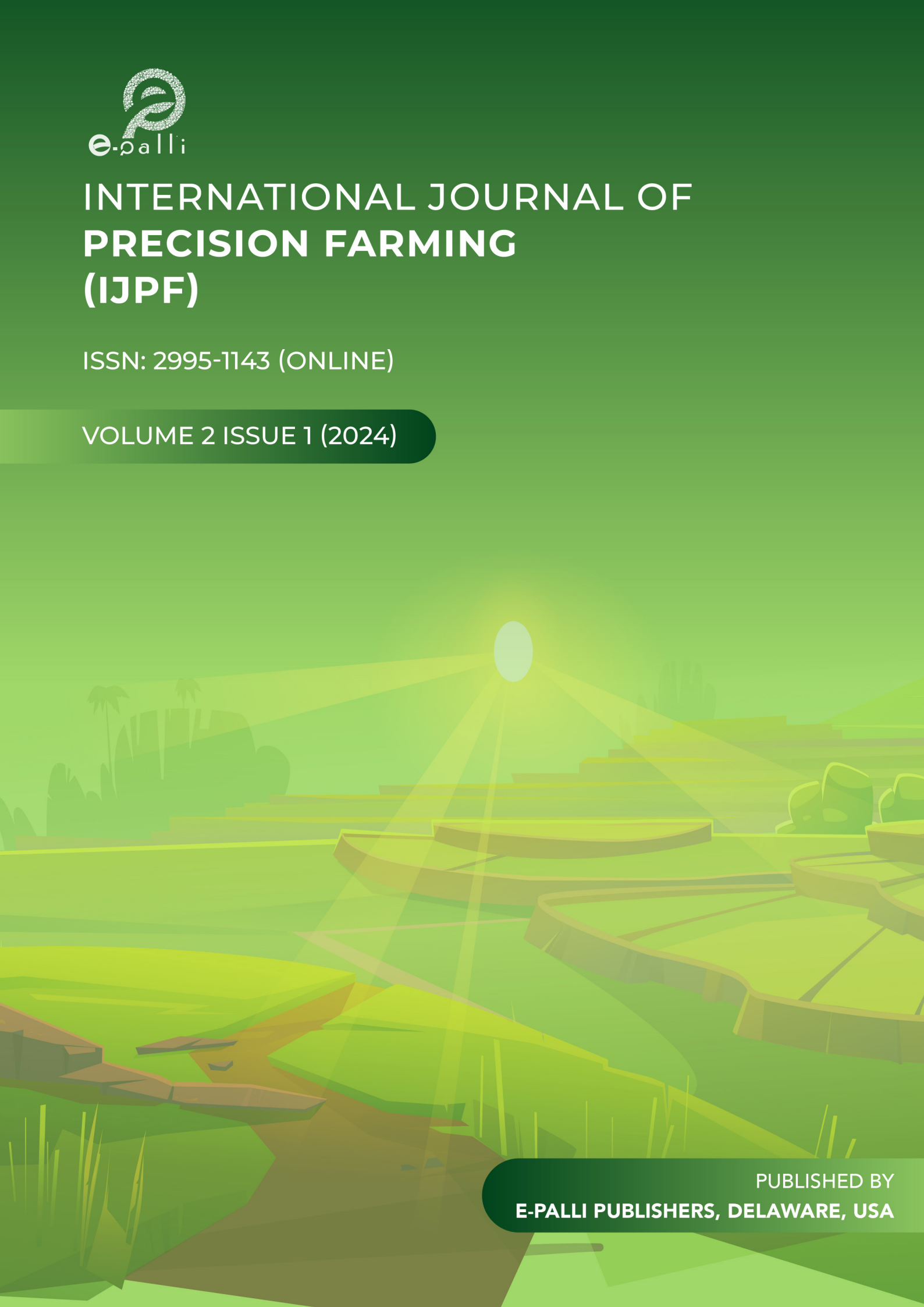

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Effect of Maleic Hydrazide and Ethrel on Performance of Cucumber (*Cucumis sativus* var Kamini)

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ABSTRACT

Cucumber is one of the widely cultivated crops of the Cucurbitaceae family, with a higher male: female ratio as a major problem. Exogenous application of plant growth regulators (PGR) has been widely used in cucurbit production because of its significant impact on yield attributing parameters. Therefore, an experiment was conducted in a randomized complete block design using maleic hydrazide (MH) (50, 100, 150 ppm) and Ethrel (100, 200, and 300 ppm) with control replicated thrice. Results revealed that 100 ppm of MH was most effective ($P<0.05$) which enhanced higher number of female flowers (10.2) statistically at par with 50 ppm MH (9.2), low male: fe-male ratio (0.27) statistically similar with 200 ppm Ethrel (0.55), a greater number of fruits per plants (10.13) statistically similar with 50 ppm MH (8.26) and maximum fruit yield (18.44 t h-1) which was statistically similar with 50 ppm MH (15.36). Similarly, 50 ppm MH showed early female flower appearance (25 DAT) statistically at par with MH100 (26 DAT), while 300 ppm Ethrel took a longer time for the appearance of flowers (28 DAT). In contrast, 100 ppm Ethrel showed the lowest ($P<0.05$) number of female flowers (4.6), control showed highest ($P<0.05$) male: female ratio (7.36), 300 ppm Ethrel showed lowest number ($P<0.05$) of fruits per plant (2.4) and lowest ($P<0.05$) yield (3.29). Length and diameter of fruits were not significantly affected using any PGR. Hence, 100 ppm MH proved best for improvement of yield attributing parameters in cucumber.

