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Interaction of Plant Growth Regulators on Reversal of Reproductive Character In *Cucumis Sativus* L. Leading to Crop Improvement

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ABSTRACT: *A field experiment was conducted to study the effect of interaction of plant growth regulators onreversal of reproductive character in cucumber.* GA_3 *at 100, 250, 500 and 1000 µg/ml was applied to the seedlings of cucumber. After an interval of 7 days the second compound ethrel sprayed to the seedlings at the concentration of 50, 100, 250, 500 and 1000 µg/ml. The number of female flowers increased in response to* GA_3 *and ethrel application.* GA_3 *at 250 and ethrel at 250 concentrations proved optimal for maximum production of female flower in cucumber. At the respective concentration the number of female flower was 77.86 against 28.4 at control. The same range of* GA_3 *concentration was applied to cucumber seedlings grown in an another plot, after 7 days of interval the second compound CCC was applied and* GA_3 *at 250 µg/ml and CCC at 100 µg/ml was recorded as optimum (75.2) for production of maximum number of female flower. Excessive vegetative growth of cucumber was also reduced by* GA_3 *and ethrel,* GA_3 *and CCC treatment. The experiment established the reversal of reproductive character from male to female which ultimately leads to crop improvement.*

Key words: *CCC, Cucumber, Ethrel,* GA_3.

INTRODUCTION

The change of the meristems from the vegetative to the reproductive stage is one of the most important aspects in a life of a plant. This process, called flowering is controlled by many factors, for example duration of light, a balance of nutrients and plant growth regulators. Normally the plant growth regulators appear to be formed in the leaves. This substance transported through the phloem reaches the apical on lateral branches and causes transformation from vegetative primordial to floral primordial. The external application of plant growth regulators may induce flowering in plants. During the last four decades or more numerous experiments have been done with the application of growth retarding chemicals.These days, many researches from the different parts of the world are concentrating their field of works on higher productivity of agricultural and horticultural crops using growth retardants. There are a lot of reports on extensive works done with conventional retardants like CCC, SADH, AMO 1618, 2, 4-DNC, Phosphon-D etc. The spectacular achievements in sex modification of plants have been reported from several quarters by the application of auxins. Das and Prasad (2003) worked on the effect of plant growth regulators CCC and NAA on the growth and yield of summer mungbean. The results of their study show that application of CCC at 750 ppm or NAA at 20 or 40 ppm can be advantageously employed for increasing the grain yield of summer mungbean. Rahman and Sharma (1999) reported that the effects of foliar application of IAA (100 ppm), GA_3 (50 ppm), TIBA (75 ppm), B (4 ppm) and MO (2.5 ppm), alone or in combination on flower male: female ratio and crop yield were investigated in *C.moschata* grown in India. The work of Meena and Dhaka (2003) suggested that two sprays of GA_3 (100ppm) at 35 and 45 days after transplanting, 47.54 per cent more yield can be obtained over control in Brinjal. These results indicate that auxins and gibberellins can act as determinants directing the differentiation of primordial cells to develop either male or female flowers and are of great economic value for breeding purposes in the production of male sterility or hybrid with normal viable seeds.

It is well known that application of auxins shifts the balance of sex expression from maleness to

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femaleness in some Cucurbitaceous plants. Soon after ethephon became available for experimentation, the compound was observed to shift the sex expression of cucumber to femaleness (Robinson *et al*., 1970). Identical results was also obtained by McMurray and Miller (1969) in green house experiments. The staminate to pistilate flower ratio was approximately 10:1. This works have been substantiated by other workers (Sims and Gledhill 1969 Rudich*et al*. 1969 and Lower *et al*., 1970). Application of ethephon also increases femaleness in the Musk melon cultivar Ananas PMR, application of SADH results in changing the sex ratio in *Cucurbita moschata* (Hopp and Rochestra 1967). Sreemula (1984) worked on *Luffa cylindrica* L. to find out the effect of ethrel on sex expression as well as on endogenous auxin content. He found that application of ethrel caused a shift towards femaleness. Zodenka Girek *et al*., (2013) reported that in *Cucumis melo* L. ethrel increased the number of pistillate flowers per plant, reduced the number of male flowers per plant and thereby affected earlier appearance of the first pistillate flower and delayed the appearance of the first staminate flower.

