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Influence of Plant Growth Regulators on Growth and Yield of Bitter Gourd (*Momordica charantia* L.) var. Priyanka

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Abstract

A field experiment was conducted at Vegetable Yard, Department of Horticulture, Annamalai University, Chidambaram during the year 2024 with objects to influence the plant growth regulators on growth and yield of bitter gourd (*Momordica charantia* L.) var. priyanka. The experiment was carried out in randomized block design with three replications and ten treatments viz., three concentration each of NAA (50, 100 and 200 ppm), ethrel (125, 250 and 500 ppm), CCC (100, 200 and 400ppm) with control. Observations recorded on different growth and yield characters showed significant differences among different treatments. With regard to growth characters, application of NAA @ 200 ppm significantly increased the vine length, while CCC @ 400 ppm produced maximum number of branches vine^{-1}. The result of this experiment revealed that the plants sprayed with CCC @ 100 ppm showed the earliest days to first male flowering, whereas ethrel @ 250 ppm showed the earliest days to first female flowering. In case of node number of first male flower, CCC @ 100 ppm recorded least node number of first male flower, while ethrel @ 250 ppm showed least node number of first female flower. Maximum number of male flowers vine^{-1} was observed in the control followed by application of NAA @ 50 ppm, whereas ethrel @ 250 ppm produced maximum number of female flowers vine^{-1} as well as the lowest sex ratio. Fruit length was found to be maximum in plants sprayed with NAA @ 200 ppm. In case of fruit girth, the biggest fruit was observed in CCC @ 400ppm. Application of Ethrel @ 250 ppm was found to record maximum average fruit weight, number of fruits vine^{-1} and yield vine^{-1}. The highest net return and benefit cost ratio as exhibited in ethrel @ 250 ppm. Among the different treatments, ethrel @ 250 ppm was found to be superior to other treatments in increasing yield potential of Bitter gourd.

***Key words*:** *Momordica charantia*, Growth, Yield, Ethrel, CCC, NAA

Bitter gourd (*Momordica charantia L.*), commonly known as balsam pear, karela, or bitter melon, is a tropical and subtropical vine in the Cucurbitaceae family, genus *Momordica*. It is widely cultivated for its edible fruit, which is notable for its distinctively bitter flavor and medicinal properties. This plant thrives in warm climates and is popular in many cuisines across Asia, Africa, and the Caribbean. Besides its culinary uses, bitter gourd is valued for its potential health benefits, including its role in managing blood sugar levels, due to compounds like charantin, vicine, and polypeptide-p, which have shown hypoglycemic effects. The origin of this crop is probably India with a secondary diversity in China and South East Asia. It is a large genus comprising nearly 23 species in Africa alone. In India, the important species like *Momordica charantia*, *Momordica cochinchinesis*, *Momordica balsamina* and *Momordica dioica* are extensively cultivated in summer as well as in rainy season. Bitter gourd is grown extensively throughout India. In India, it is cultivated in an area of 95.00 lakh ha, with 1087 MT/ha production and productivity of 10.87 MT/ha [1]. Bitter gourd is monoecious in nature, and bears staminate and pistillate flowers separately where the proportion of staminate flowers is very high as compared to pistillate flowers. Bitter gourd is found to be the rich source of macro and micronutrients. According to Behera *et al*. [2], the nutritive value of bitter gourd (100g of edible portion) is as follows: Moisture (83.2g), carbohydrates (10.6 g), proteins (2.1 g), fiber (1.7 g), calcium (23 g), phosphorus (38g), potassium (171 g), sodium (2.4 g), iron (2 g),copper (0.19 g), manganese (0.08g), zinc (0.46 g), B carotene (126), vitamin C (96).

