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**Research Article**

# Plant growth regulators: One of the techniques of enhancing growth and yield of Bangladeshi local cucumber variety (*Cucumis sativus*)

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**Abstract**

Cucumber (*Cucumis sativus*) is becoming an essential part of the regular food menu for both health cautiousness and its dietary value over other foods. Availability of high yielding cucumber variety is one of the major obstacles for cucumber production in Bangladesh. Plant growth regulators (PGRs) play a significant role to alter the various type of physiological and morphological characters in cucumber. In this research, Bangladeshi local cucumber variety 'Baromashi' was used to observe the effect of PGRs on growth and yield-related characters. Four different treatments (Control: untreated plant, T1: maleic hydrazide 200 ppm, T2: ethephon 300 ppm and T3: NAA (1-naphthaleneacetic acid) 18 ppm) were used. Application of PGRs showed an increased number of primary and secondary branches however, negative effect on stem length and node for the first flower was also observed. PGRs showed the opposite effect on the time required for the first flowering where male flower needed more time and female flower required less time compared to the untreated plants. In the case of fruit-related characters, PGRs possessed positive effect and ethephon 200 ppm showed the best result among the treatments. Total yield might be directly related to the number of branches as well as with the number of female flowers in local cucumber variety.

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**Keywords:** Cucumber; plant growth regulator; maleic hydrazide; ethephon; NAA; flowering; fruit quality and yield.

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## Introduction

Plant growth regulators (PGRs) are known as short, simple chemicals, naturally produced by plants to alter the different characteristics of plants (1). PGRs are also called as plant hormones but these can also be synthesized artificially for different purposes in life sciences. Plant growth regulators are especially found in plants and also in algae but these having similar functions with higher plants (2,3).

Microorganisms like fungi and bacteria also contain some of the phytohormones however; these are regarded as secondary metabolites because they do not play similar hormonal functions (4). Five major classes of PGRs have been reported. Those are abscisic acid, auxin, cytokinins, ethylene and gibberellins (5).

Plant growth regulators are widely using in the agricultural sector for different purposes from seed germination to final yield. PGRs improved the germination of vegetable seeds, increased total yield, protected the plant from pests and sometimes also used to avoid the loss of yield due to the unfavorable condition (6-10). In addition to these PGRs were extensively used for the quick plant growing purpose through seed soaking (11). PGRs have an excellent effect on the sex expression and flowering in different vegetables including cucurbits (12,13). Foliar application of PGRs changed the sex ratio along with the sequence during the two- or four-leaf stage (14).

Agricultural sector plays a vital role in Bangladesh economy (15). The development of Bangladesh highly depends on the development of agriculture sector contributing 14.74 percent of the national GDP including the vegetables (16). Bangladesh is a developing country and vegetable sub-sector can play a significant role to increase the export earnings and can also supply the nutrients for the native peoples (17,18). Moreover, vegetables require a short duration for the yield and can be grown the whole year. However, total production of vegetables is highly dependent on the high yielding varieties. Nowadays, cucumber is getting more and more attention for its nutritional value for providing low-calorie in the diet (19).

Cucumber (*Cucumis sativus*) is one of the common vegetable crops in Bangladesh growing in warm season. Growth and development of cucumber plants are affected by low temperature. Cucumber is a monoecious plant under the family Cucurbitaceae used in various purposes including fresh and processed food (20). In Bangladesh, the total area under cucumber cultivation is estimated at about 1000 ha and the total production around 54854 metric tons (16). However, total production of cucumber is still very low and cultivation is mostly dependent on the availability of high yielding varieties. Farmers use local cucumber variety due to high price and unavailability of high yielding varieties. Another problem of cucumber production is the high sex ratio between male and female flower. Frequent abortion of fruit also observed in cucumber plant leading to the less cucumber production (21,22).

Different studies suggested that the number of female flower in cucumber can be increased through the application of plant growth regulators in the different levels of plant growth. Exogenous application of growth regulators has been shown to shift the sex expression towards femaleness by increasing the production of the female flowers by suppressing the male flower in cucumber (23). PGRs also showed to have an effect on the initiation of early flowering, increased the number of fruits, fruit weight, and the yield (24,25). Early female flowering and fruit maturation were reported after the application of PGRs in a high yielding variety of cucumber and bitter gourd (26).