INTRODUCTION

Cucumber is extensively cultivated and most important crop belonging to the family Cucurbitaceae. Cucumber (*Cucumis sativus* L.) is the most significant and popular cross-pollinated vegetable, with chromosomal number 2n=14. It is an herbaceous annual climber plant. Their stems are hairy or scabrous, with shallow and sharp sinuses. It displays an enthralling array of floral morphology that includes all staminate, pistillate and hermaphrodite type of flowers appearing in several arrangements which may yield different type of sexual expression (Thappa *et al.,*2011). Sex ratio may vary from 15:1 to 13:1. This plant has a strong propensity toward maleness; thus, fruit yield is determined by the quantity of female blooms. Cucumber was grown in an area of 10,309 ha of land in Nepal with a production of 159,625 MT and a productivity of 15.48 MT/ha (MoALD, 2021/22). In Lamjung, the total area under cucumber cultivation is 32 ha, with production of 364 MT and productivity of 11.38 MT/ha (MoALD,2021/22).

According to folklore, cucumber fruit has a cooling effect, eases indigestion, stops jaundice, and prevents constipation. Additionally, raw fruits are employed in cosmetic preparations while cucumber seeds are used in Ayurvedic remedies. The fruits have a very high-water content, a very low-calorie count, and are incredibly nutrient-dense. The fruit can be eaten raw or in a salad. It is abundant in vitamins C, thiamine, and minerals. (0.38 g, 0.3 mg, 0.2 mg, and 78 mg per 100 g of edible fruit, respectively). 80 percent of fruits are edible and comprise 95 percent water, 0.7% protein, 0.1% fat, 3.4% carbs, 0.4% fiber, and 0.4% ash (Aykroyd, 1963).

Plant growth regulators are classified into two types: plant growth promoters (auxin, gibberellins, cytokinin, maleic hydrazide, ethephon, etc.) and plant growth inhibitors (ethylene, abscisic acids, dormins, etc.). The usage of auxins and gibberellins together results in increased secondary growth. The first few flowers that a cucumber bears are staminate, and they are not particularly essential in terms of cucumber production and yield (Rafeekher *et al.,* 2002). Therefore, promoting early female blooms could help farmers harvest fruit earlier. PGRs are widely practiced in other countries to induce female flowers in cucurbits, however, they are not widely used in Nepal.

According to Hossain *et al.* (2006), PGRs play a major role in sex ratio alternation if applied at the two- and four-leaf stage, the critical stage for promotion or suppression of both sexes. Exogenous use of growth regulators such as ethylene has changed cucumber sex expression towards femaleness by enhancing female flower output and reducing male flower production (Arora, Malik, & Batra, 1994). MH inhibited plant growth and aided branch development, but had no effect on chlorophyll content of leaves, fresh and dry biomass of plant and root (Sarkar *et al.,* 2019). The use of MH increased cucumber fruit set by 12% as per Verma and Choudhury (1980).

Research Problem

Cucumber is usually monoecious with both male and female flowers in the same plant. Also, the number of

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male flowers to female flowers is generally high. The female flowers are only liable to produce fruits but male flowers are required in few amounts only to pollinate the female flowers. Changing the sex ratio of male and female flowers is the most significant aspect of cucurbit sex manipulation (Sarkar *et al.,* 2019). The majority of cucumber research in Nepal focuses mostly on variety selection, general management, growing practices, etc., while very little work has been performed on sex regulation.

Justification of Study

Lower (1970) observed that cucumber bears unisexual blooms, that sex expression is genetically determined, but that it can be adjusted by environmental variables and the use of growth regulators. Male and female flower ratio varies from 15:1 to 13:1. This ratio can be lowered by the alteration of temperature and the exogenous application of plant growth regulators. High temperatures and long photoperiods promote male flower production, while low temperatures (24°C to 25°C) and photoperiods up to 12 hours enhance pistillate flower production; however, photoperiod has very little effect on gynoecious stability under high temperatures above 30°C (Shrestha & Kumar Jha, 2019). Anatomical studies revealed that in the primordial stage, all flowers include both sets of sex organs, and that the change of male flowers to female flowers can be triggered by the application of specific chemicals (Ito *et al.*, 1954). The main problem in cucumber production is the higher number of male flowers than that of female flowers which occur due to high temperature and humidity. PGRs applied foliarly to cucurbits have altered physiological and developmental processes such as plant vegetative growth, sex expression, yield, and yield components (Tantasawat *et al.,* 2015). Kaur *et al.* (2018) found that the use of PGRs in cucurbit production must be specific in order to improve production. To improve yield, it is required to increase the number of female flowers as well as fruiting. Thus, by the application of PGR, early female flowers can be induced and early harvest can be achieved. This research aims to modify the sex ratio and help farmers to increase the yield of cucumber. This kind of research is considered important by the farming community to increase farm profitability.

Research Objectives

General Objective

To know the effects of different doses of MH and Ethrel on the vegetative and reproductive parameters of cucumber

Specific Objectives

i. To know the effects of different doses of MH and Ethrel on the vegetative characters of cucumber

ii. To find out the effects of different doses of Ethrel on sex ratio of cucumber

iii. To know the effects of different doses of MH on the fruit yield of cucumber

LITERATURE REVIEW

Plant growth regulators such as MH, GA3, NAA, and Ethrel have been shown to impact sex expression in many cucurbits, either suppressing male flowers or increasing the number of female flowers. Plant growth regulators are used to influence physiological processes such as plant growth and development, fruit color enhancement, flower differentiation, fruit ripening, tissue growth, and so on (Prajapati *et al.,* 2015). If PGRs are applied during the two- and four-leaf stage, the essential stage for promoting or suppressing both sexes, it plays an important role in sex ratio alternation (Hossain *et al.,* 2006).