The immature fruits are boiled, curried, stuffed or sliced and fried, before consumption. The fruits are also pickled, canned and dehydrated. The leaves and fruits have both been used to make teas and beer or to seasonal soups in western country. Numerous medicinal properties of nearly all part of the plants have been reported. The fruits are used as tonic, purgative, stomachic carminative, anthelminthic, anti-inflammatory, febrifuge, vulnerary, stimulant, thermogenic, anti-diabetic etc. [3]. During the past decade the antidiabetic properties of the crop have been studied extensively and a hypoglycemic principle called "Charantian" has been isolated. The bitter principle in Bitter gourd is due to presence of "momodicine" an alkaloid which is different from "cucurbitacins" present in other genera of cucurbits. Gourdin a product made from the seeds of Bitter gourd, has many beneficial effects such as lowering blood sugar level, acting as preventive (hyperglycemic), reducing cholesterol and

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triglycerides, taking care of diabetic neuropathy, greater healing power and strong immune system and improved insulin receptors [4]. Due to its huge demand, for its medicinal and nutritive values, it should be grown in large area to meet the current requirements and achieving the targeted yield in future years. Growth, development and yield analysis in crop plants helps in understanding the contribution of various growth and yield components. Plant growth regulators considered as a new generation agrichemicals when added in small amounts, modify the growth of plants usually by stimulating or modifying one part of the natural growth regulatory system, thereby enhancing the yield. The growth regulators have therefore, been known to be one of the quick means of increasing production.

Plant growth regulators have profound influence on fruit production in cucurbits. It can modify sex expression, improve fruit set, and ultimately increase the yield in number of cucurbits. A relationship between growth substances and sex expression probably exists in these plants. Sex modification through shift towards femaleness in sex expression by exogenous application of auxins, gibberellins, growth retardants, other plant growth regulators, macro and micronutrient elements has been reported. The monoecious form also possesses a great diversity in the pistillate and staminate flowering ratio. Normally in monoecious type, the production of staminate flowers is considerably more in number than pistillate flowers. Since a direct relationship exists between the number of pistillate flowers and total yield, increasing the number of pistillate flowers could increase yield. It is important to study the possibility of increasing the number of pistillate flowers by using plant growth regulators.

Sex ratio is highly sensitive to environment and high nitrogen, long days and high temperature generally promote a greater number of male flowers. Main limitation in its production is the lack of initiation of more female flowers in proportion to male. The mechanism of sex expression in most of the cucurbitaceous crops which are monoecious is considered to be controlled by genetical and environmental factors. Plant growth regulators are known to have great potential to increase the productivity of vegetables. The potentialities of growth promoters and growth retardants can be used to maximize the yield of several vegetable crops. The response of plant parts to growth regulators varies due to fluctuations in endogenous hormonal levels of the plant. The principle in sex modification shift in Bitter gourd lies in altering the sequence of flowering and sex ratio [5]. Besides the environmental factors, endogenous levels of Auxins, Ethylene and Cycocel at the time and seat of ontogeny determine the sex ratio and sequence of flowering. Exogenous application of plant growth regulators can alter the sex ratio and sequence, if applied at two or four leaf stage, which is the critical stage for suppression or promotion of sexes [6]. Hence, modification of sex in desired direction has to be manipulated by exogenous application of plant growth regulators. With this background, the present investigation was aimed to find out the suitable plant growth regulator for increasing the yield potential and quality in Bitter gourd. with the objectives to find out the influence of plant growth regulators on growth and yield parameters in Bitter gourd.

MATERIALS AND METHODS

The present study was carried out at the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2022-2024. The experiment was laid out in randomized block design with three replications. Bitter gourd seeds collected from Dharani Agro technologies located in Udumalpet, Coimbatore District is used in this experiment. The experiment consists of nine treatments having three growth promoters, a growth retardant each in two concentrations and a control. Chemical used and their concentrations was listed below:

T. No.	Growth regulator	Concentration (ppm)
T_1	NAA	50
T_2	NAA	100
T_3	NAA	200
T_4	Ethrel	125
T_5	Ethrel	250
T_6	Ethrel	500
T_7	CCC	100
T_8	CCC	200
T_9	CCC	400
T_{10}	Control	-

Pits were taken at a spacing of 1.5 × 1.5 m. In each pit, three seeds were sown. The cultural and management practices were adopted according to the management practices recommended by Tamil Nadu Agricultural University (TNAU), Coimbatore. Five plants were tagged randomly in each treatment for recording the various biometric characters like vine length (cm), number of branches per vine, intermodal length (cm), days to first male flowering, days to first female flowering, node number of first male flower, node number of first female flower, number of male flowers per vine, number of female flowers per vine, sex ratio, fruit length (cm), fruit girth (cm), number of fruits per vine, average fruit weight (g) and yield per vine (kg). Cost economics was also worked out to study the effectiveness of different treatments. The data were statistically analyzed by adopting the standard procedure of Panse and Sukhatme [7] and using AGRISTAT software.

