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IMPACT OF PLANT GROWTH REGULATORS ON BITTER GOURD DEVELOPMENT AND GROWTH IN HIGH-TEMPERATURE ENVIRONMENTS

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ABSTRACT
Bitter gourd is a common vegetable crop and is popular for its medicinal properties, including treatment for blood diseases, rheumatism, and diabetes. We conducted an experiment to study the impact of plant growth regulators on bitter gourd growth and yield attributes at the Research Farm, IANS, DDUGU, Gorakhpur. We arranged the plant growth regulators, 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), along with a control, in a Randomised Block Design (RBD) with three replications. The results show that the spray of GA_3 (80 ppm) was found to be most effective in reducing the days to first female and male flowers, Days taken to 50% flowering, sex ratio, and yield.

KEYWORDS: Momordica charantia, sex expression, yield, plant growth regulators.

INTRODUCTION
Bitter gourd (Momordica charantia L.) is one of the most popular vegetable crops for its medical benefits. The Bitter gourd belongs to the Cucurbitaceae family, which originated in Asia. The Bitter gourd is grown in tropical and subtropical regions, including India, China, Sri Lanka, Thailand, the Philippines, Japan, Australia, and other countries (Singh et al., 2024). Bitter gourd has antiviral, antibacterial, antioxidant, antihepatotoxic, and antiulcerogenic qualities. Among the various vegetables grown in India, the bitter gourd occupies an area of 1.13 lakh hectares with an annual production of 14.33 lakh metric tonnes and a productivity of 12.68 tonnes per hectare (Anonymous, 2021). Bitter gourd's nutritive value is maximum compared to other cucurbitaceous vegetables, especially in vitamins. C (88 mg per gram per edible section). Water (83-92%), carbohydrates (4-10.5%), proteins (1.5-2%), fat (0.2-1%), minerals (0.5-1%), and fibre (0.8-1.7%) are found in bitter gourd (Momin, 2007). In the cucurbits, staminate and pistillate flowers are produced on separate nodes of the same plant due to the monoecious nature of flowering behaviour (Asghar, 2016). 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 (Dey et al., 2005). A small amount of certain substances known as growth regulators is used to manage this ratio. By using regulators controlling sex ratio, promoting fruit setting, and enhancing seed germination, which is helpful for increasing crop yield, because the yield of cucurbits is influenced by the sex ratio and sex expression. Male flowers are most abundant on early nodes, while female flowers are seen on later nodes. This has decreased the crop yield and resulted in poor fruit bearing. PGRs directly alter the male and female flower ratio, fruit set, and fruit drop, and eventually affect yield. The regulators are substances, either synthetic or naturally occurring, that mostly exist in trace amounts and influence the metabolic or developmental processes of higher plants (Rademacher, 2018). The function of regulators in a variety of physiological and biochemical processes in plants has been widely understood. These physiological processes regulate the initiation of flower buds and the growth of flowers and fruits (Farhana, 2015). The exogenous application changed the expression

towards femaleness by increasing the production of female flowers and suppressing that of male flowers, leading to an increase in the seed yield and quality in bitter gourd (Hirpara et al., 2014).

METHODOLOGY

The experiment was conducted at the Research Farm of the Department of Horticulture, Institute of Agriculture & Natural Sciences, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur – 233009, 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°C to enhance sprouting and seedling growth. The seedlings of bitter gourd were 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.	Treatments Name	Concentrations
T_1	Control	...
T_2	Ethephon	75 ppm
T_3	Ethephon	150 ppm
T_4	GA_3	40 ppm
T_5	GA_3	80 ppm
T_6	NAA	150 ppm
T_7	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 applications, with a control (water spray), at the 2-leaf and 4-leaf stages, at the flowering stage, and thereafter 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 yield parameters, number of fruits per plant, length of fruits (cm), diameter of the fruits, fruit yield per plot (kg), fruit yield(q/ha), 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 parameters were measured at 30 DAS, 45 DAS, and 60 DAS.

