Original Research Article

Growth and Yield of Bitter gourd as Influenced by Gibberellic acid and Naphthalene acidic acid (*Momordica charantia L.)*

ABSTRACT

An experiment was carried out in the departmental field of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during February to May 2021 on bitter gourd (*Momordica charantia* L.) to find out the best treatments of plant growth regulators for better growth and yield in bitter gourd. The experiment include growth regulators like GA_3 and NAA with different ppm. Nine treatments were made and replicated thrice in randomized block design. Application of plant growth regulators was done as per the treatment allocation at four leaf stage. The experimental results revealed that treatment 25 ppm GA_3 was found most effective in terms of vine length and results maximum at 20,40,60 and at harvest, and days to first appearance of male flowers whereas treatment T_8 NAA 150ppm was recorded significantly minimum at days to first harvest (57.267) and maximum in fruit weight (134.933), fruit length (14.107), fruit diameter (4.453), No. of fruits per plant (11.867), average yield per plant (1,609.100), yield tonne per hectare (10.725).

Keywords*: Bitter gourd, GA_3, NAA, growth, yield*

1. INTRODUCTION

Bitter gourd [*Momordica charantia* L.,2n= 2x =22] is one of the most important cucurbitaceous vegetables widely cultivated in India. It is also known as balsam pear, bitter melon, bitter cucumber, and African cucumber. Like other cucurbits, maleness is one of the major obstacles in bitter gourd which significantly reduces the fruit and seed yields. The importance of bitter gourd has long been recognized due to its high nutritive value and medicinal properties. It is a luscious, climbing vine with slightly fuzzy stems clothed with dark green, deeply lobed leaves and yellow, monecious flowers. The fruit has a distinct warty exterior and an oblong shape. It is hollow in cross-section, with a relatively thin layer of flesh surrounding a central seed cavity filled with large, flat seeds and pith. The fruit is most often eaten green, or as it is beginning to turn yellow. Gibberellins are one of the longest-known classes of plant hormone. Gibberellins are involved in the natural process of breaking dormancy and other aspects of germination. Before the photosynthetic apparatus develops sufficiently in the early stages of germination, the stored energy reserves of starch nourish the seedling. Usually in germination, the breakdown of starch to glucose in the endosperm begins shortly after the seed is exposed to water. Gibberellins in the seed embryo are believed to signal starch hydrolysis through inducing the synthesis of the enzyme α-amylase in the aleurone cells. α-Amylase then hydrolyses starch, which is abundant in many seeds, into glucose that can be used in cellular respiration to produce energy for the seed embryo. Studies of this process have indicated gibberellins cause higher levels of transcription of the gene coding for the α-amylase enzyme, to stimulate the synthesis of α-amylase.

Gibberellins are produced in greater mass when the plant is exposed to cold temperatures. They stimulate cell elongation, breaking and budding, seedless fruits, and seed germination. Gibberellins cause seed germination by breaking the seed's dormancy and acting as a chemical messenger. Gibberellic acid (GA) is an important PGR used to modify growth and yield of plants (Rafeekher et al., 2002). Exogenous application of GA has increased gynoecy in bitter gourd (Wang and Zeng, 1996) and was found very effective at a concentration of 50 mg L-1 in sex expression modification, enhancement in vegetative growth, fruit and seed yields (Nagamani et al., 2015). GA delays staminate flower setup and promotes pistillate flowers at lower concentrations (Wang and Zeng, 1997). The application of NAA at certain level improves the maximum number of fruits per plant, and increase in yield of crop. It induces root formation on cuttings and transplants and also Inhibits the fruit drop. It is effective against storage diseases. NAA was famed to catalyse cell division, cell elongation, elongation of shoot, photosynthesis, RNA synthesis membrane permeability etc. NAA is an important plant growth regulator, which stimulates cell division, cell elongation and cell enlargement in apical region of plant resulted in better plant growth of bottle gourd. NAA is used in chemical thinning and prevention of fruit drop or induction of flowering, increase fruit setting, size and thus increasing yield. External application of NAA in bitter gourd also increased the yield of the crop (Melisa and Nina, 2005; Biradar et al., 2010). Hence keeping all the above points in view an experiment was undertaken to find out the effect of different GA_3 and NAA on growth and yield of bitter gourd and to find out the best suitable treatment.