The Crop (Cucumber)

Cucumber is a widely grown vegetable belonging to the Cucurbitaceae family. *Cucumis sativus* is native to the Indian subcontinent but other species of Cucumis are known to originate from Africa (Sebastian *et al.,* 2010). It is the largest group of summer-season vegetables. These are either vines or creepers with simple, palmately five-lobed leaves that become sub cordate at maturity. Plants are mainly monoecious bearing staminate and pistillate flowers on the same plant and are cross-pollinated in nature. Fruit is a pepo that varies in shape, color, flavor, and taste.

The seed oil contains four major fatty acids, according to (Mariod *et al.,* 2017) linoleic acid (61.6%), oleic acid (15.7%), stearic acid (11.1%), and palmitic acid (10.7%), and the seed is extremely rich in nutritional compounds, including protein (33.8%), fat (45.2%), carbohydrates (10.3%), and crude fibers (2.0%). The fruits are high in nutrients, comprise 95% water, and have little calories (around 15 calories per cup) (Mukherjee *et al.,* 2013).

Cucumber thrives in a wide range of soil types, including sandy, sandy loam, clay loam, and silt loam. When an early yield is required, sand and sandy loam soil are employed. It grows best on soil with a pH between 5.5 and 6.7. The soil should be adequately drained (Bajaj *et al.,* 2022).

Plant growth regulators are employed to control plant vegetative development, boosting plant population per unit area in terms of production (Latimer, 1991).

Effect of Plant Growth Regulators on Horticultural Crops

The combined treatment of GA3 at 20ppm and NAA at 100ppm outperformed all other treatments, producing the greatest vine length of 155.28cm per plant over the least of 138.08cm per plant and the most branches (4.66 per plant) compared 2.41 per plant in the control treatment (Dalai *et al.,* 2015). Asghar *et al.* (1990) discovered the most female flowers per plant and the lowest sex ratio (3.31) when GA3 was applied at a concentration of 20 mg/liter. Pretreatment with salicylic acid at two doses, 0.07mm and 0.18mm, was shown to be very useful for enhancing chlorophyll content, stem diameter, and leaf count (Sultan *et al.,* 2016). Cucumber sprayed with a mixture of GA3 at 200ppm and NAA at 100ppm produced the maximum number of fruits per plant with the largest fruit width and length (Dalai *et al.,* 2020).

The vegetative characteristics like as number of nodes,

internodal distance, length of main vine, number of primary branches per vine, length of leaf and width of leaf of cucumber are influenced by the use of various plant growth regulators and it is due to the effect of chemical in the apical portion which cause rapid cell division and cell elongation in plants (Gosai *et al.,* 2020).

Effect of Maleic Hydrazide in Vegetative Parameters

Maleic hydrazide inhibits apical growth by affecting cell division (Greulach & Atchison, 1953). At 100ppm, combining MH with ethephon leads in the most nodes (19.97) per unit length of vine and the smallest internodal distance (5.02 cm) (Thappa *et al.,* 2011). Mishra and Sharma (1965) found that foliar treatment of maleic hydrazide at 200 ppm reduced internode and node elongation significantly.

Maleic hydrazide's influence on cell division (Graulach & Atchinson, 1953) and plant polar auxin transport (Arora *et al.,* 1982) could explain the inhibition of apical growth. Maleic hydrazide and ethephon inhibited vegetative development more severely and persistently at increasing concentrations (Abdel-Rahman & Thompson, 1969). Miller *et al.* (1969) explained the increased number of branches in eggplant and pepper to forced lateral bud development and terminal bud injury caused by growth regulators.

Effect of Ethrel on Vegetative Parameters

Watermelon vine length was decreased by administration of Ethrel at a rate of 200–500 ppm, similar to maleic hydrazide (Singh & Madan, 1971). Ethrel at 250 ppm reduced vine length in ridge gourd (Patnaik *et al.,* 1974). Ethephon applied foliarly at a 250-ppm concentration resulted in an increase in the number of cucumber branches, according to (Rafeekher *et al.,* 2002). The use of 300ppm Ethrel during the 2-leaf and 4-leaf stages in cucumber under polyhouse conditions resulted in longer vine length (131.88cm), number of branches per plant (9.87), and internodal length (Ajay *et al.,* 2018). One possible explanation is that ethylene works as an anti-gibberellin and prevents the mitotic processes in the meristem of root and shoot to stop, hence affecting plant length (Hayashi *et al.,* 2001). The administration of growth retardants inhibited both cell division and cell elongation, resulting in the formation of shorter shoots and leaves in melon (Rajala & Peltonen-Saino, 2001).

Effect of Maleic Hydrazide on Reproductive Parameters

According to (Desai *et al.,* 2011; Pandya & Dixit, 1997), low temperatures and short days help to minimize respiration and photosynthates buildup, which may be the cause of fewer male flowers. With the foliar application of maleic hydrazide at 50 ppm and 100 ppm, Singh and Choudhary (1988) observed the early emergence of female flowers in cucumber. Maleic hydrazide administration was also shown to diminish inter-nodal distance, strengthening the source-sink connection and assisting in the early buildup of photosynthates required for the flowering and fruiting processes (Currier *et al.,* 1951; Derridj*et al.,* 1986). At the flowering stage, there was no response to MH at low or high concentrations (Ries, 1985).

