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ROLE OF PLANT GROWTH REGULATORS IN MODULATING GROWTH AND DEVELOPMENT OF BITTER GOURD IN HIGH-TEMPERATURE ENVIRONMENTS

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ABSTRACT

The bitter gourd is the most common vegetable crop and is very popular for its medicinal properties, such as blood diseases, rheumatism, and diabetes. An experiment was conducted for the study on the effect of plant growth regulators on growth and yield attributes of bitter gourd at the Research Farm, IANS, DDUGU, Gorakhpur. The plant growth regulators, namely GA_3 (40 and 80 ppm), NAA (150 and 300 ppm), Ethephon (75 and 150 ppm) and Salicylic Acid (0.25 and 0.5 mM), including a control, were arranged in a Randomized Block Design (RBD) with three replications. The result shows that the spray of GA_3 (80 ppm) was found to be most effective in increasing the vine length, number of branches per plant, number of nodes, reducing the days to first female and male flower appearance, node number per branch and sex ratio.

Key words : *Momordica charantia*, Vegetative growth, Sex expression, Plant growth regulators.

Introduction

The bitter gourd (*Momordica charantia* L.) is India's most common vegetable crop and belongs to the family Cucurbitaceae, commonly known as *Karaila*. The bitter gourd was popular for its medicinal properties, such as blood diseases, rheumatism, diabetes, and asthma (Tania *et al*., 2019). The bitter gourd is used in the treatment of diabetes, reducing the blood sugar level due to the presence of charantin (Lotlikar and Rajaramrao, 1966). The bitter gourd has a different nature, which not only has fabulous digestive properties, but also it is a storehouse of remedies for some ailments, *i.e.*, diabetes, rheumatism, and gout (Mia *et al*., 2014). In India, it is cultivated in an area of 113,000 ha, producing 14.33 lakh MT (Anonymous, 2023). The bitter gourd plays the role of a blood purifier, activates the spleen and liver, and is beneficial for diabetes patients (Yibchokanun *et al*., 2006). The 100 gm of edible part of bitter gourd contains protein (2.1g), fat (1.0g), minerals (1.4g), fiber (1.7g), carbohydrates (10.6g), calcium (23g), phosphorus (38g), iron (2.0 g), 126 mg carotene, thiamine (0.07 mg), riboflavin (0.06 mg) and vitamin (96 mg) (Gopalan *et al*., 1989). Vitamin C, iron, phosphorus, and carbohydrates are present in high amounts in bitter gourd (Behera, 2004). As the three pentacyclic triterpenes momordicin, momordicinin, and momordicilin build up over time, the fruit becomes more and more bitter. However, as the fruit ripens, the bitterness subsides (Cantwell *et al*., 1996). The bitter gourd is an annual monoecious plant. The number of female flowers is less than the number of male flowers during flowering is 50:1, but this ratio can vary according to sustainability, *i.e.*, 9:1 to 48:1, due to abiotic factors. The crop produces more male flowers than female flowers, which is wasteful and drastically affects crop production. Sex expression is a complex characteristic in plants and it is influenced by genetic, environmental and hormonal factors, and others. Plant growth regulators are the chemical compounds that alter plant growth and development by modifying natural hormone reactions. The plant growth regulators are agrochemicals, which are considered after fertilizers, pesticides, and herbicides; they enhance the source-sink relationship and stimulate the translocation of photo assimilates for better fruit setting. They help in increasing the yield level by increasing the fruit setting percentage. The use of PGRs helps increase crop production. PGRs have been utilized extensively in crop production around the world because they significantly increase crop yield. PGRs are used to increase yield (Nickell, 1982). The growth regulators work as growth and yield attributes but have varying effects with the different plant species, variety, concentration of PGRs, method of application, frequency of application and stage of application. The application of PGRs is most effective in increasing the number of female flowers and modifying the sex ratio, and the ultimate effect goes on the yield (Aishwarya, 2019). Gibberellic acid is an important PGR that helps to modify the growth attributes and yield attributes of plants (Rafeekher *et al.*, 2002). The principle in sex modification in cucurbitaceous crops lies in altering the sequence of flowering and sex ratio. Besides the environmental factors, endogenous levels of auxins, gibberellins, ethylene, and ascorbic acid, at the time and the set of ontogenies, determine the sex ratio and sequence of flowering. Gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) are two important growth regulators that are used for the changes in growth attributes and yield attributes and for increasing the fruit-setting percentage of the cucurbitaceous crops. The gibberellic acid plays an important role in promoting male sex expression and maintains the sex ratio (Rudich, 1983; Zhang *et al.*, 2017).