2. MATERIAL AND METHODS

The experiment was carried out at the department of research field, department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP) during February-May 2021, which was situated in the agro climatic zone (sub-tropical belt) of Uttar Pradesh. Prayagraj is located in the south-east part of Uttar Pradesh India. Prayagraj falls under agro-climate zone IV which is named as “middle Gangetic plains” the site of experiment is located at 98 meters from sea level at 25.57º N latitude 81.51º E longitude has a typical subtropical climate with extremes of summer and winter. The maximum temperature of the location reaches up to 46ºC - 48ºC and seldom falls down as low as 4ºC-5ºC during winter the average rainfall in this area is around during winter season especially in the month of December and January the average rainfall in this area is around 1027 mm annually with maximum concentration during July to September with few showers and drizzles in winter also The treatment involving plant growth regulators viz. gibberellic acid (15, 20, 25 and 30 ppm) and naphthalene acetic acid (75, 100, 125 and 150 ppm) were imposed at four leaf stage in genotype TMBI-1304 of bitter gourd. The salient features of plant growth regulators used in the experiment. The experiment was laid out in Randomized block design with three replications. The experiment consists of nine treatments in which four treatments are gibberellic acid and four treatments are NAA. Seeds are sown at spacing of 1.5 m x 1 m each plot with 6 plants. The data collected during the course of investigation were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Fisher (1950)

3. RESULTS AND DISCUSSION

3.1 GROWTH ATTRIBUTES

3.1.1 VINE LENGTH

GA_3 had significant effect on vine length of 221.04 cm was recorded in T_4 (GA_3 25 ppm) followed by 208.673 cm in T_7 (NAA100 ppm), which was at par with each other, whereas shortest vine length 188.04 cm was recorded in T_1 control. The phenomenon of increase in vine length might be due to increasing plasticity of the cell wall followed by hydrolysis of starch to sugars which lowers the water potential of cell, resulting in the entry of water into the cell causing elongation. These osmatic driven responses under the influence of gibberellins might have attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products thus resulting in increased cell elongation and rapid cell division in the growing portion. **Mangal *et al*., (1981).**

3.1.2 DAYS TO APPEARANCE OF FEMALE FLOWERS IN 50% PLANTS

The NAA showed minimum days to appearance of first female flowering and recorded in T_9 NAA 150 ppm (40.60) followed by T_4 GA_3 25 ppm (44.93) which was at par with each other and both treatments were superior to the T_1 control (53.06) showed significant result. Application of NAA which is attributed to the suppression of male flowers and promoted more number of female flowers and increase the metabolization of auxin substances in plants and also reduce sugar thereby bringing a change in the membrane permeability. **Choudhary and Singh (1970) and Dixit *et al*., (2001).**

3.1.3 DAYS TO APPEARANCE OF MALE FLOWERS IN 50% PLANTS

Days to first appearance of male flower shows the significant result. The minimum days to appearance of first male flowering recorded in T_4 GA_3 25 ppm (39.66738.933) followed by T_9 NAA 150 ppm (39.667) which was at par with each other and both treatments were superior to the T_1 control (45.533). The increase in male flowers might be due to fact that spraying GA_3 is possibly that the substance is reported the modification of sex to desired direction has to be manipulated by exogenous application of plant growth regulators (**Rudich, 1983).**

3.1.4 DAYS TO FIRST HARVEST

The minimum days to appearance of first harvest recorded in T_9 NAA 150 ppm (57.267) followed by T_4 GA_3 25 ppm (58.00) which was at par with each other and both treatments were superior to the T_1 control (62.80) shows the significant result. NAA increases appearance of female flowers, increase fruit setting and promotes early fruit maturity and reported that the number of days required to pick the mature fruits from flowering significantly influenced by growth regulator treatments. It was also noticed that number of days was reduced with NAA treatment. **Marbhal *et al.,* (2005).**

Table No1: Effect of plant growth regulators on growth parameters of Bitter gourd (*Momardica charantia* L.)