RESULTS AND DISSCUSSION

Application of plant growth regulators had significant influence on growth characters like vine length and number of branches vine^{-1} in Bitter gourd. The present study showed that the response of different treatments on vine length (Table 1) differed significantly.

Prominent increase in the vine length was observed with NAA @ 200 ppm and NAA @ 100 ppm. The minimum vine length was observed in CCC @ 400 ppm. Reports showing that NAA promotes the growth of intact plant. Increased vine length is caused by increased cell flexibility, followed by hydrolysis of starch to sugars, which reduces the cell's water potential, allowing water to enter the cell, enabling elongation and fast cell division in the growing section. This is in agreement with the findings of Kore *et al*. [8] in bottle gourd, Dostagir *et al*. [9], Geeta *et al*. [10], Hill *et al*. [11] in ridge gourd, Sure *et al*. [12], Sinojiya *et al*. [13] and Kandasamy *et al*. [14] in sponge gourd.

A significant reduction in vine length was recorded under the treatment CCC on 400 ppm, which might be due to the inhibitory action of growth retardant that regulates growth by altering transport metabolism of auxin and inhibiting gibberellin biosynthesis. These results are in conformity with the findings of Hayashi *et al*. [15] and Kandasamy *et al*. [14].

Reduction in the vine length was noted in the plant treated with Ethrel 500 ppm (Table 1). Ethrel acts as an antimitotic, inhibiting the apical development of the main axis and acting as a gibberellin antagonist. This may be probable reason for reduction in length of vine with Ethrel treatment. This finding is backed up by Belhekar *et al*. [16] in bottle gourd, Thappa *et al*. [17], Ozgure *et al*. [18], Reenakumari [19].

Different treatments had a substantial impact on the number of branches vine^{-1} (Table 2). The maximum number of branches vine^{-1} (21.05) was recorded in CCC @ 400 ppm and the minimum number branches vine^{-1} (16.76) were observed in control. The maximum number of branches vine^{-1} by the application of CCC might be due to suppression of apical dominance, there by promoting growth of axillary buds into new shoots [20-25].

Table 1 Influence of different plant growth regulators on growth attributes in bitter gourd

Treatments	Vine length (cm)	Number of branches vine^{-1}
T_1: NAA @ 50 ppm	345.17	17.29
T_2: NAA @ 100 ppm	355.32	17.86
T_3: NAA @ 200 ppm	360.94	18.55
T_4: Ethrel @ 125 ppm	331.56	19.08
T_5: Ethrel @ 250 ppm	319.14	19.26
T_6: Ethrel @ 500 ppm	309.82	20.93
T_7: CCC @ 100 ppm	327.75	19.76
T_8: CCC @ 200 ppm	295.37	20.34
T_9: CCC @ 400 ppm	290.04	21.05
T_{10}: Control	337.29	16.76
S. Ed.	4.23	0.29
CD (p = 0.05)	8.86	0.61

In the present study, application of Cycocel (chlormequat chloride) CCC @ 100 ppm recorded early appearance of male flower (33.71days). Whereas, maximum days taken to first male flowering (38.15) was recorded in Ethrel @ 500 ppm (Table 2). The variation in the days taken to first male flowering might be due to influence of different plant growth regulators. The application of CCC resulting in reduced number of days taken to first male flower could have been achieved by suppressing the production of vegetative growth, thus increasing source and sink relationship to induce flowers at the earliest in treated plants. Ethrel evokes various physiological responses generally on flowering process and it is considered to have effect opposite to CCC [26-30].

The effect of different treatments on days required for appearance of the first female flower (Table 2) was differed significantly. In case of days required for the appearance of first pistillate flower. It was significantly lowered by the application of Ethrel. Among all the treatments, Ethrel @ 250 ppm was found to be the most effective in reducing number of days (39.96) to appearance of first female flower. Ethrel treatment brought down the number of days required for the appearance of female flower and delayed the appearance of male flowers.

The foliar spray of Ethrel shifted sex expression towards femaleness. Such effects could be attributing to the fact that at lower concentration of Ethrel slightly inhibited vegetative growth, increased lateral development, reduced respiration, thus increasing the source, sink relationship and helped in the production of female flowers [31-32]. The studies indicated that the node number of first male flower appearance were significantly lowered by CCC application (Table 2) Among the treatments, CCC @ 100 ppm (12.32) was found to be effective in reducing the node number for the appearance of first male flower. This might be due to the inhibited vegetative growth that causes the accumulation of carbon that could be utilized to induce male flowers at lower node [31].