Materials and Methods

The experiment was conducted at the Research Farm of the Department of Horticulture, Institute of Agriculture & Natural Sciences, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur – 233 009, U.P., during the summer season of 2024. The seed variety of bitter gourd used was Akshay and the seeds were soaked in Bavistin at a rate of 2.5 g/kg of seed for 17 hours at 25! to enhance sprouting and seedling growth. The seedlings of bitter gourd used of 30 days old for transplanting at the spacing of 90 cm × 45 cm on 10th February, 2024, in Randomized Block Design with nine treatments, including control, and replicated thrice. A spacing of 0.5 m was maintained between each replication to facilitate proper growth and data observation. During final field preparation, FYM @ 25 tonnes/ha, Nitrogen @ 100 kg/ha, Phosphorus @ 60 kg/ha and potassium @ 60 kg/ha were applied.

The field studies were conducted to evaluate the efficacy of PGR dose and stages of application on bitter gourd, *viz*.

Table 1 : Different treatments with their concentrations.

Treatment No.	Treatment bame	Concentrations
T_1	Control	.....
T_2	Ethephon	75 ppm
T_3	Ethephon	150 ppm
T_4	Gibberellic Acid (GA_3)	40 ppm
T_5	Gibberellic Acid (GA_3)	80 ppm
T_6	Naphthalic Acetic Acid (NAA)	150 ppm
T_7	Naphthalic Acetic Acid (NAA)	300 ppm
T_8	Salicylic Acid	0.25 mM
T_9	Salicylic Acid	0.50 mM

The plant growth regulators were used as foliar application, with Control (water spray), at 2-leaf and 4-leaf and flowering stage, and after that at 30 DAS, 45 DAS and 60 DAS. Precautions were taken during the preparation and spraying of the solution from one treatment plot to another to prevent the drifting of treatments. From each treatment, three plants were randomly selected and tagged for recording vegetative growth parameters (vine length, number of primary and secondary branches, and number of nodes), phenological parameters (days taken to first flowering, days taken to 50% flowering, number of male flowers, number of female flowers, and sex ratio). After that, the mean calculation of each data of each treatment. The above-mentioned parameters data were measured at the intervals 30 DAS, 45 DAS and 60 DAS.

Results and Discussion

The influence of various plant growth regulators on vegetative growth parameters and phenological parameters of bitter gourd which are presented in Tables 2, 3 and depicted in Figs. 1 and 2.

Vegetative growth parameters

GA_3 @ 80 ppm was observed to considerably enhance vine length (45.11 cm, 87.55 cm, and 143.42 cm) during the experiment. GA_3 @ 40 ppm and Ethephon @ 150 ppm were next in line with Salicylic acid @ 0.5 mM at 30 DAS, 45 DAS and 60 DAS, respectively. The increase in the vine length of bitter gourd by GA_3 was also confirmed by Anayat *et al.* (2020), Aishwarya *et al.* (2019) and Hirpara *et al.* (2014) in bitter gourd. Kumari

Table 2 : Effect of plant growth regulators on the vegetative growth parameters of bitter gourd during the *Summer* of 2024.