Plant growth regulators are also used to control the vegetative growth of cucumber plants, thereby increasing the plant population per unit area with regard to yield (27). However, very few researches were conducted to improve the femaleness and yield of a local variety of cucumber by using plant growth regulators. In this study, we have applied different plant growth regulators in cucumber plants and try to identify the standard PGRs for the good production of 'Baromashi' cucumber local variety of Bangladesh.

## Materials and Methods

### *Experimental site and duration*

The experimental site was Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, and the research was conducted from April 2006 to July 2006. The experimental location was lies in 23074" N latitude and 90035" E longitude with an elevation of 8.2 meters from sea level (28).

### *Plant material and soil*

The authority of Bangladesh Agricultural Development Corporation (BADC), Dhaka, Bangladesh supplied the cucumber local variety 'Baromashi' seed for the experimental purpose. The soil of the experimental site was slightly acidic (pH: 5.4-5.6) belonging to the Modhupur Tract which had medium high land.

### *Experimental design*

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. An area of 12 m x 8 m was divided into 9 equal blocks. The experiment consisted of four treatments (Control: untreated plant, $T_1$: maleic hydrazide 200 ppm, $T_2$: ethephon 300 ppm and $T_3$: NAA 18 ppm). Each block had six pits and each treatment was replicated with three replications.

### *Cultural practices*

The experimental land was plowed on 23 March 2006 with the power tiller and then it was sun dried for 4 days. The recommended dose of fertilizers was applied (29) and mixed thoroughly with the soil and weeds and stubble were removed manually. The pit size was 30 cm in length, 30 cm in width and 20 cm in depth. Irrigation and other necessary cultural practices were done regularly. Plants staking and vine management were done randomly for the proper growth and development of the cucumber plant. Malathion 57 EC and Ripcord were applied as per the manufacturing company's recommendation. Furadan 10 G was applied @ 5 gm/pit during pit preparation.

***Preparation of plant growth regulators (PGRs) solution***

Three different plant growth regulators were used in this experiment. "Crops Care" (NAA 4.5%), "Ripen-15" 42.5% ethephon and maleic hydrazide powder were used to prepare NAA 18 ppm, ethephon 300 ppm and maleic hydrazide 200 ppm solutions respectively. The solutions were prepared through the following procedures:

a. Maleic hydrazide 200 ppm ($T_1$): To make maleic hydrazide 200 ppm solution, 0.2 gm of maleic hydrazide powder was mixed with 2ml $NH_4OH$ solution. Then 2 ml surfactant was added with the solution for increasing the additive value. Then the solution was made up to 1000 ml by adding distilled water and shacked well.

b. Ethephon 300 ppm ($T_2$): For preparing ethephon 300 ppm solution, 0.705 ml "Ripen-15" was added with 2 ml of surfactant and then the solution was made up to 1000 ml by adding distilled water and shaked well.

c. NAA 18 ppm ($T_3$): NAA 18 ppm solution was made by adding 0.40 ml "Crops Care" with 2 ml of surfactant and the solution volume was made up to 1000 ml by adding the distilled water and shaked properly.

***Application of treatments***

Plant growth regulators (PGRs) were applied in three installments. The first spray was done at 2 to 4 true leaves stage of seedlings with the hand sprayer on 26th April 2006. After seven (07) days of the first spray, the 2nd spray was done. And final spray (3rd spray) was done 10 days after the second spray to the leaves and twigs of cucumber plants with a knapsack sprayer.

***Data collection***

Six cucumber plants were randomly selected from each treatment from this research and following data were taken.

***Stem length (cm)***

Stem length was taken with the help of measuring tape in centimetre from the ground level to tip of the main stem from each plant. Data were taken for three times for each treatment and mean value was calculated.

***Number of primary and secondary branches per plant***

Primary and secondary branches were counted at the last harvest from each plant of the treatment and mean value was calculated. Mean value was calculated by the following formula -

Number of primary branches = Total number of primary branches/6.

Number of secondary branches = Total number of secondary branches/6.

***Node number for 1st male and female flower***

Node number of each plant of every treatment was counted with the first appearance of the male and female flower. This data was taken three times and the mean value was calculated.

