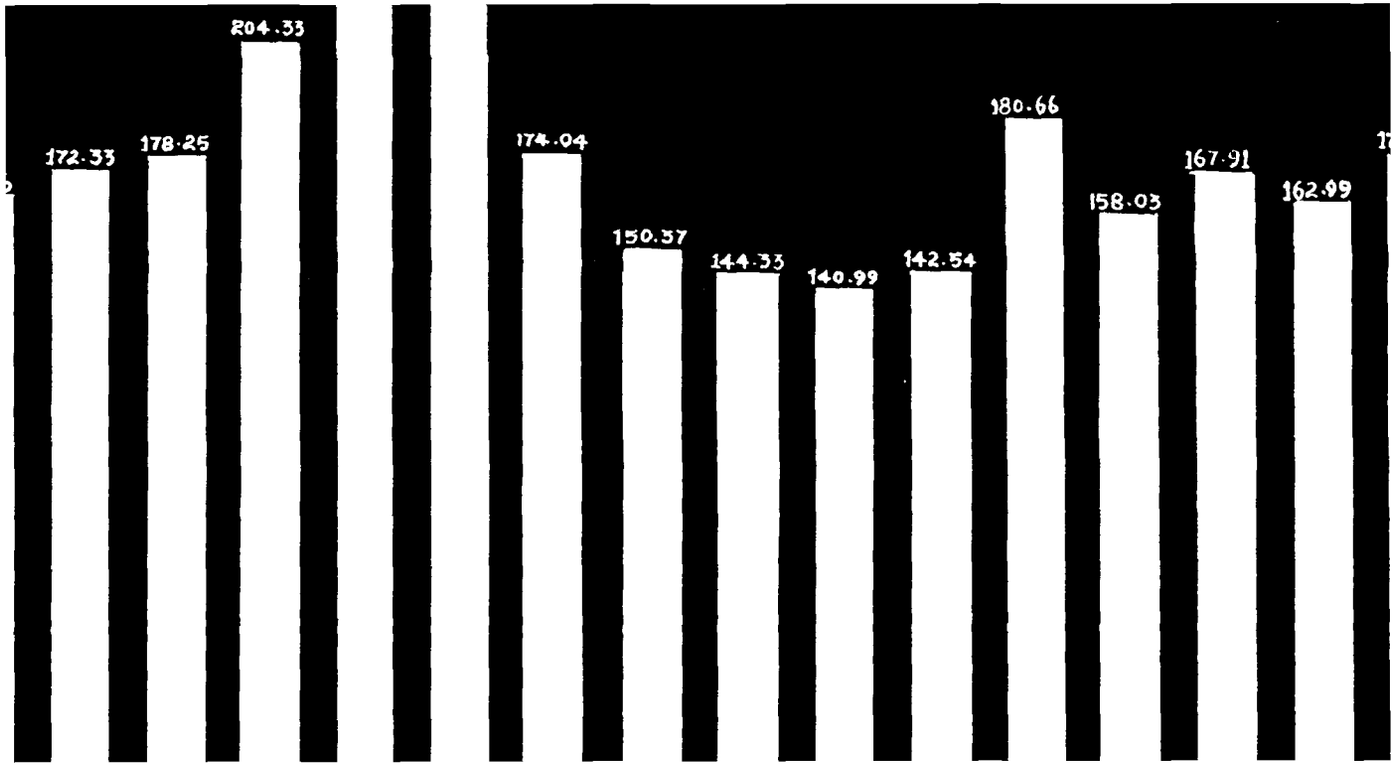
Table - 10

Analysis of variance for female flowers - February crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	10.66	
Treatments	19	14.32	1.95*
Error	57	7.34	

* 'F' test of significance at 5%.level.

In July crop there was suppression of male flowers in all the treatments except in the treatments, MH- 200, 400, 600, IAA - 100 ppm. (Table - 7 & 11 and Fig. 3). But this decrease in number of male flowers was not statistically significant. In July crop there was an increase in the number of

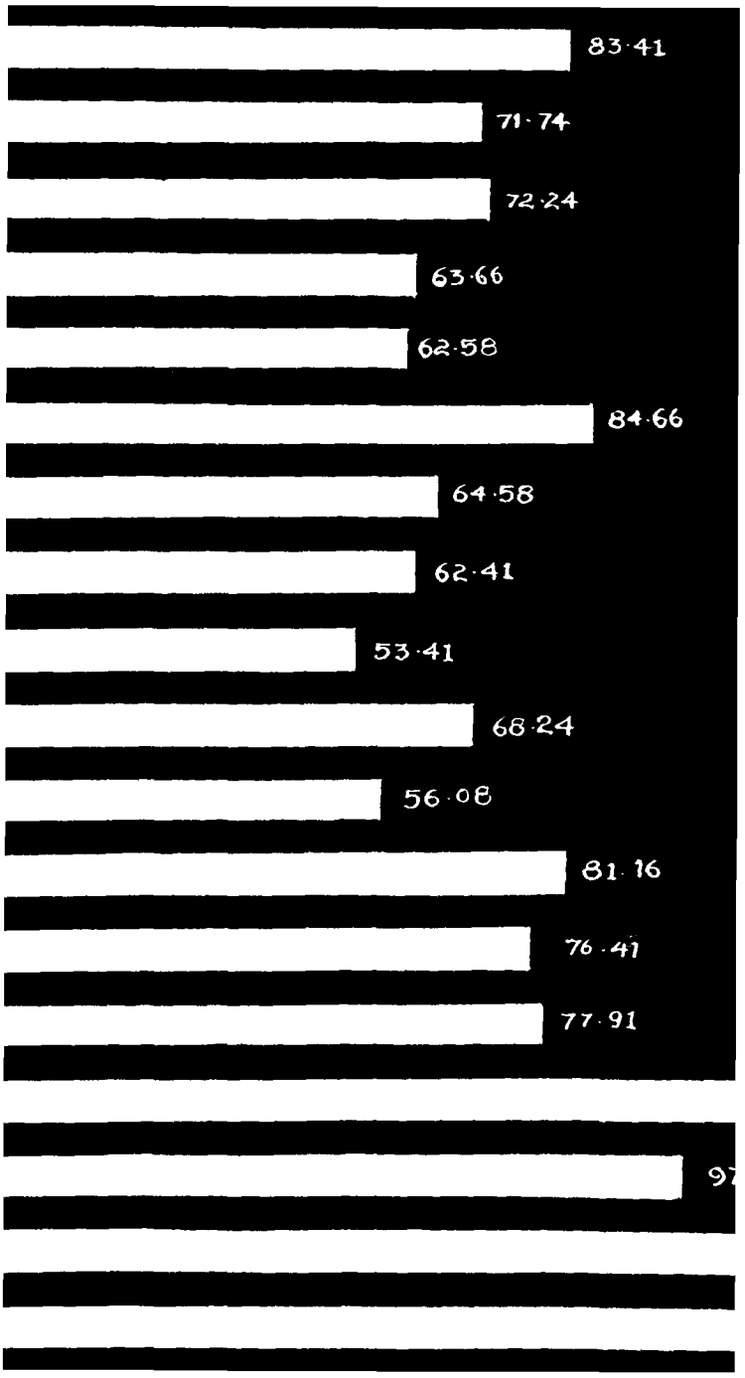

172.33
178.25
204.33
174.04
150.37
144.33
140.99
142.54
180.66
158.03
167.91
162.99

male flowers over the control in the treatments, MH- 200, 400, 600 ppm, IAA - 100 ppm. But this increase was statistically significant only in the treatment, MH- 600 ppm.