Treatment no.	Treatment name	Vine length (cm)			Number of primary branches per plant			Number of secondary branches per plant			Number of nodes per plant		
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	**Control**	30.22	80.37	124.22	2.33	4.44	7.00	2.55	4.50	7.00	5.88	13.88	23.55
T_2	**Ethephon @ 75 ppm**	34.33	82.02	124.77	2.44	5.00	7.11	2.55	5.11	7.16	6.16	13.22	22.77
T_3	**Ethephon @ 150 ppm**	36.88	83.00	131.00	2.88	4.77	6.66	2.94	4.83	6.73	6.27	14.22	23.00
T_4	**Gibberellic Acid @ 40 ppm**	40.22	85.32	137.74	3.33	5.77	7.77	3.55	5.83	7.88	7.06	14.22	23.88
T_5	**Gibberellic Acid @ 80 ppm**	45.11	87.55	143.42	3.66	6.22	8.11	3.77	6.33	8.27	7.88	15.33	25.33
T_6	**NAA @ 150 ppm**	36.00	83.22	128.11	2.33	4.88	7.22	2.55	5.00	7.27	6.16	13.22	23.11
T_7	**NAA @ 300 ppm**	36.66	84.35	132.11	2.55	5.00	7.44	2.66	5.11	7.55	6.72	14.22	23.22
T_8	**Salicylic Acid @ 0.25 mM**	34.66	81.36	129.55	2.33	4.44	7.00	2.38	4.50	7.06	5.88	13.00	22.44
T_9	**Salicylic Acid @ 0.5 mM**	36.22	82.57	130.55	2.66	5.00	7.22	2.77	5.11	7.33	6.44	13.44	22.55
	S.Em. (±)	**0.33**	**0.11**	**0.26**	**0.14**	**0.12**	**0.08**	**0.13**	**0.12**	**0.08**	**0.12**	**0.09**	**0.09**
	CV	**16.86**	**6.36**	**8.20**	**28.80**	**20.24**	**7.03**	**28.8**	**20.24**	**7.03**	**39.79**	**11.44**	**6.29**
	CD @ 5%	**3.64**	**3.01**	**6.06**	**0.44**	**0.64**	**0.28**	**0.44**	**0.64**	**0.28**	**2.11**	**0.91**	**0.83**

et al. (2019), Ansari and Chowdhary (2018) confirmed in bottle gourd, while Chaurasiya *et al*. (2016) also confirmed in muskmelon. Primary and secondary branch counts are influenced by the use of plant growth regulators. At 30 DAS, 45 DAS, and 60 DAS intervals, GA_3 at 80 ppm produced the most primary branches (3.66, 6.22 and 8.11), followed by GA_3 @ 40 ppm and Ethephon @ 150 ppm. These were comparable to Salicylic acid @ 0.5 mM and Ethephon @ 75 ppm, respectively. Gosai *et al*. (2020) and Kaur *et al*. (2016) also confirmed that GA_3 increases the number of primary branches. The plots treated with GA_3 @ 80 ppm had the most secondary branches (3.77, 6.33 and 8.27), followed by GA_3 @ 40 ppm. Other treatments were comparable at the mentioned interval. Singh and Choudhary (1989) and Dubey (1983) also confirmed that Gibberellic Acid increased the number of secondary branches. GA_3 @ 80 ppm treated plots had the most nodes per plant (7.88, 15.33, 25.33), followed by GA_3 @ 40 ppm and NAA @ 300 ppm at 30 DAS, 45 DAS and 60 DAS intervals, respectively (Table 2). Similar findings have also been found earlier by Garg *et al*. (2020) in cucumber, Chaurasiya *et al*. (2019) in muskmelon, Sandra *et al*. (2015) in bitter gourd and Prasad *et al*. (2003) in cucumber.

Phenological parameters

Plant growth regulators are reported to influence flowering and sex ratio. During the investigation, the plant growth regulators were sprayed on plants to bore male and female flowers at lower nodes with a greater number of female flowers per vine. The days taken for first flowering and the days taken to 50% flowering are also influenced by the help of spraying the plant growth regulators. Among all the PGRs, GA_3 @ 80 ppm application resulted in the minimum days taken to first flowering (35.66 days), followed by NAA @ 300 ppm, Salicylic Acid @ 0.25 mM, and NAA @ 150 ppm (35.77, 36.55 and 37.22 days, respectively) and minimum days taken to 50% flowering was observed from also GA_3 @ 80 ppm treated plot followed by GA_3 @ 40 ppm at par with NAA @ 150 ppm, Ethephon @ 150 ppm (52.88, 54.33, 54.88, 55.77, and 55.88, respectively) (Table 3). A similar finding was carried out by Thappa *et al*. (2011), Kooner *et al*. (2000), that the minimum number of days taken to first flowering was observed from the GA3-treated plot.