***Days required to 1st male and female flower***

The number of days required for first flower initiation from the sowing date for both male and female flower was recorded for every plant and average was calculated.

***Days taken to 50% flowering per plot***

Fifty percent flowering of both male and female flower recorded manually from sowing date. Data were recorded with three replications and then the observations were calculated.

***Total number of male and female flowers per plant***

The total number of the male and female flower of each plant was counted from first flower appearance and it was taken at three days intervals. The total number of male and female flowers was recorded from each treatment.

***Number of fruits per plant***

The total number of fruit of six plants was counted from the first harvest to the last harvest. After that the number of fruits of each plant was recorded by the following formula-

Total number of fruits/plant= Total number of fruits from six plants of each treatment/6.

***Fruit length and girth***

Fruit length and girth were taken with the help of measuring tape in centimeter. Girth i.e. breath of fruit was measured at the middle portion of fruits from each plot and their average was taken. The average length of the same fruits was also taken.

***Yield of fruits***

All matured fruits from every harvest of plants of each treatment were considered for the total yield. After that, the average yield of every plot was measured by an electric balance. The yield per hectare was calculated considering the area covered by the six plants.

***Statistical analysis***

MSTAT software was used to analyze the collected data for finding the significant variation of different parameters. *F* test (variance ratio) was performed to identify the variance of each data. The differences between the treatment means were evaluated by the LSD test at 1% or 5% probability.

**Results and Discussion**

Effect of plant growth regulators was evaluated on the vegetative growth, flowering and yield contributing characters of cucumber (*Cucumis sativus*). Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh was selected for the present study. Experimental period was April 2006 to July 2006.

***Effect of plant growth regulators on vegetative growth of cucumber***

Applied plant growth regulators showed a reduced pattern in stem length compare to the control treatment (Table 1). Among the plant growth regulators NAA 18 ppm ($T_3$) showed the highest stem length after the control in both 30 days after sowing (DAS) and 40 days after sowing (DAS), respectively. In addition to this maleic hydrazide ($T_1$) showed the highest stem length after control at 50 DAS. These results indicated that PGRs might not involve in increasing plants height. However, all PGRs increased the number of primary and secondary branches and ethephon ($T_2$) showed the highest effect (Table 1). This result pointed out that ethephon is important in branching rather than stem elongation. Most of the PGRs except $T_2$ showed the negative effect on the node for 1st male flower compare to the control. NAA had no effect on the node for male flower initiation. From the above result, it can be concluded that PGRs positively associated with the initiation of primary and secondary branches rather than flower initiation factors.

Foliar application of plant growth regulators might affect in various ways on plant growth as well as plant physiology. From the research, plant growth regulators showed the negative effect on the length of the stem and node for first female flower compare to the untreated plant. It might be due to applied PGRs may not involve in stem elongation and formation of the node for flower initiation in cucumber plant. It was reported that application of ethephon 250 ppm suppressed the internode elongation which resulted in stunted growth of cucumber (30). In addition, gibberellic acid like $GA_3$ plays an important role in stem elongation of the plant (13,31). However, primary and secondary branches were significantly increased in all treatments. Ethephon 300 ppm showed the highest value compare to other PGRs in branching characteristics. Generally, functions of PGRs differ with the variation of temperature and work effectively during low temperature (32). In Bangladesh, April to July is the hot period and the high temperature might affect the proper function of applied PGRs in case of stem length as well as the node for the male and female flower.

***Effect of PGRs on flowering characteristics of cucumber***

Plant growth regulators alter the sex expression and also the duration of flower initiation leading to yield and fruit quality. It has been found that PGRs showed the opposite relationship for first male and female flower initiation. Days requirement of male flower increased whereas

**Table 1.** Effect of plant growth regulators on vegetative growth and node for 1st male and female flower of cucumber plant

| Treatments | Stem length (cm) | | | No. of branches/ plant | | Node for 1st flower | |
|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | Primary | Secondary | Male | Female |
| **Control** | 92.4 a | 155.2 a | 193.2 a | 10.7 c | 20.7 c | 9.7 b | 11.9 a |
| **$T_1$** | 85.4 bc | 147.1 bc | 178.1 b | 11.2 bc | 21.8 bc | 6.3 c | 6.1 c |
| **$T_2$** | 82.5 c | 144.4 c | 167.5 c | 12.4 a | 24.3 a | 11.3 a | 5.4 d |
| **$T_3$** | 88.6 ab | 151.3 ab | 176.6 b | 11.6 ab | 23.3 ab | 9.04 b | 7.2 b |