Treatments	**Vine length (cm)**	**Days to first appearance of female flowers**	**Days to first appearance of male flowers**	**Days to first harvest**
T_0 Control (water spray)	188.707	53.067	45.533	62.80
T_1 GA_3 15PPM	199.613	49.133	41.533	59.333
T_2 GA_3 20PPM	196.527	49.600	43.067	59.400
T_3 GA_3 25PPM	221.040	44.933	38.933	58
T_4 GA_3 30PPM	200.687	49.067	41.067	58.933
T_5 NAA 75PPM	200.427	49.067	41.133	59
T_6 NAA 100PPM	208.673	47.800	40.800	58.667
T_7 NAA 125PPM	199.013	49.133	41.200	59.133
T_8 NAA 150PPM	200.780	40.600	39.667	57.267
F-test	S	S	S	S
SE(d)	2.485	0.703	0.757	0.487
C.D at 5%	5.313	1.503	1618	1.041

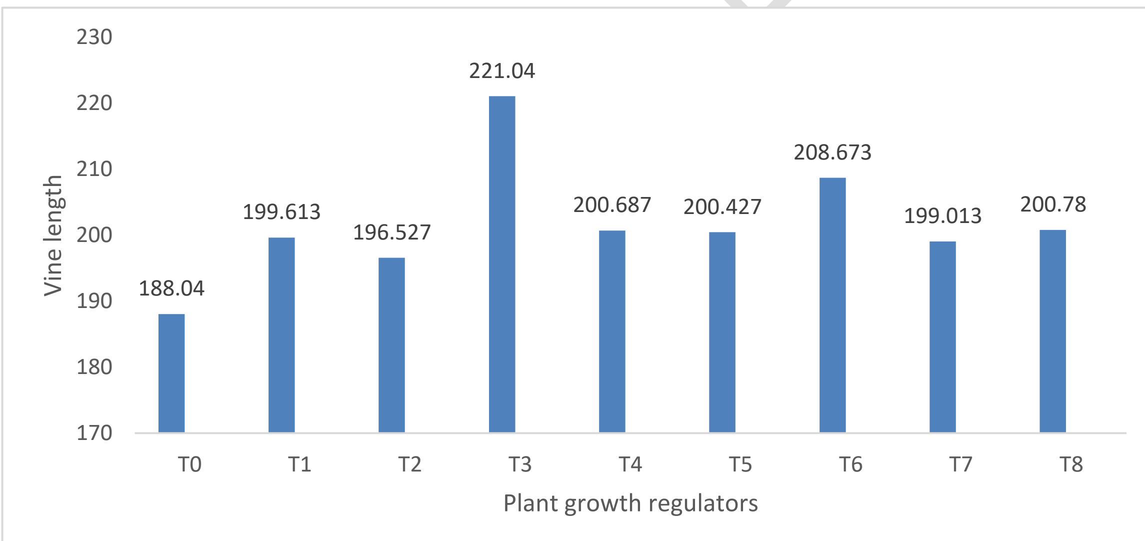

Fig. 1. Effect of Gibberellic acid and Naphthalene acetic acid on vine length of Bitter gourd.