RESULT & DISCUSSION

The influence of various plant growth regulators on yield parameters and phenological parameters of bitter gourd is presented in Tables 2 and 3 and depicted in Figures 1 and 2.

Yield parameters

Fruit length (cm) was found to be significantly higher when NAA 300 ppm (18.33 cm) was applied, followed by GA_3 80 ppm (17.44 cm) and GA_3 40 ppm (16.77 cm), which were comparable to Ethephon 150 ppm and Salicylic acid 0.5 mM (16.55 cm and 16.77 cm, respectively). The control plot had the shortest fruit length (16.44 cm). The findings of Moniruzzaman et al. (2019) in bottle gourd, Sarkar et al. (2019) in cucumber, Kaur et al. (2016) in cucumber, Sinojiya et al. (2015), and Bhat et al. (2014) in watermelon were all supported by the results, diameter of fruits (cm) Fruit diameter grew significantly when GA_3 80 ppm was applied (5.77 cm), followed by GA_3 40 ppm (5.22 cm), Ethephon 150 ppm, and NAA 300 ppm (4.24 cm) at par with each other. The Control plot yielded the minimum fruit diameter of 3.96 cm. Similar results were also noted in watermelon by Bhat et al. (2014), cucumber by Kaur et al. (2016), and cucumber by Sarkar et al. (2019); the number of fruits per plant: GA_3 80 ppm (20.33), NAA 300 ppm, and salicylic acid 0.5 mM (19.00) were found to increase the number of fruits per plant. The Control plot had the fewest fruits per plant (16.00). Additionally, Moniruzzaman et al. (2019) in bottle gourd, Sarkar et al. (2019) in cucumber, Kaur et al. (2016) in cucumber, and Murthy et al. (2007) in gherkin reported the maximum quantity of fruits per plant. It was found that the plant growth regulators greatly boosted the amount of

fruit produced per plant. Under GA_3, the highest fruit output per plant is 80 ppm (7.96 kg). The increased quantity of female flowers, fruits, and fruit weight under the GA_3 80 ppm treatment may have contributed to the higher production under GA_3 ppm. Jatoi et al. (2011), Sonkar (2003) in cucurbits, Moniruzzaman et al. (2019) in bottle gourd, Sinojiya et al. (2015) in watermelon, and Murthy et al. (2007) were all supported by the results. In gherkin, they reported that the maximum fruit yield was achieved with the application of plant growth regulators.

Phenological Parameters

It has been found that plant growth regulators affect the sex ratio and flowering. In order to produce both male and female flowers at lower nodes, with more female blooms per vine, the plant growth regulators were sprayed on the plants during the study. Spraying the plant growth regulators also affects how long it takes for first flowering and 50% flowering. The PGR with the shortest time to first flowering (35.66 days) was GA_3 @ 80 ppm, 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 GA_3-treated plot.

The application of all treatment concentrations was found to be most significant when compared to the control, as indicated in Table 3. The number of male flowers was considerably decreased by salicylic acid at 0.5 mM, GA_3 at 80 ppm, and NAA at 300 ppm (42.33, 45.10, and 45.66, respectively). The Control (untreated plot) had the highest number of male flowers (49.44). The number of female flowers was greatly increased by applying GA_3 @ 80 ppm (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). GA_3 @ 80 ppm, Salicylic Acid @ 0.5 mM, and GA_3 @ 40 ppm were sprayed to increase the sex ratio (1.83, 1.91, and 1.96, respectively). Similar results were found in bottle gourd by Moniruzzaman et al. (2019), cucumber by Sarkar et al. (2019), and cucumber by Thappa et al. (2011).

Table 2: Impact of plant growth regulators on the yield parameters of bitter gourd during the Summer of 2024.