In February crop, there was suppression in the number of male flowers in all the treatments except in the treatment GA - 100 ppm. (Table - 8 & 12 and Fig. 4). But this suppression was statistically significant only in the treatments MH - 100, 200, 400, 600 ppm, NAA - 100 ppm, 150 ppm, 200 ppm, IAA - 50, 100 ppm, 2,4-D 5 ppm. and removal of male flower buds treatment. There was an increase in the number of male flowers in the treatment GA - 100 ppm, but it was not statistically significant. Another observation regarding all the GA treatments was that the number of flowers produced were near about the control plants. The reduction in the number of male flowers was negligible.

In July crop, there were no significant differences in the number of male flowers within MH treatments, 25, 50, 100, 200 ppm. But MH - 600 ppm significantly increased the number of male flowers over the treatments, MH - 25, 50, 100 ppm. There was no significant difference in the treatments, MH - 400 and 600 ppm. There were no significant differences within NAA treatments in number of male flowers. Similar was the case with IAA and 2,4-D treatments.

In February crop, within MH treatments there were no significant differences in the number of male flowers. Similar was the case within NAA, IAA, 2,4-D and GA treatments.


83·41
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81·16
76·41
77·91

Table - 11

Analysis of variance for male flowers - July crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	17921.47	
Treatments	15	13686.98	16.4**
Error	45	841.25	

** 'F' test of significance at 1% level.

Table - 12

Analysis of variance for male flowers - February crop

Due to	D.F.	M.S.S.	V.R.
Blocks	3	2408.75	
Treatments	19	1454.98	2.59**
Error	57	561.24	

** 'F' test of significance at 1% level.

There was a reduction in the number of total flowers in all the treatments except in MH - 100, 200, 400, 600 ppm, NAA - 50 ppm, IAA - 100 ppm, (Table - 7 & 8) in July crop. In February crop, there was a reduction in total number of flowers except in GA - 25, 50, 100 ppm treatments where there was a slight

increase in the average total number of flowers. There was an increase in the average number of total number of flowers in the treatments MH - 100, 200, 400, 600 ppm, NAA - 50 ppm, IAA - 100 ppm in July crop. This reduction in average total number of flowers was observed even in the treatments, which had increased the average number of female flowers. This reduction in average number of total flowers was due to suppression of male flowers. (Table - 7 & 8). In July crop,it was observed that the higher concentrations increased both the male and female number of flowers and finally total number of flowers in MH treatments. (Table - 7).

In February crop, the lower concentrations of MH increased the number of male flowers more than the number of female flowers. The higher concentrations of MH decreased the number of male flowers but increase in number of female flowers was more upto certain concentrations (i.e. 200 ppm) and then there was a drop in the number of female flowers in higher concentrations. (Table - 8).

In July crop, lower concentrations of NAA did not decrease the number of male flowers much but increase in number of female flowers was high. Higher concentrations of NAA decreased the number of male flowers, but there was an increase in the number of female flowers with higher concentrations as compared with the control. But with higher concentrations of NAA there was a slight decrease in the number of female flowers as compared with the lower concentration of NAA (50 ppm). (Table - 7).

In February crop, there was a gradual decrease in the number of male flowers as the concentration of NAA increased but there was an increase in the number of female flowers as the concentration of NAA lowered. (Table - 8). As regards GA treatments with lower concentrations there was a decrease in the number of male flowers, but increase in the number of female flowers. Higher concentrations of GA gave higher number of male flowers and lower number of female flowers. (Table - 8).

Table - 13

Growth record of the main axis - July crop.

(Average length in cms. per plant)

S.No.	Treatment	Observation		
		First	Second	Third
1.	MH - 25 ppm	11.58	43.70	92.24
2.	" - 50 ppm	10.70	39.16	88.91
3.	" - 100 ppm	9.41	35.39	83.24
4.	" - 200 ppm	8.97	29.12	79.58
5.	" - 400 ppm	8.41	27.79	75.49
6.	" - 600 ppm	8.62	27.50	71.16
7.	NAA - 50 ppm	11.16	49.50	91.29
8.	" - 100 ppm	10.62	42.08	88.08
9.	" - 150 ppm	10.72	44.08	83.05
10.	" - 200 ppm	10.24	50.41	105.66
11.	IAA - 50 ppm	9.08	44.29	88.41
12.	" - 100 ppm	9.33	32.49	89.24
13.	2,4-D - 2.5 ppm	8.66	33.37	77.08
14.	" - 5 ppm	11.16	34.62	71.08
15.	Removal of male flower buds	11.24	46.43	117.65
16.	Water (Control)	16.08	46.12	85.25

In July crop, growth was recorded three times after the 2nd spray. (Table - 8). The observations were taken at an interval of 15 days after the 2nd spray. In the first observation there was a suppression of growth in each treatment. In the final growth observation the surprising fact was that the anti-auxin like MH in lower concentration increased the growth over the control. In higher concentrations, however, there was a suppression of growth over the control. The NAA - 200 ppm treatment gave maximum growth among growth regulators, but the male flower bud removal treatment surpassed in growth over all the treatments. There was a slight check in growth in treatment 2,4-D - 2.5 & 5 ppm over the control. The treatments, IAA - 50 and 100 ppm slightly increased growth of the main axis over the control.

Similar growth observations were maintained in the February crop. In the first growth observation also the lower concentrations of MH (MH - 25, 50, 100 ppm) stimulated the growth of the main axis. While higher concentrations checked the growth of main axis. All the treatments of NAA and IAA stimulated the growth of the main axis over the control. The treatments, 2,4-D checked the growth. In final growth observations all the MH treatments except MH 50 ppm checked the growth of the main axis. NAA higher concentrations stimulated the growth of the main axis over the control. (Table - 14). In February crop, the growth of IAA treatments was comparable to control, but 2,4-D treatments checked the final growth of main axis. As regards GA treatments, all the treatments stimulated the growth of the main axis. The higher concentration giving more growth than lower concentrations.

(Table - 14). In the February crop, the treatment of removal of male flower bud increased the growth of the main axis over the control and it compared favourably with most of the auxin treatments.

Table - 14

Growth record of the main axis - February crop.

(Average length in cms. per plant)

S.No.	Treatment	Observation		
		First	Second	Third
1.	MH - 25 ppm	8.12	39.45	81.24
2.	" - 50 ppm	7.16	36.24	71.58
3.	" - 100 ppm	7.41	31.33	65.33
4.	" - 200 ppm	6.43	28.33	65.24
5.	" - 400 ppm	6.83	28.41	65.12
6.	" - 600 ppm	6.58	25.08	62.83
7.	NAA - 50 ppm	7.16	46.58	77.66
8.	" - 100 ppm	7.08	47.99	79.82
9.	" - 150 ppm	8.12	55.79	86.66
10.	" - 200 ppm	8.08	55.75	86.74
11.	IAA - 50 ppm	9.07	44.16	71.41
12.	" - 100 ppm	9.24	50.91	72.29
13.	2,4-D - 2.5 ppm	5.41	38.83	61.16
14.	" - 5 ppm	5.49	31.87	56.08
15.	Removal of male flower buds	5.83	45.91	81.33
16.	Water (Control)	6.83	46.41	78.37
17.	GA - 10 ppm	8.74	51.66	89.41
18.	" - 25 ppm	10.22	59.37	94.66
19.	" - 50 ppm	10.45	62.91	117.91
20.	" -100 ppm	13.16	63.58	133.99

C. Fruit set, development and maturity as affected by plant regulator sprays.

Besides the effects on the number of male and female flowers, it was also observed whether these sprays have any effect on the fruit set, development and maturity.