Cucumber is very popular vegetable in North Eastern region of India. The crop is growing in family gardens and also cultivated on commercial basis. The yield potentiality of these crops is not satisfactory although agroclimatic condition of the region offers a wide scope for extensive cultivation. The most important disadvantage in cucumber cultivation is that all the cultivators of these vegetables are facing with the problems of non-uniform growth, asynchronous flowering production of more male flowers than female and consequently the irregular low fruiting among the individual in a field. The production of more female flowers is directly correlated with the yield of the crop. The present experiment was carried out to study the effect of interaction ofGibberellic acid, 2-chloroethyl phosphonic acid (Ethrel) and Chlorocholine chloride (CCC) on reversal of reproductive characters in *Cucumis sativus* L. which is associated with crop improvement.

MATERIALS AND METHOD

The experiment was conducted at Bongaigaon, Assam, to find out the effect of PGRs on reversal of reproductive character of cucumber. Botanically cucumber is known as *Cucumis sativus* L. belonging to the family Cucurbitaceae. The experimental field is well prepared by mixing organic manure and vermi compost before sowing of seeds. The site received free sunshine. The soil of the field is sandy loam with pH value 5.10.

The healthy seeds of cucumber were collected from Assam Seed Corporation, Guwahati. The experiment was carried out in two experimental plots with six treatments of PGRs including an untreated control. Each treatment was replicated three times. For interaction of PGRs, the growth promoter GA_3 (Gibberellic acid) at100µg/ml, 250µg/ml, 500 µg/ml and 1000 µg/ml were prepared. When the plants were at seedling stage and about 20 days of emergence of the seedlings the concentrations of GA_3 were applied. The growth retardant Ethrel (2-chloroethyl phosphonic acid) was applied at five concentrations namely 50, 100, 250, 500, 1000 µg/ml after 7 days of interval. One kept as control (distl. water treatment). Similarly in another experimental plot seedlings of cucumber were grown and GA_3 at 100µg/ml, 250 µg/ml, 500 µg/ml and 1000 µg/ml were applied and after 7 days the second compound the growth retardant CCC (2-chloroethyl trimethyl ammonium chloride) was also made to seedlings of cucumber at 50, 100, 250, 500 and 1000 µg/ml by foliar spraying of the solutions. The spray was done twice at 30 days after sowing and again after 7 days of first application. The data was recorded on number of male and female flowers at the flowering stage.

RESULTS AND DISCUSSION

The number of male and female flowers was recorded after the application of both the compounds. The number of flowers increased several folds even in the controls. The number of male flowers was recorded as 39.73, 39.96, 28.4 and 26.66 at GA_3 concentrations of 100, 250, 500 and 1000 µg/ml respectively. The number of male flowers in response to ethrel was of the order of 35.73, 44.3, 28.63 and 21.06 at the concentrations of 50, 100, 250 and 1000µg/ml respectively. The combined effect resulted in production of more number of flowers than they produced individually. The optimal

Table 1
Interaction of Ethrel and GA_3 on production of male flowers (Mean of male flowers for 3 consecutive years)

	GA_3 Conc. (µg/ml)					
Ethrel (µg/ml)	*0*	*100*	*250*	*500*	*1000*	*Mean for Ethrel*
0	35.4	39.73	39.96	28.4	26.66	34.03
50	35.73	56.4	55.3	46.53	28.96	44.6
100	44.3	66.43	60.2	55.1	34.06	52.01
250	28.63	46.86	42.16	45.86	34.06	39.5
1000	21.06	26.3	38.4	33.4	33.73	30.6
Mean for GA_3	33.02	47.1	47.2	41.9	31.5	

CD for GA_3 (n = 15) at 5% probability level = 1.62, at 1% probability level = 2.12
CD for ethrel (n = 15) at 5% probability level = 1.62, at 1% probability level = 2.12

Table 2
Analysis of Variance for interaction of ethrel and GA_3 on male flower of *C.sativus* L

Sources of Variance	*Df*	*SS*	*Mean SS*	*Variance ratio (F)*
GA_3	4	3408.6	852.2	167.1**
Ethrel	4	4342.9	1085.7	212.9**
Interaction (Ethrel × GA_3)	4 × 4 =16	2116.7	132.3	25.9**
Error	50	256.6	5.1	
Total	75-1= 74	10124.75		

Significant at 1% probability level.

concentration of GA_3 (100µg/ml) in combination with 50, 100, 250 and 1000 µg/ml of ethrel produced 56.4,66.43, 46.86 and 26.3 number of male flowers respectively against 35.4 number at the control (Table 1). Statistical analysis of the pooled data (Table 2) reveals the effects of both the compounds to be highly significant. The interaction also turned out to be highly significant establishing their additive effect on production of flowers.