(DAS: Days after sowing; in a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability 5% level of probability).
Control: Untreated plants, $T_1$: Maleic hydrazide 200 ppm, $T_2$: Ethephon 300 ppm , $T_3$: NAA (1-napthaleneacetic acid) 18 ppm)

**Table 2.** Effect of plant growth regulators on flowering characteristics of cucumber with different treatments

| Treatments | Days required for 1st flowering | | Days required for 50% flowering | | Total number of flower | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| **Control** | 31.1 c | 35.9 a | 46.6 c | 50.1 a | 134.9 a | 14.9 d |
| **$T_1$** | 32.3 bc | 32.4 b | 47.8 bc | 46.6 b | 93.0 c | 19.5 c |
| **$T_2$** | 34.8 a | 29.7 c | 50.4 a | 43.9 c | 62.9 d | 22.9 a |
| **$T_3$** | 33.3 ab | 31.0 bc | 48.9 ab | 45.24bc | 105.1 b | 21.0 b |

(In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability 5% level of probability).
Control: Untreated plants, $T_1$: Maleic hydrazide 200 ppm, $T_2$: Ethephon 300 ppm, $T_3$: NAA (1-napthaleneacetic acid) 18 ppm)

**Table 3.** Effect of PGRs on cucumber fruit harvesting, fruit setting and fruit quality

| Treatments | Days required for harvesting green fruit | Total number of fruits/ plants | Fruit setting (50%) | Average length of individual fruit (cm) | Average girth of each fruit (cm) | Individual fruit weight (g) |
|---|---|---|---|---|---|---|
| **Control** | 11.6 a | 9.6 d | 53.1 c | 14.3 c | 11.8 c | 173.1 c |
| **$T_1$** | 9.3 b | 13.0 c | 66.5 b | 16.6 b | 12.5 bc | 185.2 c |
| **$T_2$** | 7.9 c | 17.1 a | 74.8 a | 19.3 a | 14.3 a | 239.8 a |
| **$T_3$** | 9.6 b | 14.4 b | 68.3 b | 17.6 b | 13.5 ab | 215.0 b |

(In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability 5% level of probability).
Control: Untreated plants, $T_1$: Maleic hydrazide 200 ppm, $T_2$: Ethephon 300 ppm, $T_3$: NAA (1-napthaleneacetic acid) 18 ppm)

female flower needed fewer days for the first flower initiation compares to the untreated cucumber plant (Table 2). Application of ethephon 300 ppm showed less time requirement for female flower initiation. Similar results were also found for the time required for 50% flowering for both male and female. However, the total number of the male flower was decreased compared to untreated plants. On the other hand, PGRs increased the total number of female flowers compare to control plants and again ethephon 300 ppm showed the best result. These results clearly indicated that PGRs have a positive effect on the sex alteration ratio in cucumber plants rather than the flowering in Bangladesh environment.

Many of the plant growth regulators are well known for altering sex ratio in different crops. PGRs showed a positive effect on the flowering characteristics of cucumber female flowers. In case of time requirement for flowering, PGRs increased the male flower initiation time and also 50% flowering whereas oppositely decreased the time for female flowering for both cases. Similarly, numbers of male flower in this research were decreased and the oppositely the total number of the female flower was increased. This result showed that the sex ratio of this PGRs applied plant was altered. Among the PGRs ethephon 300 ppm showed the best result. It has been reported that alteration of sex ratio might be resulted from either by the environmental factors or by the application of PGRs (33,34). Studies showed that foliar application of NAA 100 ppm, maleic hydrazide (MH) 50 ppm and seedling treated with ethephon 120 ppm suppress the male flower and increase the female flower in cucumber (35,36).

In addition to this ethephon 100g/L also increased the number of pistillate flowers and hastened the appearance of the female flower in the sponge gourd (37).