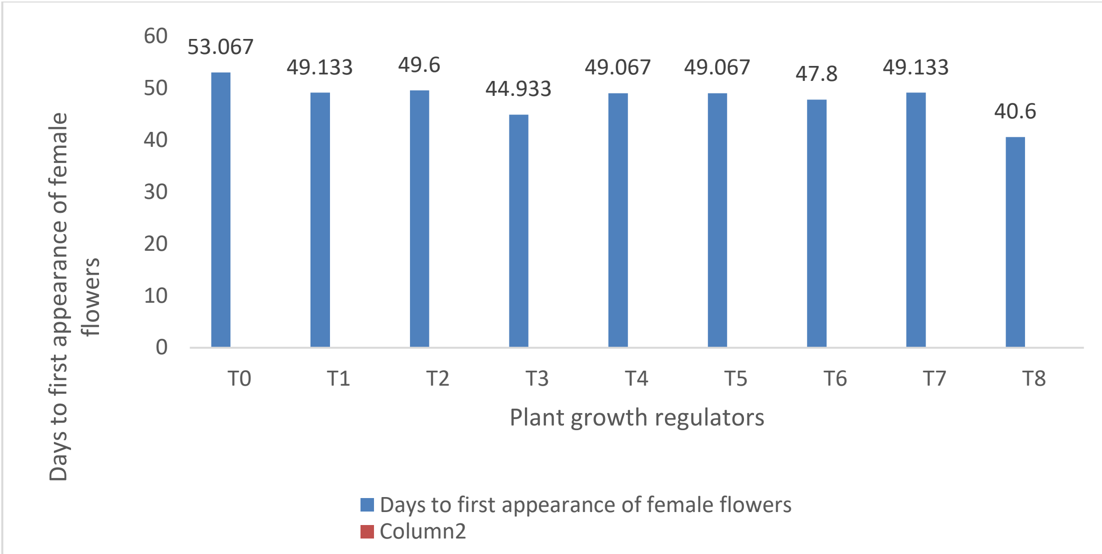

Fig. 2. Effect of Gibberellic acid and Naphthalene acetic acid on days to first appearance of female flowers of Bitter gourd.

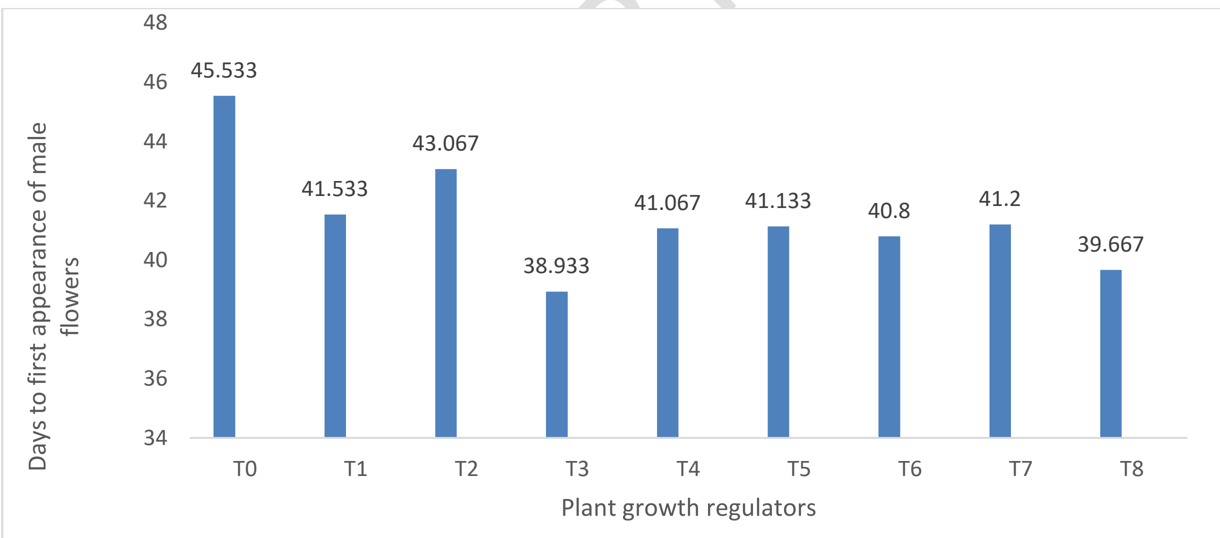

Fig. 3. Effect of Gibberellic acid and Naphthalene acetic acid on days to first appearance of male flowers of Bitter gourd.