To find the setting of a fruit, count was taken of those ovaries which continued to grow for 5 to 6 days after anthesis. The table number (15) gives the unadjusted and adjusted values of fruit set in different treatments. The statistical adjustment was done to eliminate the effect of initial number of female flowers on the fruit set. There was a clear and distinct effect of different plant regulator sprays on the fruit set in cucumber. From table - 15, 16 and fig. 5, it is evident that all the treatments increased the number of fruit set in cucumber. The treatments, MH - 100, 200, 400, 600 ppm, NAA - 100, 150, 200 ppm, IAA - 50, 100 ppm, 2,4-D - 5 ppm and GA - 10, 25, 50, 100 ppm were statistically significant. Another interesting observation made in the adjusted values was that as the concentration of each plant regulator increased there was an increased set of fruit. This was observed in all the plant regulators and lower concentrations were ineffective as far as fruit set was concerned.

It was also noticed that there was a strong correlation between initial number of flowers (female) and fruit set as seen from the 'r' value. (Table - 15 & 16).

With MH treatments, 25, 50, 100, 200, 400 ppm, there were no significant differences in average number of fruit set. But

3.
3.49
5.
4
4
2.91
3.89
2.49
1.66
3.

MH - 600 ppm was significantly superior to MH - 25 & 50 ppm in fruit set. Within NAA treatments, 100, 150, 200 ppm, there were no significant differences in fruit set. But NAA - 100, 150, 200 ppm significantly increased the fruit set over NAA - 50 ppm treatment.

Table - 15

Adjusted and unadjusted average number of fruit set and mean number of female flowers per plant - Feb. crop.

S.No.	Treatment	Av.no.of female flowers	Av. no. of fruit set	
			Unadjusted	Adjusted
1.	MH - 25 ppm	9.25	3.49	3.23
2.	" - 50 ppm	9.66	3.91	3.50
3.	" - 100 ppm	9.99	4.49	3.95
4.	" - 200 ppm	11.22	4.74	3.74
5.	" - 400 ppm	6.83	3.49	4.14
6.	" - 600 ppm	6.99	3.99	4.58
7.	NAA - 50 ppm	11.74	4.08	2.89
8.	" - 100 ppm	11.35	5.16	4.12
9.	" - 150 ppm	8.33	4.33	4.42
10.	" - 200 ppm	7.74	4.08	4.39
11.	IAA - 50 ppm	10.08	5.16	4.60
12.	" - 100 ppm	6.66	4.58	5.30
13.	2,4-D - 2.5 ppm	7.75	2.91	3.21
14.	" - 5 ppm	8.08	3.85	4.03
15.	Removal of male flower bud	6.49	2.49	3.27
16.	Water (Control)	5.83	1.66	2.67
17.	GA - 10 ppm	10.66	5.08	4.30
18.	" - 25 ppm	9.83	4.66	4.19
19.	" - 50 ppm	9.16	3.83	3.61
20.	" - 100 ppm	6.08	3.41	4.34
	$S.E_m$ ±	1.35	± 1.10	± 0.46
	L.S.D. at 5%	3.80	3.10	0.92
	'F' test of significance at 1%		1%	1%

Table - 16

Analysis of co-variance for number of female flowers and fruit set - February crop.

Due to	D.F.	S.S.(X^2)	S.P.(XY)	S.S.(Y^2)	r_{XY}
Blocks	3	31.99	25.74	54.06	
Treatments	19	272.15	91.63	93.01	+ 0.517
Error	57	418.49	157.84	95.22	

Significant at 5 % level.

Results of the analysis of covariance (Table - 16) show that on the treatment line 'r' value or correlation between the number of female flowers and the fruit set is significant at 5% level in February crop. The correlation is a positive correlation.

The effect of different regulator sprays on the maturity of the fruit.

There was no effect of different plant regulator sprays on maturity of fruits except in GA treatments. All the GA treatments i.e. GA - 10, 25, 50, 100 ppm decreased the number of days required for maturity of fruits on vines significantly over the control. The lower concentrations of GA were having more effect on early maturity than the higher concentrations. (Table - 17 & 18 and fig. 6).

The GA 25 ppm treatment significantly decreased the number of days required for maturity of fruits over the MH treatment 25 ppm.

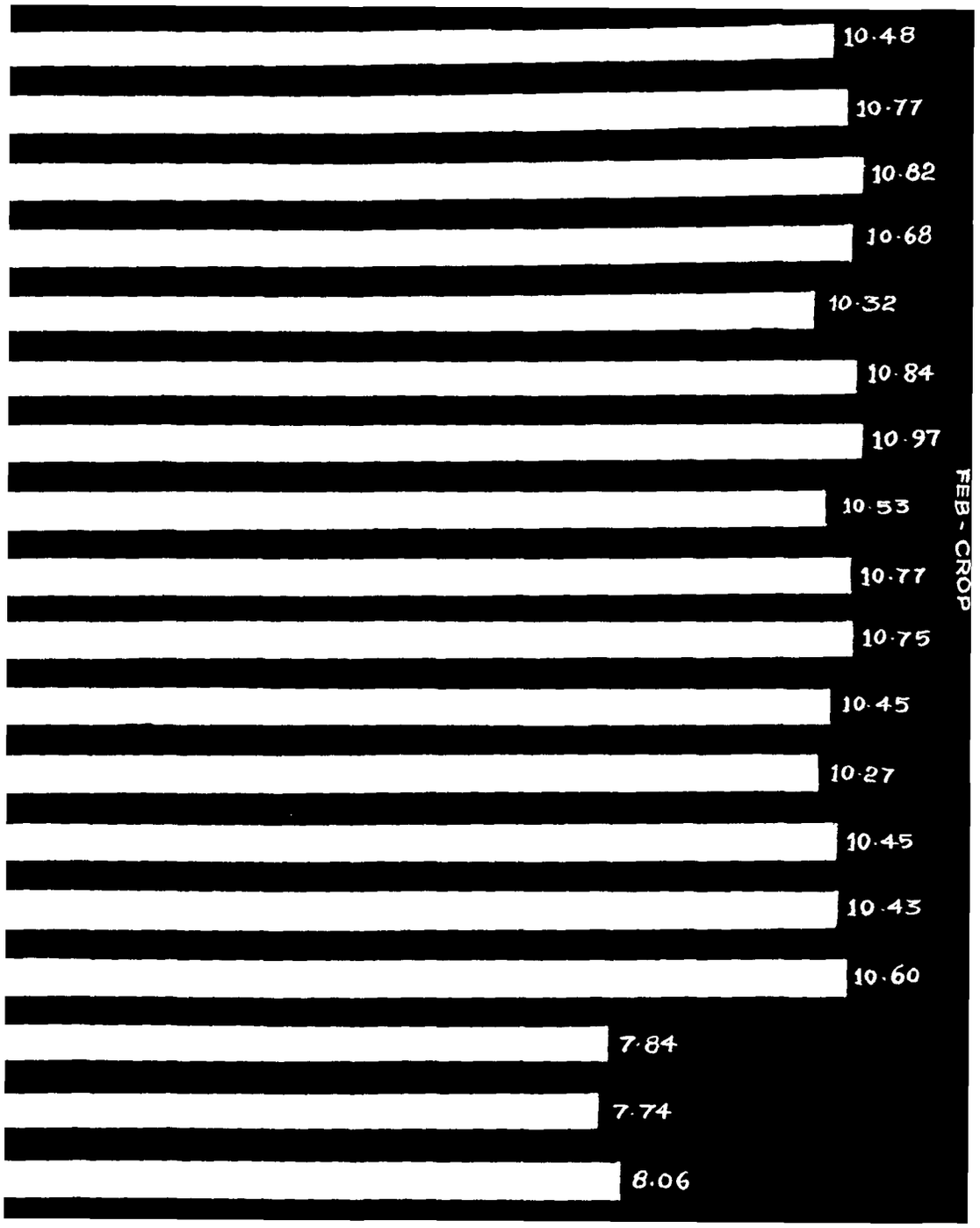

10·48
10·77
10·82
10·68
10·32
10·84
10·97
10·53
10·77
10·75
10·45
10·27
10·45
10·43
10·60
7·84
7·74
8·06
FEB - CROP

Table - 17

The effects of different plant regulator sprays on the maturity of fruits on cucumber (C. sativus) February crop.