The number of female flowers was increased in response to GA_3 and ethrel treatment (Table 3). At the concentrations of 100, 250, 500 and 1000 µg/ml of GA_3 the number of female flowers was recorded as 32.83, 42.63, 35.73 and 32.53 respectively. GA_3 at250 µg/ml was the optimal concentration. Ethrel evoked better response in increasing the number of female flowers. Thus, at the concentrations of 50, 100, 250 (optimum) and 1000 µg/ml ethrel, the number of female flowers was recorded as 38.3, 41.2, 54.1 and 28.73 as against 28.4 at control. The combination of ethrel with GA_3 produced additive effects. Thus 250 µg/ml of ethrel produced 69.96, 77.86, 51.53 and 48.1 numbers of flowers in combination with 100, 250, 500 and 1000 µg/ml GA_3. Only 250 µg/ml of GA_3 helped producing additive effect (Figure 1).

Table 3
Interaction of Ethrel and GA_3 on production of female flowers (Mean of Female flowers for 3 consecutive years)

	GA_3 Conc. (µg/ml)					
Ethrel (µg/ml)	*0*	*100*	*250*	*500*	*1000*	*Mean for Ethrel*
0	28.4	32.83	42.63	35.73	32.53	34.4
50	38.3	63.16	69.2	47.06	44.86	52.5
100	41.2	66.16	70.86	51.5	44.26	54.8
250	54.1	69.96	77.86	51.53	48.1	60.3
1000	28.73	48.73	54.1	41.73	40.86	42.8
Mean for GA_3	38.1	56.2	62.9	45.5	42.1	

CD for GA_3 (n = 15) at 5% probability level = 1.30, at 1% probability level = 1.71

CD for ethrel (n = 15) at 5% probability level = 1.30, at 1% probability level = 1.71

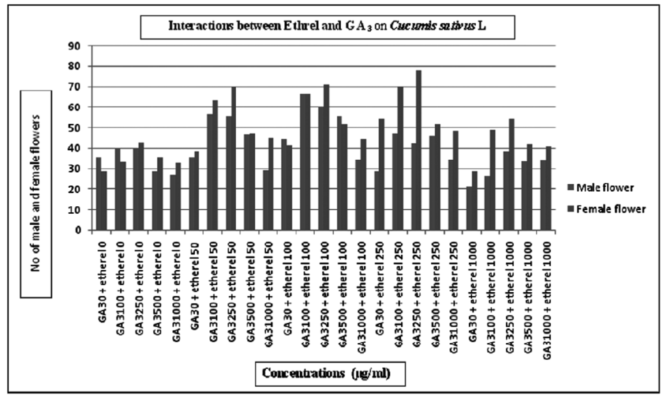

Figure 1: Interactions between Ethrel and GA_3 on *Cucumis sativus* L.

Table 4
Analysis of Variance for interaction of ethrel and GA_3 on female flower of *C.sativus*L

Sources of Variance	*Df*	*SS*	*Mean SS*	*Variance ratio (F)*
GA_3	4	6341.8	1585.5	480.5**
Ethrel	4	6366.5	1591.6	482.3**
Interaction (Ethrel × GA_3)	4 × 4 =16	1216.8	76.05	23.04**
Error	50	167.2 3.3		
Total	75-1 = 74	14092.32		

Significant at 1% probability level.