Treatment no.	Treatments	Fruit length (cm)	Fruit diameter (cm)	Number of fruits per plant	Fruit yield (kg/five plants/ plot)	Fruit yield (q/ha)
T_1	**Control**	16.44	3.96	16.00	5.91	62.85
T_2	**Ethephon @ 75 ppm**	16.56	4.28	17.33	5.92	73.25
T_3	**Ethephon @ 150 ppm**	16.55	4.24	18.33	7.03	75.25
T_4	**Gibberellic Acid @ 40 ppm**	16.77	5.22	17.66	7.41	85.25
T_5	**Gibberellic Acid @ 80 ppm**	17.44	5.77	20.33	7.96	91.25
T_6	**NAA @ 150 ppm**	16.89	4.11	17.00	5.99	74.52
T_7	**NAA @ 300 ppm**	18.33	4.08	19.00	6.73	78.95
T_8	**Salicylic Acid @ 0.25 mM**	16.78	4.24	17.33	6.76	80.23
T_9	**Salicylic Acid @ 0.5 mM**	16.77	5.17	19.00	6.83	84.68
	S.Em. (±)	0.071	0.14	0.49	0.63	2.11
	CV	10.14	22.68	5.27	6.13	1.54
	CD @ 5%	1.37	0.77	1.46	0.21	0.71

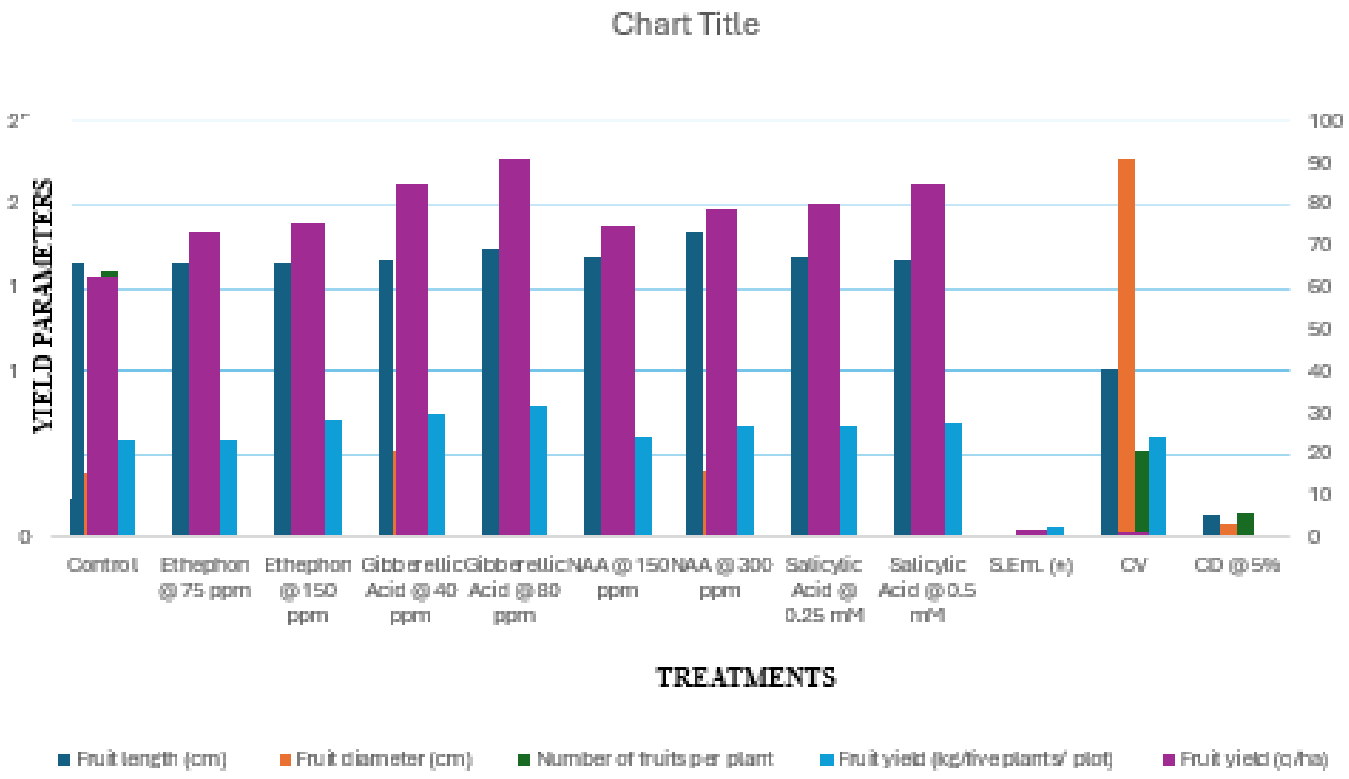


Figure 1: Mean of the impact of plant growth regulators on the Yield parameters of bitter gourd during Summer 2024.