S. No.	Treatment	Average no. of days required for maturity
1.	MH - 25 ppm	9.99
2.	" - 50 ppm	10.48
3.	" - 100 ppm	10.77
4.	" - 200 ppm	10.82
5.	" - 400 ppm	10.68
6.	" - 600 ppm	10.32
7.	NAA - 50 ppm	10.84
8.	" - 100 ppm	10.97
9.	" - 150 ppm	10.53
10.	" - 200 ppm	10.77
11.	IAA - 50 ppm	10.75
12.	" - 100 ppm	10.45
13.	2,4-D - 2.5 ppm	10.27
14.	" - 5 ppm	10.45
15.	Removal of male flower buds	10.43
16.	Water (Control)	10.60
17.	GA - 10 ppm	7.84
18.	" - 25 ppm	7.74
19.	" - 50 ppm	8.06
20.	" - 100 ppm	7.94
	$S.E_m$	± 0.72
	L.S.D. at 5%	2.03
	'F' test of significance at	1%

Table - 18

Analysis of varaince for the number of days required for maturity of fruits. February crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	0.65	
Treatments	19	5.03	23.7**
Error	57	0.212	

** 'F' test of significance at 1%.level.

Effect of plant regulator sprays on the number of fruits:

The different plant regulator sprays were quite effective in increasing the number of female flowers and also the fruit set as can be seen from the previous tables. Observations were also made to find whether these plant regulator sprays had any effect on the final number of fruits harvested. All the plant regulator treatments increased the number of fruits harvested, but the increase was statistically significant only in NAA - 50, 100, 150, 200 ppm, IAA - 50 ppm, GA - 10, 25, 50 ppm. (Table- 19, 20 and fig. 7). Though the increase in the induction of female flowers and fruit set was significant in some MH treatments, only MH - 50 and 100 ppm approached significant level in the total number of fruits harvested.

There were no significant differences within MH treatments in average number of fruits. Similar was the case with NAA - treatments. IAA - 50 ppm significantly increased the number

2.53
2.25
2.16
1.83
1.66
2.4
1.99
2.16
2.53
1.91
1.57
2.99

of fruits per vine over the treatment IAA - 100 ppm. Within GA treatments, there were no significant differences in the number of fruits per vine.

Table - 19

The effects of different plant regulator sprays on the average number of fruits per vine - Feb. crop.

S.No.	Treatment	Av. no. of fruits per vine.
1.	MH - 25 ppm	1.99
2.	" - 50 ppm	2.33
3.	" - 100 ppm	2.25
4.	" - 200 ppm	2.16
5.	" - 400 ppm	1.83
6.	" - 600 ppm	1.66
7.	NAA - 50 ppm	2.41
8.	" - 100 ppm	3.16
9.	" - 150 ppm	3.08
10.	" - 200 ppm	2.83
11.	IAA - 50 ppm	2.83
12.	" - 100 ppm	1.99
13.	2,4-D - 2.5 ppm	2.16
14.	" - 5 ppm	2.33
15.	Removal of male flower buds	1.91
16.	Water (Control)	1.57
17.	GA - 10 ppm	2.99
18.	" - 25 ppm	2.66
19.	" - 50 ppm	2.58
20.	" - 100 ppm	2.24
	$S.E_m$	$\pm$ 0.278
	L.S.D. at 5%	0.79
	'F' test of significance	at 1%

Table - 20

Analysis of variance for the number of fruits - Feb. crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	1.42	
Treatments	19	0.863	2.78**
Error	57	0.31	

** 'F' test of significance at 1% level.

Table - 21

Effect of different plant regulator sprays on the length/diameter ratio of cucumber (C. sativus) - Feb. crop.

S.No.	Treatment	Av.length in cms.	Av. diam. in cms.	Length/diam. ratio
1.	MH - 25 ppm	10.62	3.53	3.00
2.	" - 50 ppm	10.89	3.27	3.33
3.	" - 100 ppm	10.07	3.35	3.00
4.	" - 200 ppm	10.47	3.34	3.21
5.	" - 400 ppm	10.47	3.02	3.46
6.	" - 600 ppm	10.91	3.07	3.55
7.	NAA - 50 ppm	11.01	3.08	3.57
8.	" - 100 ppm	10.75	3.22	3.33
9.	" - 150 ppm	10.75	3.14	3.42
10.	" - 200 ppm	11.13	3.15	3.59
11.	IAA - 50 ppm	11.05	3.45	3.53
12.	" - 100 ppm	10.98	3.15	3.48
13.	2,4-D - 2.5 ppm	10.99	3.19	3.44
14.	" - 5 ppm	10.22	3.08	3.31
15.	Removal of male flower bud	11.06	3.13	3.53
16.	Water (Control)	10.17	3.35	3.03
17.	GA - 10 ppm	11.32	3.45	3.28
18.	" - 25 ppm	11.06	3.47	3.18
19.	" - 50 ppm	11.12	3.33	3.33
20.	" - 100 ppm	10.88	3.51	3.09
	$S.E_m$	± 0.92	± 0.72	
	Significance at 5%	Not significant	Not significant	

Table - 22

Analysis of variance for the length of the fruit February crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	0.42	
Treatments	19	0.473	1.37
Error	57	0.344	

Not significant.

Table - 23

Analysis of variance for the diameter of the fruit February crop.

Due to	D.F.	M.S.S.	V.R.
Blocks	3	0.083	
Treatments	19	0.104	0.50
Error	57	0.208	

Not significant.

Effect of different plant regulator sprays on the size of the fruit.

Observations were also taken of length and diameter of each fruit while harvesting to see whether the different plant regulator sprays had any effect on the size of the fruit. But it was found that there was no statistically significant difference in length, diameter, length/diameter ratio of a fruit. (Table - 21, 22 and 23).

Table - 24

Effect of different plant regulator sprays on the average weight of individual cucumber fruit (C. sativus) -Feb.crop.

S.No.	Treatment	Average weight of a fruit in gms.
1.	MH - 25 ppm	72.00
2.	" - 50 ppm	67.34
3.	" - 100 ppm	68.33
4.	" - 200 ppm	71.72
5.	" - 400 ppm	69.11
6.	" - 600 ppm	68.77
7.	NAA - 50 ppm	67.55
8.	" - 100 ppm	67.32
9.	" - 150 ppm	67.25
10.	" - 200 ppm	64.92
11.	IAA - 50 ppm	67.04
12.	" - 100 ppm	65.93
13.	2,4-D - 2.5 ppm	65.25
14.	" - 5 ppm	62.41
15.	Removal of male flower bud	64.49
16.	Water (Control)	60.18
17.	GA - 10 ppm	85.03
18.	" - 25 ppm	80.12
19.	" - 50 ppm	80.18
20.	" - 100 ppm	81.17
	S.Em	± 2.34
	L.S.D. at 5%	6.59
	'F' test of significance at	1%

Table - 25

Analysis of variance for the weight of a fruit.
(February crop)

Due to	D.F.	M.S.S.	V.R.
Blocks	3	58.09	
Treatments	19	177.45	8.83**
Error	57	20.08	

** 'F' test of significance at 1% level.

All the plant regulator sprays had increased the weight of individual fruit over the control. (Table - 24 & 25, Fig. 8). But the treatments which significantly increased the weight of individual fruit over the control were all MH and GA treatments, viz. MH - 25, 50, 100, 200, 400, 600 ppm, GA - 10, 25, 50, 100 ppm, NAA - 50, 100, 150 ppm, 9A A - 50 ppm. Increase in weight of individual fruit in GA treatments was more than any other treatments. In MH treatments as the concentration increased there was a decrease in the weight of individual fruit.