Table 5
Interactions between ethrel and GA_3 on *Cucumis sativus* L

Sl. No.	*Concentration*	*Male flower*	*Female flower*	*Male : female*
1	GA_3 0 + ethrel 0	35.4	28.4	1.25:1
2	GA_3 100 + ethrel 0	39.73	32.83	1.21:1
3	GA_3 250 + ethrel 0	39.96	42.63	0.94:1
4	GA_3 500 + ethrel 0	28.4	35.73	0.79:1
5	GA_3 1000 + ethrel 0	26.66	32.53	0.82:1
6	GA_3 0 + ethrel 50	35.73	38.3	0.93:1
7	GA_3 100 + ethrel 50	56.4	63.16	0.89:1
8	GA_3 250 + ethrel 50	55.3	69.2	0.80:1
9	GA_3 500 + ethrel 50	46.53	47.06	0.99:1
10	GA_3 1000 + ethrel 50	28.96	44.86	0.65:1
11	GA_3 0 + ethrel 100	44.3	41.2	1.08:1
12	GA_3 100 + ethrel 100	66.43	66.16	1.00:1
13	GA_3 250 + ethrel 100	60.2	70.86	0.85:1
14	GA_3 500 + ethrel 100	55.1	51.5	1.07:1
15	GA_3 1000 + ethrel 100	34.06	44.26	0.77:1
16	GA_3 0 + ethrel 250	28.63	54.1	0.53:1
17	GA_3 100 + ethrel 250	46.86	69.96	0.67:1
18	GA_3 250 + ethrel 250	42.16	77.86	0.54:1
19	GA_3 500 + ethrel 250	45.86	51.53	0.89:1
20	GA_3 1000 + ethrel 250	34.06	48.1	0.71:1
21	GA_3 0 + ethrel 1000	21.06	28.73	0.73:1
22	GA_3 100 + ethrel 1000	26.3	48.73	0.54:1
23	GA_3 250 + ethrel 1000	38.4	54.1	0.71:1
24	GA_3 500 + ethrel 1000	33.4	41.73	0.80:1
25	GA_3 1000 + ethrel 1000	33.73	40.86	0.83:1

The statistical analysis of the pooled data shows the effect of GA_3 and ethrel to be highly significant (Table 4). However, their interaction also emerged as highly significant establishing their positive response in changing the reproductive characters of *C. sativus* L. The male: female ratio (0.54:1) at the respective concentration (ethrel 250µg/ml and GA_3 250 µg/ml) also proves that combined effect of GA_3 and ethrel is more positive (Table 5).

The same range of concentrations of CCC and GA_3 were tried to the seedlings of cucumber. The combined effect of CCC and GA_3 also showed a positive response on cucumber. At the concentrations of 100, 250, 500 and 1000 µg/ml of GA_3 male flowers produced was recorded as 42.4, 42.76, 38.73 and 26.53 respectively. CCC at100 µg/ml was the optimal concentration. The optimal concentration (100 µg/ml) of GA_3 in combination with 50, 100, 250, 1000 µg/ml of CCC produced 44.76, 46.53, 42.86 and 38.66 number of flowers against 33.2 at the control. The combined effect of CCC and GA_3 resulted in producing more flowers on cucumber (Table 6).

Table 6
Interaction of CCC and GA_3 on production of male flowers (Mean of male flowers for 3 consecutive years)

	GA_3 Conc. (µg/ml)					
CCC (*µg/ml*)	*0*	*100*	*250*	*500*	*1000*	*Mean for CCC*
0	33.2	42.4	42.76	38.73	26.53	36.7
50	28.5	44.76	43.3	42.63	27.3	37.3
100	25.96	46.53	42.06	43.63	35.06	38.6
250	24.53	42.86	40.33	35.53	30.73	34.8
1000	20.63	38.66	38.06	30.2	30.43	31.6
Mean for GA_3	26.6	43.0	41.3	38.1	30.0	

CD for GA_3(n = 15) at 5% probability level = 1.57, at 1% probability level = 2.06
CD for CCC (n = 15) at 5% probability level= 1.57, at 1% probability level = 2.06

Statistical analysis of experimental data proves the significant effect of both the compounds. The interaction also emerged as highly significant (Table 7).

Table 7
Analysis of Variance for interaction of CCC and GA_3 on male flower of *C.sativus*L

Sources of Variance	*Df*	*SS*	*Mean SS*	*Variance ratio (F)*
GA_3	4	3103.7	775.9	161.6**
CCC	4	449.4	112.4	23.4**
Interaction (CCC×GA_3)	4 × 4 = 16	471.4	29.5	6.1**
Error	50	238.1	4.8	
Total	75-1 = 74	4262.6		

Significant at 1% probability level.