The studies indicated that the node number of first female flower appearance was significantly lowered by the Ethrel application (Table 2). Among the treatments, Ethrel @ 250 ppm was the most effective in reducing the node number (14.54) of first female flower appearance. At the primordial stage, all the flowers carry both sets of sex organ and the application of growth regulators induce the transformation of male flower buds into female flowers. This seems to be a reasonable explanation for the early appearance of female flower at lower node [33-34]. With regard to male flowers, maximum number of male flowers vine^{-1} was found in control (426.36) (Table 2), followed by NAA @ 50 ppm (382.77). The increase in male flowers in control might be due to environmental factors like high temperature and long day condition prevailing during the crop growth period. NAA was responsible to synthesize florigen hormone, which stimulates the production of male flowers [35].

Table 2 Influence of different plant growth regulators on flowering attributes in sponge gourd

Treatments	Days to first male flowering	Days to first female flowering	Node number of first male flower	Node number of first female flower	No. of male flowers vine^{-1}	No. of female flowers vine^{-1}	Sex ratio
T_1: NAA @ 50 ppm	36.03	44.89	14.80	18.95	382.77	26.61	14.38
T_2: NAA @ 100 ppm	35.87	43.65	13.92	16.53	356.42	28.72	12.41
T_3: NAA @ 200 ppm	35.62	42.12	13.54	15.46	348.93	30.85	11.31
T_4: Ethrel @ 125 ppm	37.45	41.98	14.96	15.27	306.44	32.04	9.56
T_5: Ethrel @ 250 ppm	37.84	39.96	14.37	14.54	295.61	34.66	8.53
T_6: Ethrel @ 500 ppm	38.15	42.46	15.60	18.44	276.72	26.90	10.29
T_7: CCC @ 100 ppm	33.71	43.14	12.32	16.12	318.86	29.41	10.84
T_8: CCC @ 200 ppm	34.92	45.16	13.17	16.85	337.65	27.96	12.08
T_9: CCC @ 400 ppm	34.36	46.35	14.10	17.73	376.04	25.19	14.93
T_{10}: Control	36.78	48.79	14.62	19.96	426.36	23.28	18.31
S. Ed.	0.26	0.46	0.22	0.32	9.60	0.65	0.48
CD (p = 0.05)	0.56	0.98	0.47	0.68	20.08	1.36	1.01

In case of female flowers, all treatments were found superior in producing more number of female flowers over the control (Table 3). It was observed that treatment of Ethrel @ 250 ppm produced significantly maximum number of female flowers vine^{-1} (34.66). Ethrel treatment has brought down the number of days for the appearance of female flower and delayed the appearance of male flowers. The foliar application of Ethrel shifted sex expression towards femaleness. Application of Ethrel @ 250 ppm reduced level of endogenous gibberellins and increased level of auxin after Ethrel spray might be the probable reason for increased number of female flowers, decreased number of male flowers vine^{-1} and thereby sex ratio [36-37].

The present studies indicated that the response of different treatments to male: female sex ratio differed significantly and lowered the male: female sex ratio over control (Table 3). Among all the treatments, Ethrel @ 250 ppm and 125 ppm were found to be more effective in lowering the male: female sex ratio (8.53 and 9.56 respectively). The sexual differentiation is controlled by endogenous levels of auxins, which developed flowering primordial at flowering act as an anti-gibberellin substance. This anti gibberellin cause suppressed staminate flowers and promotes more number of pistillate flowers [38-39]. The treatment control produced maximum sex ratio (20.99). It might be due to environmental factors like high temperature and long days suppressing the production of pistillate flowers and induced more number of staminate flowers [40].

Among the plant growth regulators, NAA @ 200 ppm recorded the fruits with maximum fruit length (20.89cm) (Table 3). NAA triggers the cell division and cell elongation, induced the stimulation of fruit growth simultaneously to produce the lengthiest fruit [41]. In case of fruit girth, all concentrations of CCC @ 400 ppm, 200 ppm and 100 ppm recorded the fruits with maximum girth (16.98 cm, 16.76 cm and 16.55 cm respectively (Table 3). It may be due to the suppression of the fruit elongation and simultaneous accumulation of carbohydrates [42-45].