There were no significant differences in weight of individual fruit within all MH treatments. Similarly within all NAA treatments there were no significant differences in individual weight of fruit. Similar was the case within all 2,4-D and GA treatments.

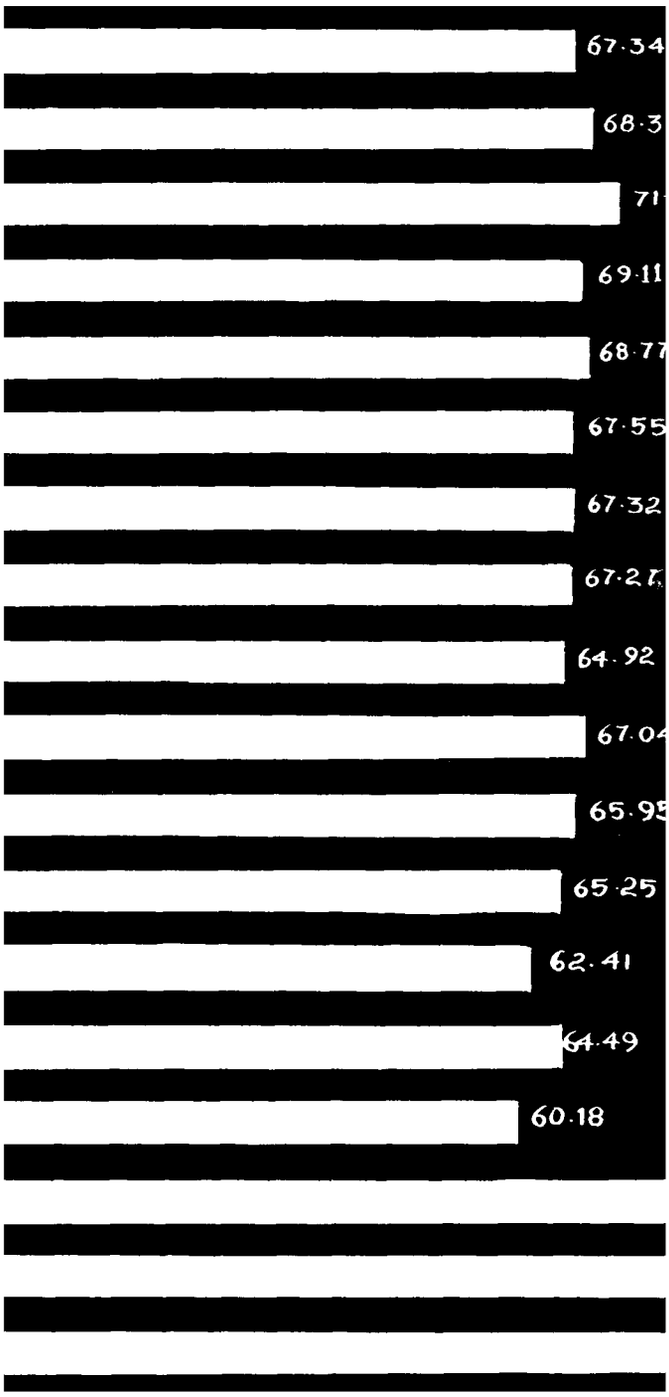

67·34
68·3
71
69·11
68·77
67·55
67·32
67·2
64·92
67·04
65·95
65·25
62·41
64·49
60·18

Table - 26

Effect of different plant regulator sprays on the average yield per vine (in grams) of cucumber.(C.sativus) (February crop)

S. No.	Treatment	Average yield per vine in grams.
1.	MH - 25 ppm	144.83
2.	" - 50 ppm	158.08
3.	" - 100 ppm	152.08
4.	" - 200 ppm	152.99
5.	" - 400 ppm	125.91
6.	" - 600 ppm	113.41
7.	NAA - 50 ppm	163.33
8.	" - 100 ppm	218.29
9.	" - 150 ppm	207.49
10.	" - 200 ppm	183.91
11.	IAA - 50 ppm	172.24
12.	" - 100 ppm	131.24
13.	2,4-D - 2.5 ppm	148.99
14.	" - 5 ppm	150.24
15.	Removal of male flower buds	123.66
16.	Water (Control)	95.24
17.	GA - 10 ppm	245.91
18.	" - 25 ppm	214.66
19.	" - 50 ppm	207.08
20.	" - 100 ppm	178.83
	$S.E_m$	± 19.57
	L.S.D. at 5%	56.48
	'F' test of significance at	1%

Table - 27

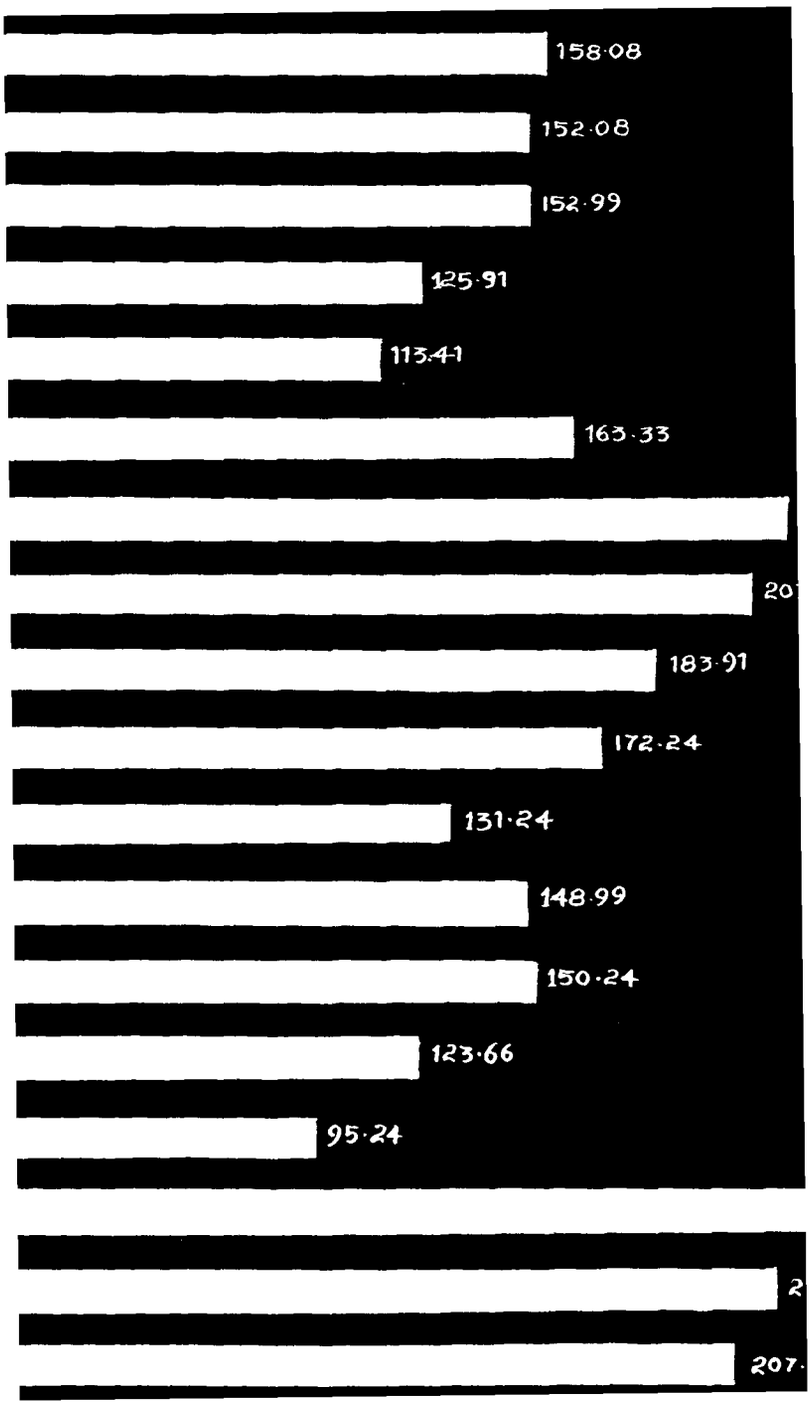
Analysis of variance for yield (weight) of fruits
(February crop)