### *Effect of PGRs yield-related characters and total yield*

The number of female flowers and subsequently individual fruit weight has a significant impact on the total yield of cucumber. It was found that exogenous application of PGRs decreased the total time required for harvesting green fruit (Table 3). Although all PGRs had a positive effect on green fruit harvesting and also the total number of fruits in each plant but ethephon 300 ppm showed the best effect in both cases. Similarly, 50% fruit setting also enhanced by the application of selected plant growth regulators. Average fruit length and fruit girth of each fruit were increased by the plant growth regulators which reflect the individual fruit weight of cucumber (Table 3). From the above results, it can be concluded that exogenous application of PGRs has a positive effect on cucumber fruit quality. This fruit quality affected the total yield compared to the untreated cucumber plants. The yield of cucumber in kg/ plot and ton/ ha were significantly increased in PGRs treated plants. In all yield-related characters and in total yield ethephon 300 ppm showed the best results among the other two treatments (Figure 1).

The yield had a direct relationship with the number of female flowers and also with the rate of fruit abortion. Individual fruit features can be improved through the application of plant growth regulators. Several studies pointed that application of 1-naphthaleneacetic acid (NAA) had not much significant effect on fruit weight, however; foliar application of maleic hydrazide (MH) had increased the fruit weight compare to the untreated cucumber plants (38,39). Cell division, cell elongation and cell differentiation are regulated by auxins (40). Fruit size is highly dependent on cell enlargement and this process is controlled by the hormones like auxins (32). Application of maleic hydrazide 200 ppm, ethephon 300 ppm, and NAA 18 ppm might alter the auxin levels in cucumber plants which enhanced the cucumber fruit size. Similar result also found from a research where of maleic hydrazide 100 ppm, ethephon 100 ppm, and NAA 100 ppm increased the total yield of cucumber plants compare to the untreated plants (41). Individual improved fruit-related characters finally increase the total yield. However, ethephon showed the best fruit-related characters among the three selected PGRs in this experiment.

## Conclusion

Cucumber (*Cucumis sativus*) is getting more and more attention not only for its nutritional quality

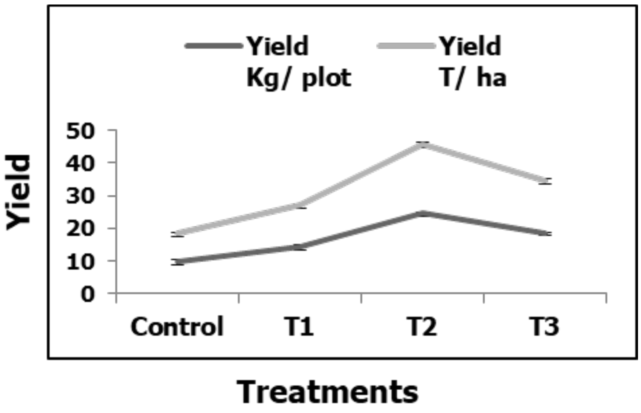


**Fig. 1.** Effect of PGRs on cucumber fruit yield

Control: Untreated plants, $T_1$: Maleic hydrazide 200 ppm, $T_2$: Ethephon 300 ppm, $T_3$: NAA (1-napthaleneacetic acid) 18 ppm)

but also for the short duration of cultivation. In Bangladesh, cucumber is used as salad, pickle and in cocking. However, production of cucumber varies depending on the high yielding variety (HYV) having more female flowers and the availability of HYV is a major problem in Bangladesh. Plant growth regulators can apply for the high production of cucumber. Our experiment found the negative effect of PGRs on stem length and node for the 1st flower but significantly increased the primary and secondary branches. Interestingly, days required for male flower increased but decreased for female flower after PGRs application. In addition, the total number of male flower found less but the female flower was more. However, PGRs also showed a positive effect on fruit quality and total yield of cucumber and ethephon 300 ppm showed the best results in respect of fruit quality and total yield. Foliar application of PGRs with pruning might maximize the cucumber yield in local variety 'Baromashi' by reducing the harvesting time in Bangladeshi environment.

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## Authors' contributions

AAM and MNI conceived and designed the experiment; AAM performed the experiment; AAM, MAS, and MRA analyze the data; AAM and MAS wrote the paper; MNI and MRA supervised the experiment.

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## Conflicts of Interest

The authors have no conflict of interests.