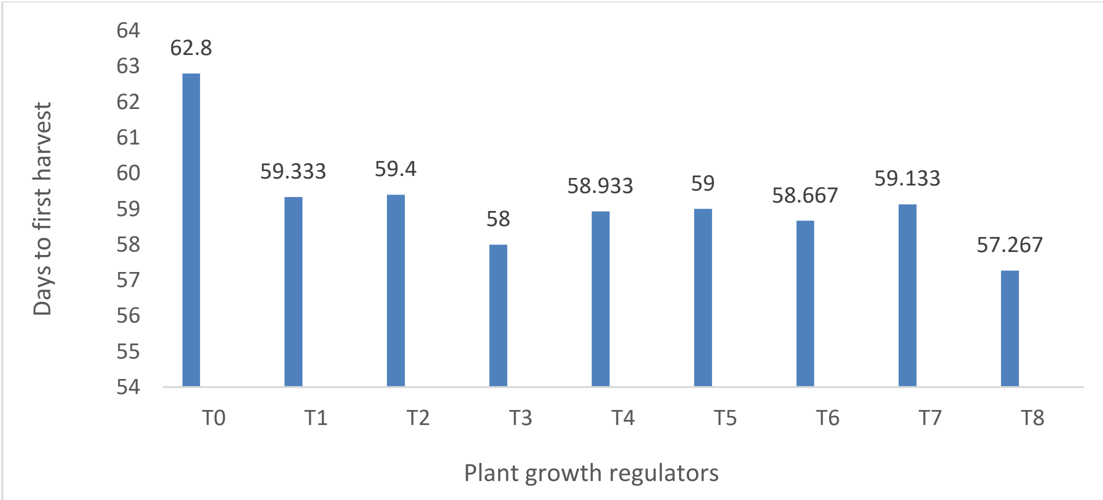

Fig. 4. Effect of Gibberellic acid and Naphthalene acetic acid on days to first Harvest of Bitter gourd

3.2 QUALITY ATTRIBUTES

Table No2: Effect of GA_3 and NAA on yield parameters of Bittergourd

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	No. of fruits	Average yield per plant (g)	Average tonne per hectare (t)
T_0 Control (water spray)	107.020	12.847	3.960	8.467	905.487	6.036
T_1 GA_3 15PPM	115.427	13.447	4.067	9.200	1062.573	7.083
T_2 GA_3 20PPM	112.567	13.407	4.027	8.867	998.380	6.655
T_3 GA_3 25PPM	126.947	13.773	4.333	11.200	1421.693	9.476
T_4 GA_3 30PPM	120.573	13.547	4.120	10.067	1216.227	8.107
T_5 NAA 75PPM	112.820	13.513	4.120	9.667	1088.740	7.257
T_6 NAA 100PPM	121.487	13.747	4.153	10.400	1263.920	8.424
T_7 NAA 125PPM	115.527	13.513	4.073	9.400	1086.940	7.245
T_8 NAA 150PPM	134.933	14.107	4.453	11.867	1609.100	10.725
F-test	S	S	S	S	S	S
SE(d)	1.839	0.129	0.062	0.167	32.503	0.216
C.D at 5%	3.932	0.276	0.133	0.358	69.496	0.463

3.2.1 FRUIT WEIGHT

The maximum fruit weight recorded in T_9 NAA 150 ppm (134.93) followed by T_4 GA_3 25 ppm (126.947) which was at par with each other and both treatments were superior to the T_1 control (107.02). Fruit weight is maximum may be due to the application of NAA and GA_3

which activating cell division and cell elongation along with increasing the metabolic activity which stimulates the cell and heavy fruits might be due to more carbohydrate's accumulation due to increased photosynthesis. **Gedam *et al., (*1998).**

3.2.2 LENGTH OF THE FRUIT

Analysis of Length of fruit data shows the significant result. The maximum length of the fruit recorded in T_9 NAA 150 ppm (14.107) followed by T_4 GA_3 25 ppm (13.773) which was at par with each other and both treatments were superior to the T_1 control (12.847). Fruit length is maximum may be due to the application of plant growth regulators NAA which activating cell division and cell elongation along with increasing the metabolic activity which promotes the length of fruit.