Due to	D.F.	M.S.S.	V.R.
Blocks	3	5909.79	
Treatments	19	6137.06	3.99 **
Error	57	1534.41	

** 'F' test of significance at 1% level.

All the treatments increased the yield with regard to weight of fruits per vine. (Table - 26 & 27, fig. 9). But the treatments which increased the yield significantly over the control are MH - 50, 100, 200 ppm, NAA - 50, 100, 150, 200 ppm, IAA - 50 ppm, GA - 10, 25, 50, 100 ppm. There were no significant differences within MH treatments in average yield per vine. Similarly within NAA treatments there were no significant differences in average yield per vine. Similar was the case with IAA and 2,4-D treatments. Within GA treatments there were no significant differences among the treatments GA - 10, 25, 50 ppm. But GA - 10 ppm significantly increased the yield over the treatment GA - 100 ppm.

This yield increase in MH treatments was due to increase in weight of individual fruit and there was no statistically significant increase in the number of fruits. The increase in NAA treatment was due to both, increase in number of fruits and increase in weight per fruit. This is one of the


158·08
152·08
152·99
125·91
113·41
163·33
20
183·91
172·24
131·24
148·99
150·24
123·66
95·24
2
207·

reason why the increase in yield in NAA treatments is more than the MH treatments.

Similar was the case in GA treatments. In these treatments also the increase in yield was due to both increase in number of fruits and increase in weight.

Table - 28

Meteorological Data

Month	Maximum temperature.	Minimum temperature.	Relative humidity	Hours of Sunshine
1	2	3	4	5
1959				
January	19.5	6.4	91.2	10.353
February	21.6	8.0	84.5	10.782
March	30.2	12.2	74.0	12.081
April	35.7	18.0	49.7	12.913
May	39.5	23.1	41.7	13.621
June	41.0	27.9	51.0	14.000
July	35.1	26.8	80.3	7.100
August	33.1	25.8	86.6	6.600
September	33.0	24.6	84.9	7.100
October	32.7	19.3	79.8	9.000
November	27.3	10.5	81.1	9.500
December	23.2	5.9	75.1	9.000
1960				
January	20.2	4.8	85.4	7.600
February	26.5	7.9	74.6	9.400
March	28.1	13.2	67.0	7.600
April	34.8	16.6	48.5	9.300
May	40.3	23.3	35.1	10.300

2. Mean monthly maximum temperature in degrees centigrade.
3. Mean monthly minimum temperature in degrees centigrade.
4. Mean monthly relative humidity at 7.00 a.m. Local Time.
5. Average mean hours of sun shine from Sun rise to Sun set.

Latitude - 28.4" N. Longitude - 77.10" E.

DISCUSSION

The present studies on the effect of different plant regulator sprays on floral biology of cucumber had shown that different plant regulator sprays had no effect on opening and closing of male flowers except the GA treatments. These data have also confirmed the previous findings that the opening and closing of the male flower is mainly influenced by the sunrise and sunset i.e. by the light and time of the day. The temperature and humidity had no effect on opening of the male flowers. There was a slight delay in opening and closing of the male flowers in GA treatments. Similar observations have also been made by Brian et al. (1959) in Cupid sweet pea flowers.

The different plant regulator sprays had no effect on dehiscence of anthers. Temperature was found to have a pronounced effect on anther dehiscence. The anthers in all the treatments including GA dehisced between the temperature 20.5°C to 22.0°C. Similar observations regarding temperature effect on anther dehiscence had been made by Seaton and Kremmer (1938) in different cucurbits including cucumber. Phatak (1959) reported the similar observations in cucumber grown under Delhi conditions. Hayse (1960) had also reported in cucurbits that anther dehiscence is modified by temperature and humidity.

The effect of different plant regulator sprays on fertility of pollens 21 days after the second spray in July crop

was practically very little. But in the summer (February) crop the adverse effect on fertility of pollens was seen even 21 days after the second spray. This may be attributed to the high temperature in this season. Wittwer et al. (1954) and Hillyer et al. (1959) had also observed in cucurbits that MH treatments had sterility effect on male flowers. They also made some morphological observations on MH treated plants and observed that the MH treatments suppressed the development of pollen grains and that the pollen grains had shrunken protoplasm. These plant regulators like MH and NAA inhibit microsporogenesis to certain extent.

The lower treatments of GA produced the giant ovaries. Similar findings have been reported by Choudhury et al. (1959). They reported that the longitudinal section of the giant ovary showed elongated large cells. Ovulesize in giant ovaries and normal ovaries were compared and it was found that giant ovaries had larger ovules than the normal ovaries. Nitsch et al. (1952) while studying the development of sex expression in cucumber reported that plants grown at 17°C (night) and 8 hours of sunlight produced female flowers with giant ovaries. The GA spray might be producing similar effects.

The different floral abnormalities as a result of plant regulator sprays had been observed. The giant male flower produced as a result of GA treatments may be due to increased cell size of GA treated plant. Plack (1958) had also reported the effect of GA on corolla size of Glechoma hedracea flower. As regards other abnormalities observed as

a result of GA - 10 ppm and 25 ppm treatment and 2,4-D 2.5 ppm treatment, there was a fusion of axillary branch with themain branch giving the whole stem an appearance of fasciation. Beal (1946) found that the application of 2,4-D in lanolin produced extensive growth abnormalities over the entire bean plant. He cited the possible reason as a destruction of primary phloem due to active proliferation of the young phloem cells. Sawheny (1919), Bose (1934), Pathak and Singh (1953) have reported different teratology in cucurbits.

The epinastic effect observed in seedlings sprayed with different plant regulators supposed to be due to more cell activity on the ventral surface of the leaves after spraying. Isenberg (1954) reported that the principal effect of MH is the modification of the respiratory activity. In actively growing plants this change in respiratory activity is generally accompanied by morphological changes, usually of an undesirable character. The plants came to normal condition 36 hours after the spray. This might be because the absorption and translocation of the plant regulators take some time which in turn nutralizes the cell activity. In the February crop the epinastic effect lasted for 48 hours. This was probably due to high temperature at that time. In MH, it was reported by Smith (1955) that 40% absorption takes place four hours after the spray in tomato. He also observed that 90% absorption takes place 48 hours after the spray. Mitchell et al. (1946) reported in 2,4-D translocation that in bean plants the stimulus resulting from 2,4-D treatment was

not readily translocated from the leaves of bean plants whose sugar content was relatively low such as those exposed to extended periods of darkness. They also observed that translocation of stimulus takes place along with translocation of organic food material. The different morphological effects like modification in shape, reduction in size of leaves etc. were observed with different plant regulators. The different morphological effects of MH sprays were in accordance with those reported by Moore (1950) in different plants. The protruberances on leaves observed in 2,4-D treated plants might be due to increase in peroxidase activity in the proliferated tissues as reported by Falber (1948). The GA treatments generally produced no visible morphological effects on leaves except long petioles.