## References

1. Srivastava LM. Plant growth and development: hormones and environment. Academic Press, Oxford. 2002; (pp. 140). https://doi.org/10.1093/aob/mcg209
2. Went FW, Thimann KV. Phytohormones. New York. The Macmillan Company, 1937.
3. Tarakhovskaya ER, Maslov Y, Shishova MF. Phytohormones in algae. Russian *Journal of Plant Physiology* 2007;54:163-170. https://doi.org/10.1134/S1021443707020021
4. Rademacher W. Gibberellin formation in microorganisms. *Plant Growth Regulation* 1994; 15:303-314.
5. Thomas EW, Thomas LR. Botany: a brief introduction to plant biology. Wiley, New York, 1979;155-170. https://doi.org/10.1007/BF00029903
6. Halter L, Habegger R, Schitzler WH. Gibberellic acid on artichokes (*Cynara scolymus* L.) cultivated in Germany to promote earliness and to increase productivity. *Acta Horticulture* 2005;681:75-82. https://doi.org/10.17660/ActaHortic.2005.681.5
7. Kadiri M, Mukhtar F, Agboola DA. Responses of some Nigerian vegetables to plant growth regulator treatments. *Revista de biologia tropical* 1997;44:23-28.
8. Mukhtar FB. Effect of some plant growth regulators on the growth and nutritional value of *Hibiscus sabdariffa* L. (red sorrel). *International Journal of Pure and Applied Science* 2008;2:70-75.
9. Saglam N, Gebologlu N, Yilmaz E, Brohi A. The effects of different plant growth regulators and foliar fertilizers on yield and quality of crisp lettuce, spinach, and pole bean. *Acta Horticulture* 2002;579:619-623. https://doi.org/10.17660/ActaHortic.2002.579.109
10. Turan MA, Taban N, Taban S. Effect of calcium on the alleviation of boron toxicity and localization of boron and calcium in the cell wall of wheat. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 2009;37:99-103. https://dx.doi.org/10.15835/nbha3723241
11. Jankauskiene J, Surviliene E. Influence of growth on seed germination and biometrical parameters of vegetables. Science works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture 2009;29:69-77.
12. Al-Masoum AA, Al-Masri AA. Effect of ethephon on flowering and yield of monoecious cucumber. Egyptian Journal of Horticulture 1999;26:229-236.
13. Kadi AS, Asati KP, Barche S, Tulasigeri RG. Effect of different plant growth regulators on growth, yield and quality parameters in cucumber (*Cucumis sativus* L.) under polyhouse condition. International Journal of Current Microbiology and Applied Sciences 2018;7(4):3339-3352.
14. Hossain D, karin MA, Pramani MHR, Rahman AAS. Effect of gibberellic acid ($GA_3$) on flowering and fruit development of bitter gourd. International Journal of Botany 2006;2:329-332. https://doi.org/10.3923/ijb.2006.329.332
15. Lutfa AF, Happy A, Yasmin F, Hera HR. Production and marketing of cucumber in some selected areas of

Mymensingh district. Agricultural Research & Technology 2018;15:555969. https://doi.org/10.19080/ARTOAJ.2018.15.555969

16. BBS (Bangladesh Bureau of Statistics). Statistical year book Bangladesh. Bureau of Statistics Division, Ministry of Planning, Government Republic of Bangladesh, Dhaka, 2014.

17. Akter S, Islam MS, Rahman MS. An economic analysis of winter vegetables production in some selected areas of Narsingdi district. Journal of Bangladesh Agricultural University 2011;9:241-246. https://doi.org/10.3329/jbau.v9i2.11036

18. Thakur O, Kumar V, Singh J. A review on advances in pruning to vegetables tools. International Journal of Current Microbiology and Applied Science 2018;7:3556-3565. https://doi.org/10.20546/ijcmas.2018.702.422

19. Khan Z, Shah AH, Gul R, Majid A, Khan U, Ahmad H. Morpho-agronomic characterization of cucumber germplasm for yield and yield associated traits. International Journal of Agronomy and Agricultural Research 2015;6:1-6.