The increased number of female flowers was caused by MH, which had a sex-balancing impact in plants by lowering respiration and increasing photosynthate accumulation. Hidayatullah *et al.* (2009), found that pistillate flowers of cucumber increased after MH application at 450 M/l concentrations. He also observed an increase in the number of cucumbers pistillate flowers/ plant with 50 to 200 ppm MH application.

Verma and Choudhury (1980) reported a 12% increase in cucumber fruit set following the use of MH. MH aids in the regulation of the C:N ratio in plants, which contributes to maximal female blooming and fruit yield.

Maleic hydrazide and ethephon provide the maximum yield (11.72 tons per acre) at 100 ppm, whereas the control treatment produces only 7.23 tons per acre, which is 45% lower than the most effective treatments (Thappa *et al.,* 2011). All plant growth regulator concentrations help to increase fruit yield per vine, with maleic hydrazide and ethephon at 100ppm giving the highest fruit yield (Kaur *et al.,* 2016).

Ethrel's Influence on Reproductive Parameters

Yamasaki *et al.* (2000) discovered that when endogenous hormone (ethylene) levels are high, CS-ETR and CS-ERS mRNA are highly accumulated, aiding in the formation of female flowers in cucumber, and found that ethylene and auxin are the main regulators of femaleness in cucumber. Ethrel at 200 ppm or 300 ppm produced a smooth fruit surface, but NAA and GA3 produced a rough surface, with GA3 at 200 ppm producing the most fruit (Kadi *et al.,* 2018).The maximum fruit yield/plant is obtained when 450 M/l ethrel is used (Bano & Khokhar, 2009).

There was a substantial drop in sex ratio in all treatments compared to the control, and Ethrel 150 ppm was demonstrated to be one of the best treatments in this respected discovery of Chaurasiya *et al.* (2017). Ripen-15 (ethephon) had a good impact on the development of female flowers in cucumber and bitter gourd in an experiment done by Hossain (2004).

MATERIALS AND METHODS

This research entitled "Effect of Maleic Hydrazide and Ethrel on Vegetative and Reproductive parameters of Cucumber" was carried out from Mid-March to Mid-July in 2023 in the field of Lamjung Campus, Sundarbazar. Research site: The field experiment was conducted at IAAS, Lamjung. It lies in the Gandaki Province of Nepal. The coordinates are 20.2765°N 84.3542°E, and the elevation is 760 meters above sea level.

Experimental Design

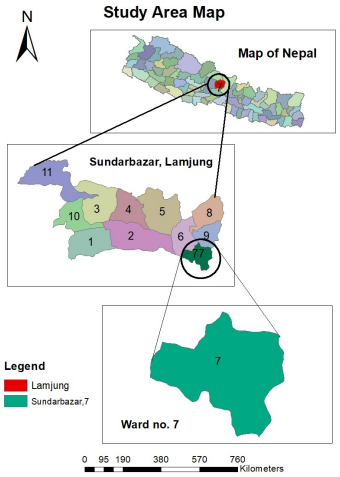

Figure 1: Location of research site

The experiment was conducted in Completely Randomized Block Design (RCBD) with seven treatments which were replicated thrice. The area of each block was 48 sq m and that of each plot was 6 sq m. The total area of field was 188 sq m. The spacing between plant to plant and row to row were 1m*1m.

Experimental Details:

The two plant growth regulators (Ethephon and MH) were used in three different doses at two- and four-leaf stages (Dahal & Dahal, 2022). The experiment was carried out in open field conditions. A total of seven treatments including control in RBD and were replicated thrice. The detail of treatments and its formulations are given below: Treatments were sprayed 3 times at two- and four-leaf

Table 1: List of treatments with formulations

Treatments	Name of trt	Formulation
T1	Control	500 ml
T2	MH 50 ppm	25mg/500ml
T3	MH 100 ppm	50mg/500ml
T4	MH 150 ppm	75mg/500ml
T5	Ethrel 100 ppm	125µl/500ml
T6	Ethrel 200 ppm	250µl/500ml
T7	Ethrel 300 ppm	375µl/500ml

stage with the use of hand sprayer; each at an interval of seven days. The Ethrel and Maleic Hydrazide were sprayed at two- and four-leaf stages for 3 times in the interval of 7 days. The first foliar application was done 7 DAT. The actual amount of PGR was measured by using microbalance and micropipette. Firstly, the weighed amount of MH was dissolved in few ml of ethanol and then well mixed. Then, distilled water was added to make the final volume of spray solution i.e.500ml. The spray solutions were prepared fresh on the very day of spray. The solutions were sprayed uniformly throughout the plants.

Experimental Material

The variety of cucumber used for the research was Kamini because of its preference among the farmers and was most easily available in that region.