As shown in Table 3, the result revealed that the application of all the treatment concentrations was found to be most significant as compared to the control. Salicylic Acid @ 0.5 mM significantly reduced the number of male flowers, followed by GA_3 @ 80 ppm, NAA @ 300 ppm

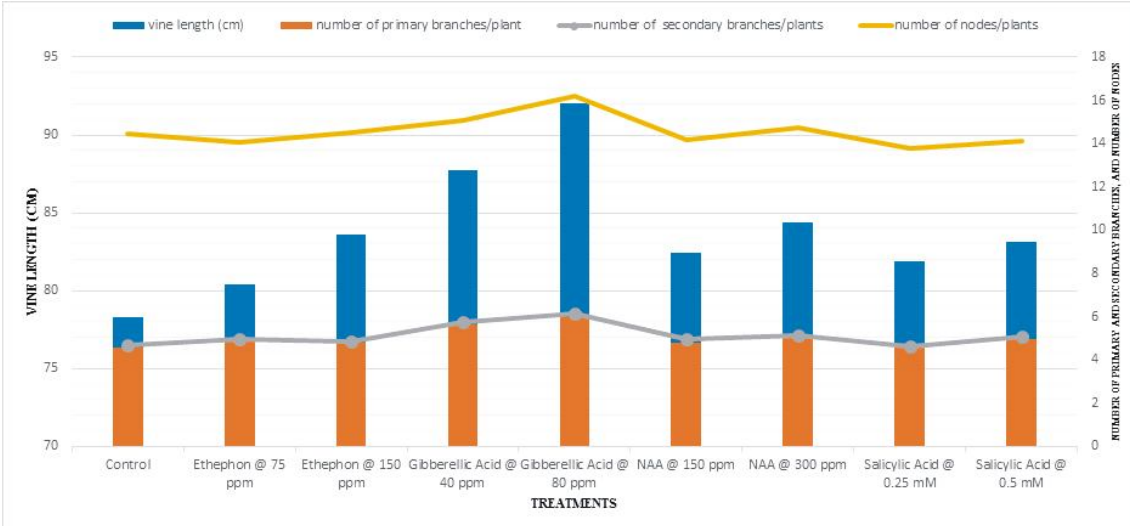

Fig. 1 : Mean of the effect of plant growth regulators on the vegetative growth parameters of bitter gourd during *Summer* 2024.