The suppression of apical dominance with higher concentrations of MH was observed. There are number of theories about the suppression of dominance. Gruelach and Atchisan (1953) have shown that MH acts as an antimitotic. Watson reported that growth inhibition of bean leaf was apparently due to inhibition of cell multiplication. Hillyer (1958) reported in squash that morphological studies of MH treated plants showed suppressed cell differentiation in apical meristem. The lowest concentration of MH did not show any inhibiting effect on vine growth. It has been seen in studying the effects of some antiauxins that at very low concentrations often they have stimulatory effect instead of the usual inhibitory effect on the growth of the plant. The removal of male flowers at bud

stage has given higher extension growth. This may be attributed to economy of food reserves as a result of removal of flower bud and which in turn resulted in more vegetative growth.

In the February crop, the suppression in MH treatments is more than the July crop. But Hubburd (1955) reported that maximum absorption of sodium salt of MH (MH 40) takes place within the humidity range 80-100%. He reported less absorption of MH as sodium salt (MH 40) at 50% relative humidity. There was more humidity in July season i.e. 80.3% (Table - 28) and less humidity in March, 67.0%.(Table - 28). This meant there was less absorption in February crop than the July crop. So less suppression of growth in July crop can only be explained by the fact that in July crop, due to more cell sap activity, there might be a dilution of MH concentrations which in turn resulted in less suppression of growth by MH treatments. In February crop also male flower bud removal gave better growth of the main axis. All the GA treatments stimulated the growth. These results agree with those of Brian, Hemming and Lowe (1958) and Wittwer and Buckovac (1958). However, Galun (1959) reported that GA first induced elongation, but if these treatments were repeated for two or more weeks, inhibition results. In the present studies there were no repeated treatments upto 2 to 2 weeks, hence our results cannot be compared with those of Galun (1959). Brian and Hemming (1958) suggested the theory on the mode of action of GA in elongation of pea internodes. They thought that GA nutralised a mutant inhibitory system, which prevented internode elongation. Choudhury et al. (1959)

reported similar effects in cucumber by Gibberellin treatments.

There exists some correlation between appearance of first female flower on the main axis with the female to male flower ratio. All thetreatments induced the formation of first female flower on the lower nodes on the main axis and they had higher female to male ratio. These results are in agreement with those reported by Nitsch (1950, 1952) and Nitsch et al. (1952) with Cucurbita pepo var. Acorn squash and Choudhury et al. (1959) with cucumber var. Straight '8'. Ito et al. (1954) suggested that in a primordial stage all flowers carry both sets of sex organs and application of certain growth substances induce the transformation of staminate flower buds into pistillate flowers. Laibach and Kribben (1951), Laibach (1952) and Nitsch et al. (1952) had supported the hypothesis that flower sexuality may be determined by auxin level at the time of initiation of the flower primordium. Choudhry (1957) put forward a theory in which he anticipated a set of two hormones which he had named as 'Y' and 'Z', stamens and carpel inducers respectively. He also further stated that short photoperiods seemingly favour the production and accumulation of 'Z' type of hormones in staminate inflorescence which changes the male character of flowers to female. Such a transformation apparently, results in the activity of latent female structures present in the sporophylles and to the relative suppression of male ones. Long photoperiods, similarly, seem to favour the accumulation of

hormone 'Y' in the female or pistillate inflorescence resulting in the changed expression from femaleness to maleness. Galun (1959) concluded that there seems to exist three phases in the flowering sequence of cucumber plant - male (staminate), mixed (staminate and pistillate) and female (pistillate). Any treatment which brings the mixed and female phase closer to the base of the plant causes a more female sex expression, while any treatment which prolongs the duration of the first phase delays the appearance of the second phase or suppressing it altogether results in male sex expression.

A marked increase in the average number of female flowers in all the treatments in July crop was observed. The increase was statistically significant with MH - 100, 200, 400, 600 ppm, NAA 50, 100 ppm, in July crop, and in February crop, MH - 50, 100, 200 ppm and NAA - 50, 100 ppm, IAA - 50 ppm, GA - 10, 25 ppm. MH and NAA seem to be very effective in increasing the average number of female flowers in both the crops. Lower concentrations of GA were also effective in increasing average number of female flowers in February crop. Very high concentrations of GA (i.e. 100 ppm) has slightly reduced the average number of female flowers. This trend of MH and NAA treatments in increasing the average number of female flowers is in agreement with the results reported by Choudhury et al. (1959). But results reported by Galun (1959) do not agree with our results regarding increase in the average number of female flowers by GA treatments. He reported that treatments of GA induced maleness in

cucumber. But these results cannot be compared with our results as Galun had given repeated treatments of GA for 2 to 3 weeks. The results of the present investigation for GA treatments agree with those results obtained by Choudhury et al. (1959) under similar conditions of nutrition and light.

The mean maximum and minimum temperatures were ranging from 35.0°C to 40.3°C and 26.8°C to 23.3°C and the day length from 9.0 hours to 10.3 hours during both the seasons. (Table - 28). The results show that even under these conditions of high temperature and long days which keep the plants in male phase (Nitsch et al. 1952), it is possible to modify the sex expression in cucumber. These results do not agree with those reported by Maheswari(1957) but support those obtained by Ito and Saito (1957d) and Choudhury et al. (1959). The average number of female flowers as a result of different treatments were comparatively more than those obtained in summer season. This could be explained due to vigorous growth in July crop than summer crop. Moreover, more humidity in July crop might have some effect in inducing more femaleness in July crop. (Minina and Matzkevich 1944).

All the treatments in both the crops increased female to male ratio as compared with control, except in higher concentrations in GA treatments. The low female to male ratio in higher concentration of GA treatment was due to high number of male flowers produced with comparatively less high number of female flowers, which brought down the

ratio. The highest ratios were obtained with NAA 100 ppm (1 : 10.20) and MH 100 ppm (1 : 10.54) for July crop, and with February crop, it was obtained in NAA 100 ppm (1 : 5.68) and MH 200 (1 : 6.43). The lowest ratios was obtained in water (control) treatments in both the seasons, (i.e. 1 : 33.07) in July and (1 : 18.98) in February crop. In GA 100 ppm treatment also the ratio was as low as 1 : 18.88. These results are quite comparable with those obtained by Laibach and Kribben (1950, a,b,c, 1951 a,b, 1953), Laibach (1951, 1952), Nitsch (1950, 1952), Nitsch et al. (1952) and Choudhury et al.(1959). The lower female to male ratio obtained in July crop may be attributed to higher number of male flowers produced in this season which might be the result of high temperature prevalent in that season. Heslop - Harrison (1957) has suggested a tentative hypothesis for the auxin action in sexual differentiation. He suggested that sexual differentiation is controlled by the indigenous level of auxins in the regions near the flower primordia and during flowering and formation of pistillate organs may be favoured by high auxin levels in the vicinity of differentiating primordia and of staminate organs by the low auxin levels. The supplementary action of applied auxins in increasing the auxin level of the plant may be a probable cause of more number of female flowers. Maheswari et al. (1958) contended that MH being antiauxin should increase number of male flowers instead of reducing them. But Hillyer (1958) and Hillyer et al. (1959) have suggested that MH suppressed the development

of androcia of staminate flowers. They explained the sexual inhibition of staminate flowers due to auxin versus antiauxin theory. Leopold et al. (1952) had suggested that inhibition of MH is relieved by addition of auxin and conversely inhibition of growth by high concentration of auxin can be relieved by the addition of MH. This suggests that action of MH in inhibition depends upon the relative auxin content of the plant.