In the present study, all the treatments had shown a significant increase in average weight of fruit than the control (Table 3). Among the treatments, Ethrel @ 250 ppm recorded significantly maximum average weight of fruit (114.18 g). This increase in fruit weight with Ethrel might be attributed to the reason that the plants remained physiologically more active in building up sufficient food stock for developing fruits. The heaviest fruit formed due to increase in cell division and cell elongation as well as enhanced metabolic activity under the influence of Ethrel [46-47].

All the treatments produced significantly higher number of fruits vine^{-1} compared to control (Table 3). Among all the treatments, Ethrel @ 250ppm recorded significantly maximum number of fruits vine^{-1} (29.12). This may be due to the fact that Ethrel suppressed the number of male flowers vine^{-1} and promoted number of female flowers vine^{-1} and thereby increased number of fruits vine^{-1} [48-50].

The yield was found to be strongly influenced by the application of different plant growth regulators, thus indicating the importance of these compounds in increasing the yield potential. All the plant growth regulators significantly increased the yield in comparison to the control (Table 3). In the present study, the plants treated with Ethrel @ 250 ppm produced the maximum yield vine^{-1} (2.94 kg), while the control produced the lowest yield vine^{-1} (1.34 kg). The increase in fruit yield vine^{-1} with Ethrel application was owing to the efficiency of Ethrel to build up high levels of ethylene in plants, which increased yield components such as more number of pistillate flowers and the number, size and weight of the fruits [51-53].

Table 3 Influence of different plant growth regulators on yield attributes in sponge gourd

Treatments	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (g)	Number of fruits vine^{-1}	Yield vine^{-1} (g)
T_1: NAA @ 50 ppm	19.05	15.57	94.61	21.37	1.91
T_2: NAA @ 100 ppm	19.76	15.32	104.15	23.05	2.15
T_3: NAA @ 200 ppm	20.89	15.11	105.39	25.86	2.40
T_4: Ethrel @ 125 ppm	19.21	15.82	109.44	26.98	2.68
T_5: Ethrel @ 250 ppm	18.08	16.20	114.18	29.12	2.94
T_6: Ethrel @ 500 ppm	15.93	16.49	100.75	20.99	1.89
T_7: CCC @ 100 ppm	18.46	16.55	107.93	24.75	2.37
T_8: CCC @ 200 ppm	17.24	16.76	96.62	23.53	1.95
T_9: CCC @ 400 ppm	14.84	16.98	92.17	19.80	1.72
T_{10}: Control	16.68	14.52	84.35	18.36	1.34
S. Ed.	0.41	0.15	2.01	0.55	0.10
CD (p = 0.05)	0.86	0.32	4.21	1.17	0.21

Among different treatments, Ethrel @ 250 ppm was found to be superior to other treatments for increasing the yield potential of Bitter gourd. The economics of crop production was worked out for each treatment separately. The highest net return of Rs. 100821 hectare^{-1} was obtained with Ethrel @ 250 ppm, followed by Ethrel @ 125 ppm (Rs. 87503 hectare^{-1}). The net returns from Ethrel treatments were higher due to maximum number of fruits vine^{1} and low cost of growth regulators. Lowest net return Rs. 23021 was obtained from control.

CONCLUSION

The present study reveals that plant growth regulators (PGRs) exert a significant influence on growth, flowering, and yield attributes in bitter gourd. NAA at 200 ppm showed remarkable results in enhancing vine length, attributed to its role in cell elongation and division, while CCC at 400 ppm was effective in maximizing branch number by promoting axillary growth. Ethrel at 250 ppm proved to be particularly effective in optimizing flowering parameters, encouraging femaleness and thereby enhancing the number of female flowers, leading to a higher fruit count and yield per vine. Moreover, Ethrel-treated plants showed significant increases in average fruit weight and yield per hectare, resulting in the highest net returns. These findings suggest that targeted PGR applications can greatly enhance bitter gourd productivity, with Ethrel at 250 ppm emerging as the optimal treatment for maximizing economic returns. All the growth regulators increased the net returns over control. The production and net returns from Ethrel treatments were higher due to maximum fruit numbers per vine and low cost of growth regulators. Lowest net return (Rs. 23021 / ha) was obtained from control.

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