Field Layout

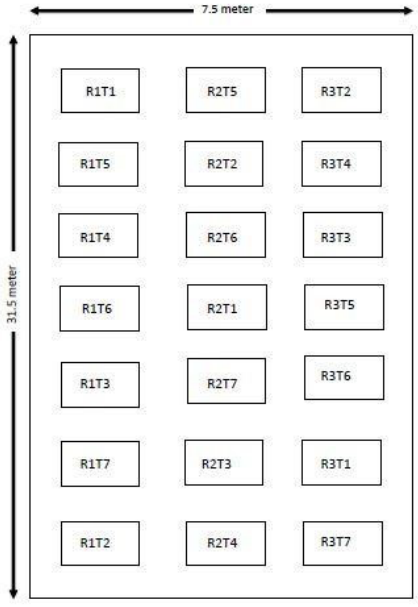

Figure 2: whole field layout

Cultural Practices

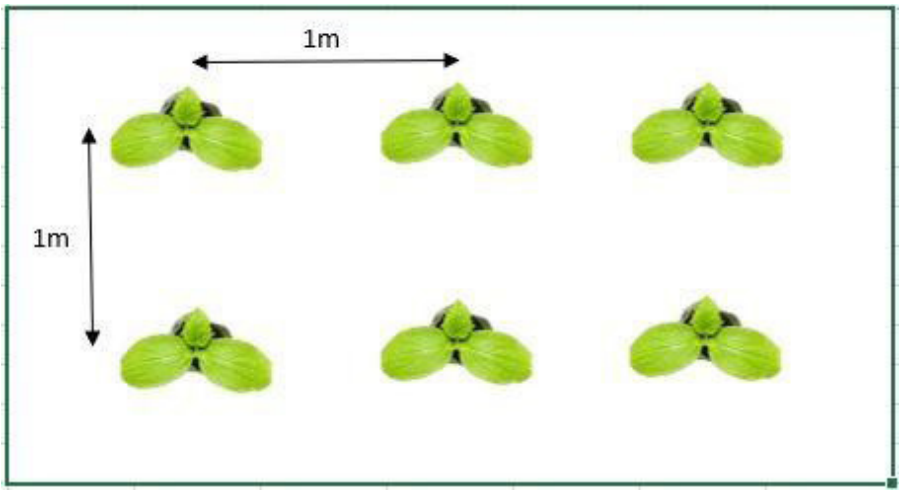

Figure 3: layout of each plot

Nursery Preparation

The media used for sowing seeds was prepared by mixing soil (forest soil+ field soil), sand and FYM in the ratio 2:1:1. Two seeds were sown per polybag of size 15*8 cm on 24th Magh. The polybags were then placed inside protected conditions made up of plastics. Regular watering was done at evening observing moisture level. The plastics were kept open during the day. Seeding establishment is important for crop development which can be hindered due to poor germination (Bastakoti and Poudel, 2022).

Transplanting of Seedlings

Seedling became ready for transplanting at 25 DAS. At first, seedlings were transported to the main field from protected house. They were irrigated before plantation. Seedlings were transplanted with spacing of 1m*1m. There were six plants per plot. Pits were dug for each plant and filled with FYM about 10 days earlier to transplanting. Transplantation was done on 19th Falgun,2079. Exchanging of wilted seedling with uniform, healthy seedling was done up to 7 days of initial transplanting.

Fertilizer Application

Fertilizers were applied at the rate of 100:80:80 kg NPK per ha in pit soil. FYM was filled in pit 10 days before transplanting. The amount of fertilizer required per plant is calculated by using the formula;

Amount of fertilizer per plant= Rate of NPK per ha (in kg)/ Total number of plants accommodated in 1ha at a spacing of 1m*1m.

Irrigation

Irrigation was done soon after transplanting. The seedlings were irrigated in the morning so that fungal diseases could be avoided. Irrigation was provided daily till the establishment of seedlings. Moisture level was observed manually before irrigation.

Intercultural Operations

Weeding and hoeing were done regularly to prevent weed growth. Weeds were scouted manually through visual inspection in this study. However, this process can be automated using advanced computer vision techniques leveraging Artificial Intelligence (AI) (Shrestha *et al.,* 2024). Earthing up was done along with split dose of urea application. Staking was done after 3 weeks of transplantation.

Harvesting And Data Collection

Harvesting was done after the fruits attain horticultural maturity and data were taken on same day of harvesting of fruits.

Observations

During the study period, various observations such as morphological, floral, and yield parameters were done as shown in the table below:

Five plants were randomly selected and tagged properly to measure following observations:

Table 2: List of Parameters

Vegetative parameters	Reproductive parameters
Plant height, Branch number per plant	Number of pistillate flowers, Number of staminate flowers, Sex ratio, Days of first flowering, Days to 50% flowering, Fruit length and diameter, Number of fruits, fruit yield per hectare.

Vegetative Parameters

a. Plant height= Length of plant measured from ground level (the point of emergence of the plant) to the

top of vine by using measuring tape and average length was calculated.

b. Branch number per plant= The total number of branches arising from main stem on the tagged plant were counted.

Reproductive Parameters

a. Number of pistillate flowers= The number of female flowers on each tagged plant were counted. (Female flower bears a small swollen structure at the pedicel while male flower do not have it.)

b. Number of staminate flowers= The number of male flowers on each sample plant were counted.

c. Sex ratio= The ratio of male to female flowers were calculated and noted.

d. Days of first flowering= count the days when first flowers bloom after transplanting.

e. Days to 50% flowering = The total number of days taken for 50% of the plants to bear flowers in each treatment plot from the date of transplanting were counted and the average were calculated.

f. Number of fruits= The number of fruit per plant were recorded as the average of the cumulative number of fruit in all pickings of selected plants at a marketable stage.

g. Fruit length and diameter= measure the length and diameter of single fruit individually at least for 5 fruits and average them

h. Fruit yield (tons/ha)= Calculated by multiplying the fruit yield per vine by total number of plants per hectare

Statistical Analysis

All the collected data were entered in MS Excel 2019 at first. Microsoft Word 2019 was used for word processing and all tables were created thereby. RStudio 4.2 was used for statistical analysis. Analysis of Variance was done to test the significance of difference of each parameter at 95% level of confidence. The mean of each treatment was calculated using Duncan's test and the difference between treatments was found by comparing each mean with the LSD value.