Table 3: Impact 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**

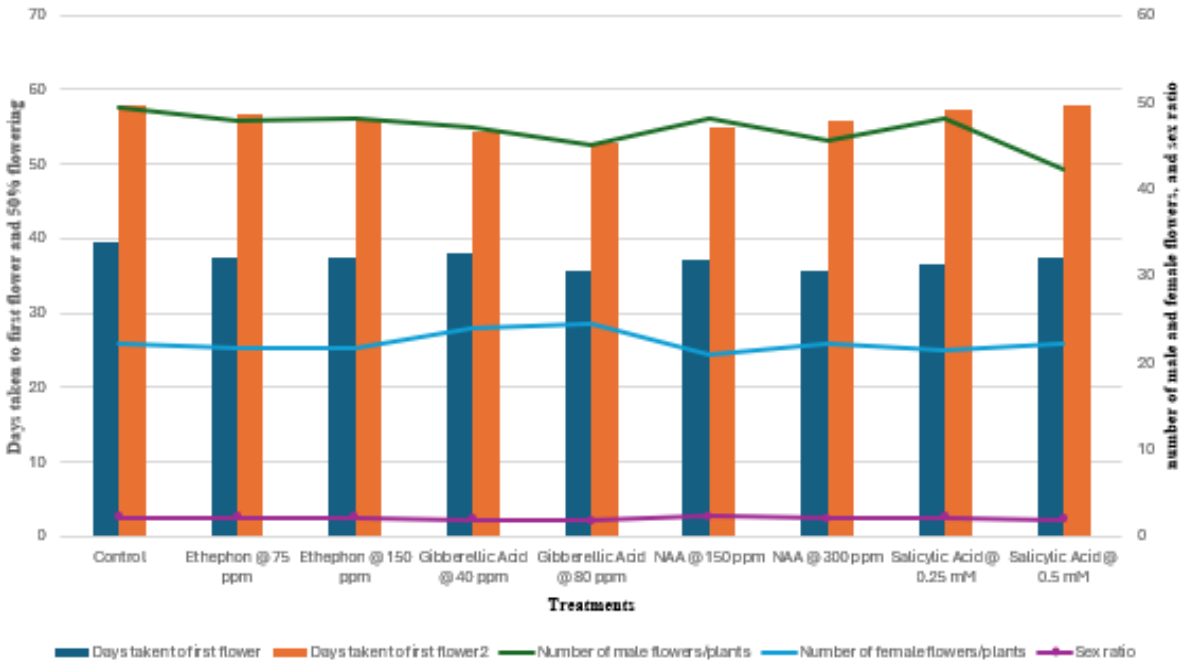


Figure 2: Impact of plant growth regulators on phenological parameters of bitter gourd during the Summer season 2024.

CONCLUSION

According to the current findings, bitter gourd production and phenological parameters are significantly impacted by the application of GA_3 @ 80 ppm. The yield and phenological characteristics of bitter gourd are also affected by salicylic acid and NAA. It was also discovered that applying these plant growth regulators was the most successful way to lessen the sex ratio of male to female flowers and the quantity of male flowers. However, compared to other treatments, including the control, the foliar application of GA_3 @ 80 ppm greatly increased yield parameters, such as the number of fruits per plant, fruit length (cm), fruit diameter, fruit yield per plot (kg), and fruit yield (q/ha); it also decreased the number of male flowers, number of female flowers, sex ratio, days taken to first flowering, and minimum days taken to 50% flowering.

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