20. Jarrick J. Training and pruning. Horticultural Science;400.

21. Marcelis LFM. Sink strength as a determinant of dry matter partitioning in the whole plant. Journal of Experimental Botany 1996;47:1281-1291. https://doi.org/10.1093/jxb/47.Special_Issue.1281

22. Schapendonk AHCM, Brouwer P. Fruit growth of cucumber in relation to assimilate supply and sink activity. Scientia Hortiulturiae 1984;23:21–33. https://doi.org/10.1016/0304-4238(84)90041-4

23. Arora SK, Pandita ML, Pandita PS, Batra BR. Response of long melon (*Cucumis melo* var. *utilissimus*) to foliar application of plant growth substances. Indian Journal of Agricultural Science 1994;64:841-844.

24. Gedam VM, Patil RB, Surawanshi YB, Mate SN. Effect of plant growth regulators and boron on flowering, fruiting and seed yield of bitter gourd. Seed Research 1998;26:97-100.

25. Gopalkrishman PK, Choudhury B. Effect of plant regulators sprays on modification of sex, fruit set and development in watermelon (*Citrullus lanatus*). Indian Journal of Horticulture 1978;35:235-241.

26. Hossain MB. Effects of "Ripen-15" and "Crops care" on the fruit set and yield in cucumber and bittergourd. M. S. Thesis. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. 2004; (pp. 20-65).

27. Latimer JG. Growth retardants affect landscape performance of Zinnia, Impatiens and Marigold. Horticulture Science 1991;26:557-560.

28. Anonymous. Annual Weather Report, IPSA. Meteorological Station, IPSA, Salna, Gazipur. 1989; (pp. 8-15).

29. Rashid MA. Sabji Biggan, Bangla Accademy, Dhaka, Bangladesh. 1994;234-269.

30. Robinson RW, Decker-Walters DS. Cucurbits crop production science in horticulture. CAB International. Oxford, United Kingdom. 1971; (pp. 61-65).

31. Bhosle AB, Khorbhade SB, Sanap PB, Gorad MJ. Effect of plant hormones on growth and yield of summer tomato (*Lycopersicon esculentum* Mill). Orissa Journal of Horticulture 2002;30:93-65.

32. Tantasawat PA, Sorntip A, Pornbungkerd P. Effects of exogenous application of plant growth regulators on growth, yield and *in vitro* gynogenesis in cucumber. Hort Science 2015;50:374-382. https://doi.org/10.21273/HORTSCI.50.3.374

33. Krishnamoorthy HN. Plant growth substances. Tata McGraw-Hall. New Delhi, India. 1981.

34. Mia MAB, Islam MS, Shamusddin ZH. Altered sex expression by plant growth regulators: An overview in medicinal vegetable bitter gourd (*Momordica charantia* L.). Journal of Medical Plants Research 2014;8:361-367. https://doi.org/10.5897/JMPR10.032

35. Choudhury B, Phayak SC, Patil AV. Effect of plant regulator sprays on sex, fruits set and fruit development in cucumber (*Cucumis sativus* L.). Proceeding Bihar Academy of Agricultural Science 1967;11: 251-257.

36. McMurray AL, Miller CH. The effect of 2-chloroethanephosphonic acid (Ethrel) on the sex expression and the yields of *Cucumis sativus*. Journal of The American Society for Horticultural Science 1969;94:400-402. https://doi.org/10.1126/science.12.3860.1397

37. Sreeramula N. Effect of ethrel on sex expression and endogenous auxin content in sponge gourd (*Luffa cylindrical* Poem). Indian Journal of Horticulture 1987;44:85-87.

38. Jadav RG, Patel TV, Parmar AB, Saiyad MY. Sex modification of cucumber vegetable through PGRs. Journal of Pure and Applied Science 2010;18:13-14.

39. Ullah H, Bano A, Khokhar KM, Mahmood T. Effect of seed soaking treatment with growth regulators on phytohormone level and sex modification in cucumber (*Cucumis sativus* L.). African Journal of Plant Science 2011;5:599-608.

40. Arteca RN. Plant growth substances: principles and application. Chapman and Hill, London, UK. 1996.

41. Thappa M, Kumar S, Rafiq R. Influence of plant growth regulators on morphological, floral and yield traits of cucumber (*Cucumis sativus* L.). Kasetsart Journal-Natural Science 2011;45:177-188.