RESULTS AND DISCUSSION

Vegetative Parameters

Plant Height

Table 3: Effect of MH and Ethrel on plant height of Cucumber

Treatment	PH-14	PH-21	PH-28
Control	38.473[a]	66.367[a]	81.987[a]
50 ppm MH	36.873[a]	61.013[a]	80.667[a]
100 ppm MH	38.253[a]	62.607[a]	76.600[a]
150 ppm MH	35.280[a]	55.647[a]	64.567[a]
100 ppm Ethrel	22.567[b]	24.533[b]	26.267[b]
200 ppm Ethrel	22.313[b]	23.593[b]	25.722[b]
300 ppm Ethrel	16.140c	18.120[b]	20.723[b]
F-test	***	***	***
LSD	4.639729	11.83933	16.30086
CV	8.69	14.937	17.035
SEm	0.9324	1.4894	1.7476
Mean	29.98571	44.55429	53.79024

The foliar applications of both growth regulators i.e. maleic hydrazide and Ethrel, resulted in decreased vine length at all rates. When no growth regulators were applied to the vines, they reached their maximum length. A maximum of 81.986cm height was obtained at 28 days after transplanting when no growth regulators are applied. It was in accordance with previous findings (Mansurogle *et al.,* 2009; Caprita & Caprita, 2005) that plant growth inhibitors slowed metabolic activity and consolidated vegetative development. MH inhibit vegetative growth significantly (Sarkar *et al.,* 2014; Hoffman & Parups, 1964; Brian & Hemming, 1957). Maleic hydrazide's influence on cell division (Graulach and Atchinson, 1953) and plant polar auxin transport (Arora *et al.,* 1982) could explain the inhibition of apical growth. Arora *et al.* (1994) found similar results in longmelon, and Murthy *et al.* (2007) found similar results in gherkin. Miller *et al.* (1969) linked the increased number of branches in eggplant and pepper to forced lateral bud development and terminal bud injury caused by growth regulators, which supported the current findings.

Tendril

For tendril numbers, the control seemed to have

Table 4: Effect of MH and Ethrel on tendril number

Treatment	28-Tendril	35-Tendril	42-Tendril
Control	16.800[a]	25.267[a]	39.200[a]
50 ppm MH	16.533[a]	24.933[a]	35.400[a]

100 ppm MH	16.133^{ab}	23.267^{ab}	35.433^{a}
150 ppm MH	14.133^{ab}	22.600^{ab}	32.733^{a}
100 ppm Ethrel	10.200^{b}	13.100^{c}	18.233^{b}
200 ppm Ethrel	12.500^{ab}	16.867^{bc}	22.467^{b}
300 ppm Ethrel	10.700^{ab}	12.800^{c}	18.000^{b}
F-test	NS	**	***
LSD	6.177488	7.443763	8.130213
CV	25.06	21.09	15.88
SEm	1.0759	1.1809	1.2342
Mean	13.85714	19.83333	28.78095

maximum tendril production in comparison to other treatments which were 16.80, 25.26 & 39.20 at 28, 35 & 42 DAT respectively. The maximum number of tendrils may be due to the high plant height in control.

Branch

The number of branches per plant was significantly influenced at 21, 28, and 42 DAT ($p<0.05$). Among all the treatments, maleic hydrazide application at 100 ppm

Table 5: Effect of MH and Ethrel on number of branch

Treatment	21-Branch	28-Branch	42-Branch
Control	2.550^{a}	2.800^{ab}	3.867^{ab}
50 ppm MH	2.317^{ab}	2.733^{ab}	3.933^{ab}
100 ppm MH	2.627^{a}	3.100^{a}	4.800^{a}
150 ppm MH	1.933^{bc}	2.667^{ab}	3.633^{b}
100 ppm Ethrel	1.267^{d}	1.800c	2.533^{c}
200 ppm Ethrel	1.667^{bc}	2.300^{bc}	2.933^{bc}
300 ppm Ethrel	1.367^{bc}	1.867^{c}	2.600^{c}
F-test	**	**	**
LSD	0.6114408	0.5299191	0.9368051
CV	17.527	12.076	15.169
SEm	0.3385	0.3151	0.4189
Mean	1.960952	2.466667	3.471429

produced the most branches. At 21DAT, the highest number of the branch was found in MH-100 (2.62) which was statistically at par with control (2.55) and MH-50 (2.31). At 28-DAT, the maximum number of branches was found in MH-100 (3.10) which was at par with control (2.80), MH-50 (2.73) and MH-150 (2.66). At 42-DAT, the maximum number of branches was found in MH-100 (4.80) which was at par with MH-50 (3.93), control (3.86), and MH-150 (3.63). Maleic hydrazide and auxin derivative hormones were both efficient in shortening the main stem and increasing the number of primary branches. These results supported the findings of many other researchers who have documented profuse branching in bottle gourd with foliar applications of maleic hydrazide and ethephon at 200 ppm (Robinson *et al.*, 1969; Arora *et al.,* 1982).