The number of female flowers was also enhanced by GA_3 and CCC treatments (Table 8). At the

Table 8
Interaction of CCC and GA_3 on production of female flowers (Mean of female flowers for 3 consecutive years)

	GA_3 Conc. (µg/ml)					
CCC (*µg/ml*)	*0*	*100*	*250*	*500*	*1000*	*Mean for CCC*
0	26.76	30.6	41.4	36.93	32.83	33.7
50	51.3	67.53	68.96	52.4	41.43	56.3
100	49.96	70.93	75.2	55.53	47.86	59.9
250	38.96	62.53	64.73	53.4	37.4	51.4
1000	37.73	52.3	62.63	52.63	36.96	48.5
Mean for GA_3	40.9	56.8	62.6	50.2	39.3	

CD for GA_3 (n = 15) at 5% probability level = 1.41, at 1% probability level = 1.86
CD for CCC (n = 15) at 5% probability level = 1.41, at 1% probability level = 1.86

Table 9
Analysis of Variance for interaction of CCC and GA_3 on female flower of *C.sativus*L

Sources of Variance	*Df*	*SS*	*Mean SS*	*Variance ratio (F)*
GA_3	4	6013.1	1503.3	385.5**
CCC	4	6118.1	1529.5	392.2**
Interaction (CCC × GA_3)	4 × 4 = 16	1279.7	79.9	20.5**
Error	50	197.8	3.9	
Total	75-1 = 74	13608.7		

Significant at 1% probability level.

Table 10
Interactions between CCC and GA_3 on *Cucumis sativus* L

Sl. No.	*Concentration*	*Male flower*	*Female flower*	*Male : female*
1	GA_3 0 + CCC 0	33.2	26.76	1.24:1
2	GA_3 100 + CCC 0	42.4	30.6	1.39:1
3	GA_3 250 + CCC 0	42.76	41.4	1.03:1
4	GA_3 500 + CCC 0	38.73	36.93	1.05:1
5	GA_3 1000 + CCC 0	26.53	32.83	0.81:1
6	GA_3 0 + CCC 50	28.5	51.3	0.56:1
7	GA_3 100 + CCC 50	44.76	67.53	0.66:1
8	GA_3 250 + CCC 50	43.3	68.96	0.63:1
9	GA_3 500 + CCC 50	42.63	52.4	0.81:1
10	GA_3 1000 + CCC 50	27.3	41.43	0.66:1
11	GA_3 0 + CCC 100	25.96	49.96	0.52:1
12	GA_3 100 + CCC 100	46.53	70.93	0.66:1
13	GA_3 250 + CCC 100	42.06	75.2	0.56:1
14	GA_3 500 + CCC 100	43.63	55.53	0.79:1
15	GA_3 1000 + CCC 100	35.06	47.86	0.73:1
16	GA_3 0 + CCC 250	24.53	38.96	0.63:1
17	GA_3 100 + CCC 250	42.86	62.53	0.69:1
18	GA_3 250 + CCC 250	40.33	64.73	0.62:1
19	GA_3 500 + CCC 250	35.53	53.4	0.67:1
20	GA_3 1000 + CCC 250	30.73	37.4	0.82:1
21	GA_3 0 + CCC 1000	20.63	37.73	0.55:1
22	GA_3 100 + CCC 1000	38.66	52.3	0.74:1
23	GA_3 250 + CCC 1000	38.06	62.63	0.61:1
24	GA_3 500 + CCC 1000	30.2	52.63	0.57:1
25	GA_3 1000 + CCC 1000	30.43	36.96	0.82:1

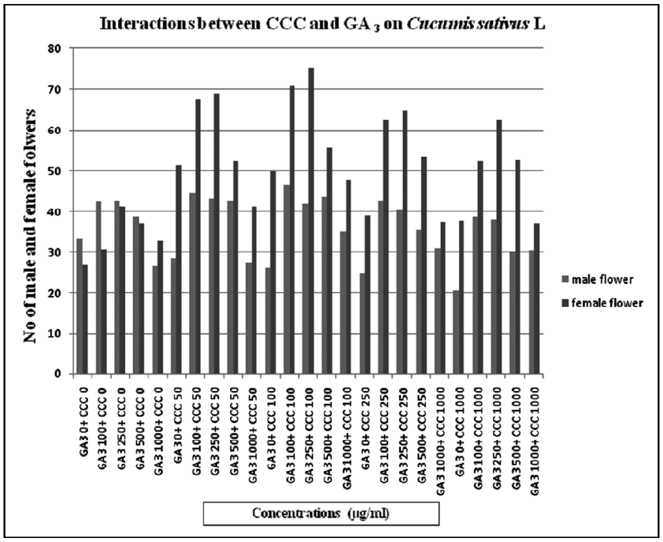

Figure 2: Interactions between CCC and GA_3 on *Cucumis sativus* L.