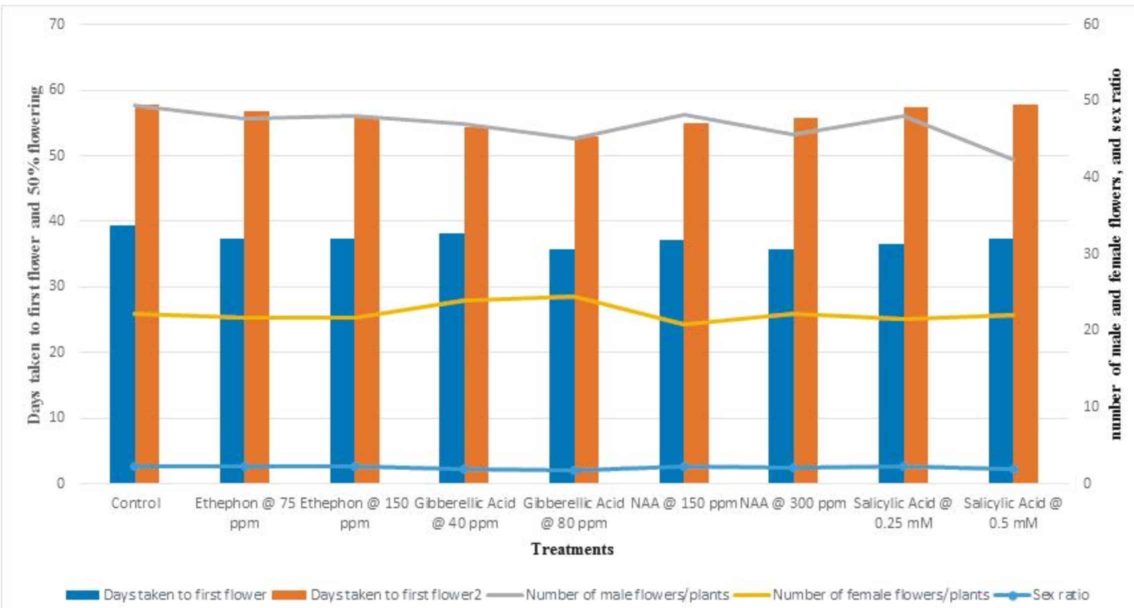

Fig. 2 : Effect of plant growth regulators on phenological parameters of bitter gourd during the *Summer* season 2024.

Table 3 : Effect of plant growth regulators on the number of male and female flowers, sex ratio.

Treatment no.	Treatment name	Days taken to first flower	Days taken to 50% flower	Number of male flowers/plants	Number of female flowers/plants	Sex ratio
T_1	**Control**	39.44	57.88	49.44	22.22	2.22
T_2	**Ethephon @ 75 ppm**	37.33	56.77	47.77	21.66	2.20
T_3	**Ethephon @ 150 ppm**	37.33	55.88	48.11	21.77	2.20
T_4	**Gibberellic Acid @ 40 ppm**	38.11	54.33	47.04	23.88	1.96
T_5	**Gibberellic Acid @ 80 ppm**	35.66	52.88	45.10	24.55	1.83
T_6	**NAA @ 150 ppm**	37.22	54.88	48.22	20.88	2.30
T_7	**NAA @ 300 ppm**	35.77	55.77	45.66	22.22	2.05
T_8	**Salicylic Acid @ 0.25 mM**	36.55	57.33	48.14	21.44	2.24
T_9	**Salicylic Acid @ 0.5 mM**	37.44	57.88	42.33	22.11	1.91
S.Em. (±)		**0.09**	**0.11**	**0.16**	**0.12**	**0.05**
CV		**52.32**	**48.5**	**32.05**	**11.50**	**43.18**
CD @ 5%		**12.57**	**18.87**	**16.18**	**1.44**	**23.33**

(42.33, 45.10 and 45.66, respectively). The maximum number of male flowers (49.44) was found in the Control (untreated plot). The application of GA_3 @ 80 ppm significantly enhances the number of female flowers (24.55), followed by GA_3 @ 40 ppm, Salicylic Acid @ 0.5 mM and NAA @ 300 ppm (23.88, 22.11 and 22.22, respectively). Enhanced sex ratio by the spraying of GA_3 @ 80 ppm, followed by Salicylic Acid @ 0.5 mM, GA_3 @ 40 ppm (1.83, 1.91, and 1.96, respectively). Similar findings were recorded by Moniruzzaman *et al*. (2019) in bottle gourd, and Sarkar *et al*. (2019) in cucumber, and by Thappa *et al*. (2011) in cucumber.

Conclusion

The present results suggest that the application of GA_3 @ 80 ppm has a significant impact on vegetative growth parameters and phenological parameters of bitter gourd. Salicylic Acid and NAA also influence the growth and phenological parameters of bitter gourd. The application of these plant growth regulators was also found to be most effective in reducing the number of male flowers and the sex ratio of male to female flowers. However, different vegetative growth parameters, *i.e.*, vine length (cm), number of primary branches, number of secondary branches and number of nodes per plant, increased significantly with the foliar application of GA_3 @ 80 ppm compared to other treatments, including control also reduce the days taken to first flowering, minimum days taken to 50% flowering, number of male flowers, number of female flowers and sex ratio.

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