Reproductive Parameters

First Female Flower, First Male Flower and 50% Male Flower

It was clear from above that the application of plant

Table 6: Effect of MH and Ethrel on flower appearance

Treatment	1st male flower	1st female flower	50%male flower	50% female produced
Control	25.000^{c}	26.333^{bcd}	27.333^{d}	28.333^{bc}
50 ppm MH	26.333^{b}	25.000^{d}	28.000^{cd}	27.000^{c}
100 ppm MH	26.333^{b}	26.000^{cd}	28.333^{bcd}	27.667^{c}
150 ppm MH	28.000^{a}	27.333^{abc}	29.000^{abc}	29.333^{abc}
100 ppm Ethrel	27.333^{ab}	27.666^{ab}	29.333^{ab}	30.333^{ab}
200 ppm Ethrel	27.333^{ab}	27.333^{abc}	29.666^{a}	31.000^{a}
300 ppm Ethrel	28.000^{a}	28.000^{a}	30.000^{a}	31.000^{a}

F-test	**	*	**	**
LSD	1.165	1.504	1.165	2.196
CV	2.433	3.152	2.272	4.222
SEm	0.3779	0.4879	0.3779	0.7127
Mean	26.905	26.809	28.809	29.238

growth regulators has a significant role in promoting earliness in flowering in cucumber. 50-ppm MH recorded the first female flower i.e. at 25.000 days after transplanting. Similarly, control recorded the first male flower appearance i.e. at 25.00 DAT which was significantly different than the rest of the treatments. Likewise, 50% male flower appeared first in control (at 27.333 DAT) and 50% female flower appeared first in MH-100 (at 27.667 DAT). The results obtained were similar to the findings of Thappa *et al.,* (2011) which documented that the least number of days to 50% flowering(63.67d) was recorded in 100ppm maleic hydrazide among all treatments which was different to that obtained at control (69.67d). The current study backs up the findings of Singh and Choudhary., (1988), who discovered early emergence of female flowers in cucumber with foliar applications of maleic hydrazide at 50 and 100 ppm.

Number of Male Flowers

The number of male flowers was significantly influenced by different doses of Maleic hydrazide and Ethrel as shown in the above table. The number of male flowers was counted thrice in 28DAT, 35DAT and 42DAT. At 28-DAT highest male flower was counted in Control (7.93) which was statistically at par with MH-50 (6.13). At 35-DAT (17.0) and 42-DAT (34.2) highest was observed in control. Growth regulators have a huge impact on sex expression and flowering in diverse cucurbits, resulting in the suppression of male flowers or an increase in the quantity of female flowers ,with no negative impacts on the environment or human health (AlMasoum & Al-Masri,1999).

Table 7: Effect of MH and Ethrel on number of male flowers

Treatment	**Male-28**	**Male-35**	**Male-42**
Control	7.93a	17.0a	34.2a
50 ppm MH	6.13ab	8.2b	14.8b
100 ppm MH	**3.10c**	**3.4c**	**6.8c**
150 ppm MH	3.80bc	4.0c	2.2c
100 ppm Ethrel	3.80bc	4.9c	3.0c
200 ppm Ethrel	4.20bc	4.4c	3.2c
300 ppm Ethrel	3.60bc	4.0c	3.0c
F-test	*	***	***
LSD	2.7216	2.8569	5.352
CV	32.89	24.491	31.336
SEm	0.8832	0.9272	1.736
Mean	4.651	6.557	9.6

Number of Female Flowers

The number of female flowers was significantly influenced by different doses of Maleic hydrazide and Ethrel as

Table 8: Effect of MH and Ethrel on number of female flowers

Treatment	**Female-28**	**Female-35**	**Female-42**
Control	4.05^{ab}	4.6^{c}	5.0^{b}
50 ppm MH	5.83^{a}	9.4^{ab}	9.2^{a}
100 ppm MH	5.00^{ab}	10.6^{a}	10.2^{a}
150 ppm MH	4.00^{ab}	6.4^{bc}	8.8^{a}
100 ppm Ethrel	3.10^{b}	3.8^{c}	4.6^{b}
200 ppm Ethrel	4.00^{ab}	4.2^{c}	5.8^{b}
300 ppm Ethrel	3.10^{b}	3.1^{c}	5.1^{b}
F-test	NS	**	**
LSD	1.995805	3.943992	2.621

CV	27.005	36.86	21.18
SEm	0.6477	1.2799	0.8508
Mean	4.154	6.014	6.957

shown in the above table. Number of female flowers were also counted three times at 28-DAT, 35-DAT and 42-DAT. Number of female flowers observed at 28-DAT was found non-significant. Highest number of female flowers was observed in MH-100 (10.6) followed by MH-50 (9.4) statistically par with each other at 35-DAT. Similarly, at 42 DAT, highest number of female flowers were counted in 100ppm MH (10.2) in comparison with Control (5.0). These findings supported the findings of Hidayatullah *et al.,* (2009), who found that pistillate flowers of cucumber increased after MH spraying at 450 M/l concentrations.