concentrations of 50,100, 250 and 1000 µg/ml of CCC the female flowers was recorded as 51.3, 49.96, 38.96 and 37.73 respectively. GA_3 250 and CCC 100µg/ml turned out to be optimal concentrations for producing female flowers on cucumber (Figure 2). The optimal concentration of GA_3(250µg/ml) produced increased number of female flowers in combination with CCC concentrations at 50, 100 (optimum), 250 and 1000 µg/ml which recorded as 68.96, 75.2, 64.73 and 62.63 respectively. Statistical analysis (Table 9) reveals that the effects of both the compounds are highly significant. The interaction between them also emerged as highly significant establishing their positive effect in producing more female flowers. The male: female ratio at GA_3 250 and CCC100 µg/ml (optimum) was recorded as 0.56:1 which can be considered as more favourable than other concentrations (Table 10).

The statistical analysis of 3 years' experiments makes it clear that GA_3 imparts a positive response to cucumber. GA_3 when applied alone increases maleness in cucumber. Greater number of male flowers was observed in treated plants than control. On the other hand GA_3 250 µg/ml in combination with ethrel 250 µg/ml produced maximum number of female flowers and thus proved to be advantageous for cucumber. Similarly GA_3 at 250µg/ml in combination with CCC at 100 µg/ml proved additive effect by producing maximum female flowers.

The present investigation confirmed the effect of interaction of Plant Growth Regulators in increasing the femaleness on cucumber over male and control. The higher concentration of GA_3 (1000 µg/ml) was found to be ineffective in inducing flowering in cucumber. But GA_3 in combination with ethrel and CCC expressed a shift towards femaleness. This result is in agreement with Hazarika and Mohan (2002) who reported 61.74 per cent flowering in pineapple cv. Kew with GA_3 (50 ppm). Sex expression in plants are controlled by maintaining the balance between auxins and gibberellins (Jayaram and Neelakandan 2000). The work of Kore *et al.*, (2003) revealed that GA at 5.0 ppm and NAA at 20 ppm were the most effective for induction of female flowers and high sex ratio (14.10-19.05/vine) than control. The application of ethrel at the early stage of plant growth might have helped in promoting the biochemical activities and thereby promoting the ovary primordial causing more number of female flowers resulting in lower sex ratio. GA_3 and ethrel significantly produced greater number of fruits per plant. Similar results were also reported by Choudhury and Singh (1970) in cucumber and Dixit *et al* (2001) in watermelon. The effectiveness of ethrel in inducing flowering in cucumber was reported by Benerji *et al* (2005), Rajagopalan *et al.*, (2004) and Yamasaki *et al.*, (2003). Application of auxin like 1-napthalene acetic acid (NAA) at 50 and 100 ppm and CEPA at 150 ppm proved to be effective in inducing earlier female flowers at lower node. Application of CEPA at 150 ppm and NAA at 50 ppm was found to be the best treatments for reducing sex ratio by increasing the female flowers by suppressing the male ones and consequently induce higher yield (Mia *et al* 2014). The present investigation reveals that the combined effect of ethrel and GA_3, CCC and GA_3 on cucumber is highly significant.

CONCLUSION

The present study revealed that in cucumber flowering was significantly enhanced by all the PGRs applied. The growth promoter GA_3 250 µg/ml (optimum) in combination with 250 µg/ml (optimum)ofgrowth retardant ethrel produced maximum number of female flowers 77.86 against 28.4 at control and thus proved to be more beneficial for cucumber. Similarly, GA_3at 250 µg/ml(optimum) in combination with growth retardant CCC at 100 µg/ml(optimum) established the production of maximum number of female flowers 75.2 against 26.76 at control. The effect of all these PGRs applied at optimum concentration were significant than other treatments, both at 5% and 1% probability level. It has been observed from the present investigation that GA_3 alone is not enough for production of female flowers in cucumber. If GA_3 is applied in combination with other growth retardants like ethrel and CCC, it results in producing more female flowers which is ultimately reflected in increased yield.

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