The action of MH in increasing the average number of female flowers has been explained by Griesel (1954). He explained that MH retards starch digestion in plant tissues and considerable starch remains for a longer period and it also reduces catabolic activities going on inside the plant. This action is similar to low temperature and short day which reduces transpiration and other activities resulting in more number of female flowers and less male flowers. Nitsch (1952) suggested that the differentiation and initiation of ovary primordia depends upon chain of biological events in which auxins play a role. Probably MH acts some where in this chain of biological events independent of the auxins already present thereby promoting ovary primordia.

The adjusted values of fruit set as a result of different plant regulator sprays show that as the concentration of the regulator increases there is an increase in set of fruits. Gustafson (1936) demonstrated that the auxins are responsible for fruit set. These results have been confirmed by many workers subsequently. Auxins have been often used to supplement pollination in glass house tomatoes. Outdoor

tomatoes had also been benefited from sprays. The fruit set is brought about by auxins in two ways. First the optimum level of auxins prevents the formation of abscission layer. Secondly, it starts the further development of ovary by cell enlargement. The increased set of fruits by application of auxins have been the result of high auxin level in the plant. In a way these auxins play the role of supplementing the role of pollens i.e. supply of auxins. It is proved beyond doubt that the role of pollens in fruit set is also of hormonal nature. Recently, Wittwer et al. (1957) and Rappaport (1956) set fruit with gibberellic acid. The present results with GA are in agreement with the above results. The GA treatments induced early development of fruit. Probably GA might be bringing the edible size of the fruit earlier by increasing the cell size of the fruit. Similar early development of cucumber fruit has been reported by gibberellin treatments by Choudhury et al.(1959).

The different plant regulators did not bring about any significant changes in the size of the fruit. There have been many claims of increase in size of the fruits by plant regulator sprays but in the present studies no such changes were observed. Probably in all the studies in which increase in size of fruits have been reported by auxin sprays, the sprays were given directly to flowers, hence the effect might be pronounced. But in the present studies the sprays were given at seedling stages.

The different treatments brought about significant

increase in weight of individual fruit. Application of auxins is reported to decline the respiration rate and this is persistent throughout the season in the fruits from the treated plants (Maxie and Crane 1956). This lower respiration rate and increased growth may mean a better energy coupling between respiration and growth.

The final number of fruits harvested also show significant differences over the control as a result of plant regulator sprays. But the trend of fruit set and final number of fruits is not the same. The biochemical action of auxins and antiauxins in fruit set and development is still not clear and the level of indigenous auxins is also one of the important factors in deciding the effect of applied auxins or antiauxins.

The final yield data show significant increases over the control. This increase in yield has been brought about by two factors. First, it is an increase in the number of fruits harvested and secondly, the increase in the individual weight of fruit. The yield increase in MH treatments was due to increase in individual weight of a fruit and there was a very little increase in average number of fruits harvested. The increase in yield in NAA treatments was due to both the factors i.e. increase in number and weight of individual fruit. The increase was more than MH treatments. Similarly, in GA treatments the increase in yield was due to increase in weight of fruit and increased number of fruits. Another interesting side observation made was that

the number of fruits were inversely related to individual fruit weight. Similar observation has been made in squash by Abdel-Samie (1958).

SUMMARY

A study on the floral biology, sex expression, sex ratio, fruit set and development as affected by plant regulator sprays in cucumber, var. Straight - 'S' was taken up at the Division of Horticulture, Indian Agricultural Research Institute, New Delhi. The observations were taken in two seasons, that is, rainy season of 1959 and summer season of 1960.

In studies on floral biology the effect of five different plant regulator sprays on the anthesis, anther dehiscence and pollen fertility was recorded. The teratology as affected by the plant regulator sprays was also studied in both the seasons. It was observed that these different plant regulator sprays had not much affected the anthesis except in the GA treatments which delayed the opening and closing of petals of male flower to a little extent. Temperature exerted no influence on the anthesis but it affected the anther dehiscence in all the treatments. No plant regulator sprays had any effect on the anther dehiscence. The different plant regulators had a temporary adverse effect on the fertility of the pollens but that effect gradually diminished and 30 days after the 2nd spray the pollens had normal fertility.

The different plant regulators affected the sex expression and sex ratio in cucumber. Five different plant regulator sprays with varying concentrations were applied twice

to cucumber at the seedling stage. Another treatment included was the removal of male flower buds till the first appearance of female flower. The plant regulators used were, MH, NAA, IAA, 2,4-D, and GA. In the control treatment the seedlings at the same stage were sprayed with distilled water. In July crop, MH - 100, 200, 400, 600 ppm, NAA - 50, 100 ppm and in February crop, MH - 50, 100, 200 ppm, NAA - 50, 100,ppm IAA - 50 ppm, GA - 10, 25 ppm treatments significantly increased the number of female flowers over the control.

All the plant regulators induced the appearance of the first female flowers on comparatively lower nodes on the main axis when compared with the control in both the seasons. All the plant regulator treatments had higher female to male ratio. The treatments, MH - 100, 200, 400, 600 ppm, NAA - 100, 150, 200 ppm, IAA - 50, 100,ppm, 2,4-D - 5 ppm significantly suppressed the number of male flowers in February crop. The probable reasons for the similar actions of auxins and antiauxins like NAA and MH respectively have been given. MH suppressed the apical dominance in higher concentrations in both the seasons. MH - 25, 50 ppm, NAA - 50, 100, 200 ppm, IAA - 50, 100 ppm and removal of male flower bud stimulated the growth of the plants in July crop. In February crop, MH - 25 ppm, NAA - 100, 150, 200 ppm, removal of male flower bud and GA - 10, 25, 50, 100 ppm stimulated the growth of the plant.

This study has confirmed the previous conclusion that even under long days and high temperature conditions, it is possible to modify the sex expression and sex ratio in

cucumber by spraying certain plant regulators.

Further study of the effect of different regulator sprays on fruit set, development and maturity was done. It was observed that different regulator sprays not only increased the sex ratio in cucumber but they also increase the fruit set. In February crop, it was observed that the treatments, MH - 100, 200, 400, 600 ppm, NAA - 100, 150, 200 pp, IAA - 50 & 100 ppm, 2,4-D - 5 ppm and GA - 10, 25, 50, 100 ppm had significantly increased the fruit set over the control. It was also observed that higher concentrations of sprays gave higher fruit set. The role of auxins in fruit set has been explained.

There was no effect of different plant regulator sprays on maturity of fruits except in GA treatments. GA treatments hastened the maturity of fruit by 2 to 3 days.

The plant regulator sprays also increased the final number of fruits harvested. NAA - 50, 100, 150, 200 ppm, IAA - 50 ppm, GA - 10, 25, 50 ppm significantly increased the number of fruits over the control. The increase in number of fruits in MH treatments, 50 & 100 ppm approach significance.

The application of different plant regulator sprays did not influence the size of the fruit significantly. But the plant regulators increased the individual weight of a fruit significantly in the treatments MH - 25, 50, 100, 200, 400, 600 ppm. NAA- 50, 100, 150 ppm, IAA - 50 ppm and GA -10,

25, 50, 100 ppm.

The final yield in weight per vine increased significantly over the control. The increase in weight was significant in the treatments, MH - 50, 100, 200 ppm, NAA - 50, 100, 150, 200 ppm, IAA - 50 ppm and GA - 10, 25, 50, 100 ppm.

The above findings of these studies, thus lead to the conclusion that the different plant regulators used in proper concentration and at the proper stage of growth hold great promise, not only in increasing the number of female flowers but also in increasing the final yield and hastening the maturity of the cucumber crop.

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* Original not seen.

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