Sex Ratio

The sex ratio was significantly influenced by the application of different doses of Maleic hydrazide and Ethrel as shown in table. At 28-DAT, the highest sex ratio was found in control (2.276) and the lowest in MH-100 (0.603). Similarly, at 35-DAT, the maximum sex ratio was found in control (5.166) and the lowest in MH-100 (0.320) which was statistically at par with MH-150 (0.736). Also, at 42-DAT, the maximum sex ratio was found in control (7.366) and the lowest in MH-150 (0.273). All treatments had a significantly lower sex ratio than the control as in the findings of Jitendra Kumar Patel Gandhi Krishi Vishwavidyalaya *et al.,*(2020). These results are in correspondence to the findings of (Moniruzzaman *et al.,* 2019) where lowest sex ratio was found in MH-150 in both the years of research

Table 9: Effect of MH and Ethrel on sex ratio of Cucumber

Treatment	SR-28	SR-35	SR-42
Control	2.276^{a}	5.166^{a}	7.366^{a}
50 ppm MH	1.076^{b}	0.996^{bc}	1.613^{b}
100 ppm MH	0.603^{c}	0.320^{d}	0.703^{c}
150 ppm MH	0.933^{b}	0.736^{cd}	0.273^{d}
100 ppm Ethrel	1.213^{b}	1.430^{b}	0.660^{c}
200 ppm Ethrel	1.070^{b}	1.100^{bc}	0.550^{cd}
300 ppm Ethrel	1.170^{b}	1.386^{b}	0.583^{cd}
F-test	NS	*	***
LSD	0.2942	0.5558	0.33627
CV	13.876	19.638	11.26
SEm	0.0955	0.1804	0.1091
Mean	1.192	1.591	1.678

Length and Diameter

The length and diameter of fruits showed non-significant

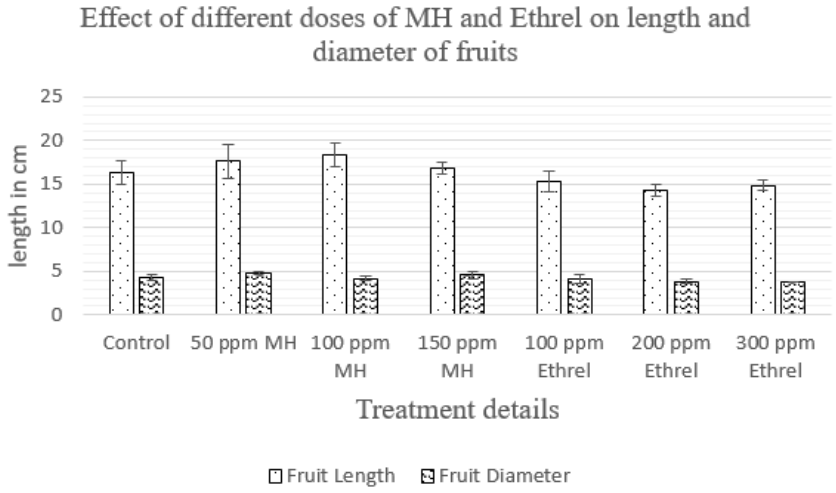

Figure 4: Effect of MH and Ethrel on length and diameter of fruits

differences between various treatments. Among them, 100 ppm MH demonstrated high length (18.367) and 50 ppm MH showed high diameter (4.853) on average. The length and diameter of cucumber fruit of Kamini variety did not differ with application of different plant growth regulators. This may be due to the reason that we harvested only the fully mature fruits which were similar and the days to harvest the fruits were not fixed.

Fruit Yield

The number of fruits per plant was significantly influenced by the use of different doses of plant growth regulators.

Table 10: Effect of MH and Ethrel on sex ratio of Cucumber

Treatment	Number of Fruits / Plants	Ton/Ha
Control	4.000^{d}	6.582^{abc}
50 ppm MH	8.266^{ab}	15.366^{ab}
100 ppm MH	10.133^{a}	18.440^{a}
150 ppm MH	4.800^{bc}	9.160^{abc}
100 ppm Ethrel	2.933^{c}	5.092^{bc}
200 ppm Ethrel	4.533^{bc}	6.026^{abc}
300 ppm Ethrel	2.400^{c}	3.293^{c}
F-test	*	*
LSD	0.401	0.498
CV	4.260	3.063
SEm	0.1302	0.1616
Mean	5.295	9.137

The average number of fruits per plant was observed highest in 100 ppm of MH (10.133) which is statistically higher than that of control (4.000). Murthy *et al.,* (2007) in gherkin report comparable results with maleic hydrazide. The findings are corroborated by Mollier's (2010) work, which revealed the use of 100 ppm maleic hydrazide in conjunction with ethephon in cucumber.

Similarly, 100 ppm of MH (18.440 t/ha) gave the maximum yield and the lowest was observed in 300 ppm of Ethrel (3.293t/ha). The above data is supported by Verma and Choudhury., (1980) who reported a 12% increase in cucumber fruit set following the use of MH. Ries (1985) proposed that the use of growth regulators such as maleic hydrazide enhanced endogenous ethylene levels, which triggered metabolic processes and changed the C:N ratio in plants, stimulating flowering, fruit set, sex ratio, and hence enhances yield.

CONCLUSIONS

The vegetative and yield components were significantly influenced after the application of MH & Ethrel at two to four leaf stage. The plant growth regulators used were MH at 50, 100 & 150ppm and that of Ethrel at 100, 200 & 300ppm, sprayed alone. Plant height, female flower appearance, sex ratio and yield were found significantly differed at various concentrations of MH and Ethrel. Whereas, length and diameter of fruits were not significantly affected by the use of growth regulators. Hence, the result showed that among different treatments, 100 ppm MH proved best for sex modification and simultaneously increasing the fruit yield in Cucumber.

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