3.2.3 FRUIT DIAMETER

Analysis of Fruit diameter data shows the significant result. The maximum fruit diameter recorded in T_9 NAA 150 ppm (4.453) followed by T_4 GA_3 25 ppm (4.333) which was at par with each other and both treatments were superior to the T_1 control (3.960). The larger size of fruit might be due to the application of plant growth regulators which increase in cell division and cell elongation and can change the morphology of plants and enhancing the metabolic activity lead to higher accumulation of food reserves in the fruit. NAA significantly increased fruit diameter in bitter gourd. **Gedam *et al.*, (1998) and Dostogir *et al.,* (2006).**

3.2.4 NUMBER OF FRUITS

Analysis of Number of fruits data shows the significant result. The maximum No. of fruits per plant recorded in T_9 NAA 150 ppm (11.867) followed by T_4 GA_3 25 ppm (11.200) which was at par with each other and both treatments were superior to the T_1 control (8.467). The increase in number of fruits per plant may be due to application of NAA by which number of female flowers produced per plant increased which resulted in higher fruit set percentage. **Nagamani *et al.,* (2015) and Ghani *et al.,* (2013).**

3.2.5 AVERAGE YIELD PER PLANT

Analysis of Average yield per plant shows the significant result. The maximum Average yield per plot recorded in T_9 NAA 150 ppm (1,609.100) followed by T_4 GA_3 25 ppm (1,421.693) which was at par with each other and both treatments were superior to the T_1 control (905.487). The phenomenon to increase fruit yield might be due to application of plant growth regulators attributed that the plants remain physiologically more active to build by sufficient assimilates for the developing flowers and fruits which leads to higher yield and effect of auxins to cause physiological modifications in the plants mainly on sex ratio, increased fruit set, fruit weight and higher photosynthetic activity, synthesis and translocation of metabolites from source to sink points **(Hilli *et al.,* 2010).** Maximum fruit yield was recorded with the application of NAA@150 ppm**. KHATOON. R., MONIRUZZAMAN. M. *et al.,* (2019).**

3.2.6 YIELD TONNE PER HECTARE

Analysis of Yield tonnes per hectare shows the significant result. The Yield tonnes per hectare recorded maximum in T_9 NAA 150 ppm (10.725) followed by T_4 GA_3 25 ppm (9.476) which was at par with each other and the minimum yield tonnes per hectare recorded in T_1 control (6.036). The maximum yield tonnes per hectare might be due to application of plant growth regulators which increase the number of fruits and average fruit yield per plant by which yield tonnes per hectare increases. External application of NAA in bitter gourd also increased the yield of the crop. **(Melisa and Nina, 2005; Biradar *et al*., 2010).**

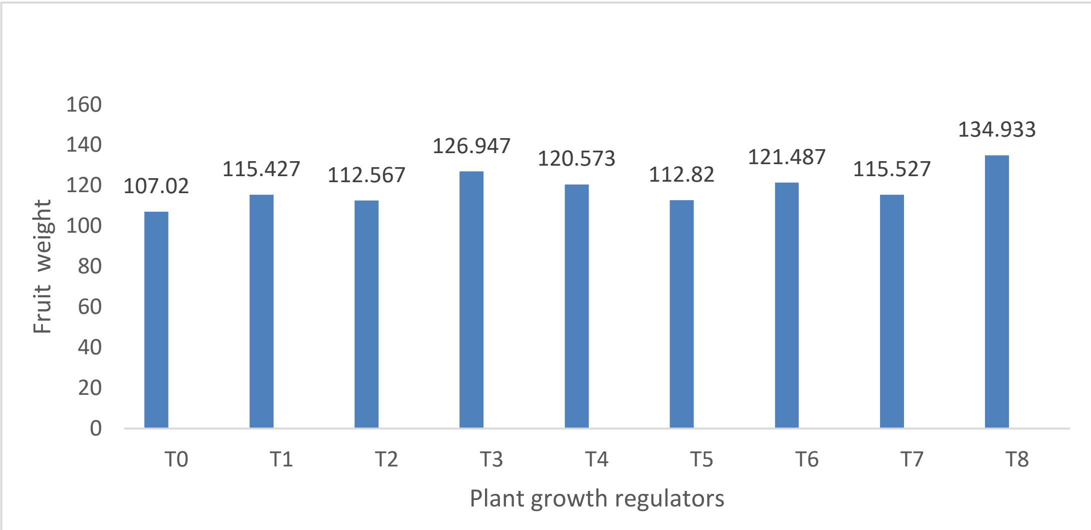

Fig. 5. Effect of GA_3 and NAA on Fruit weight of Bitter gourd

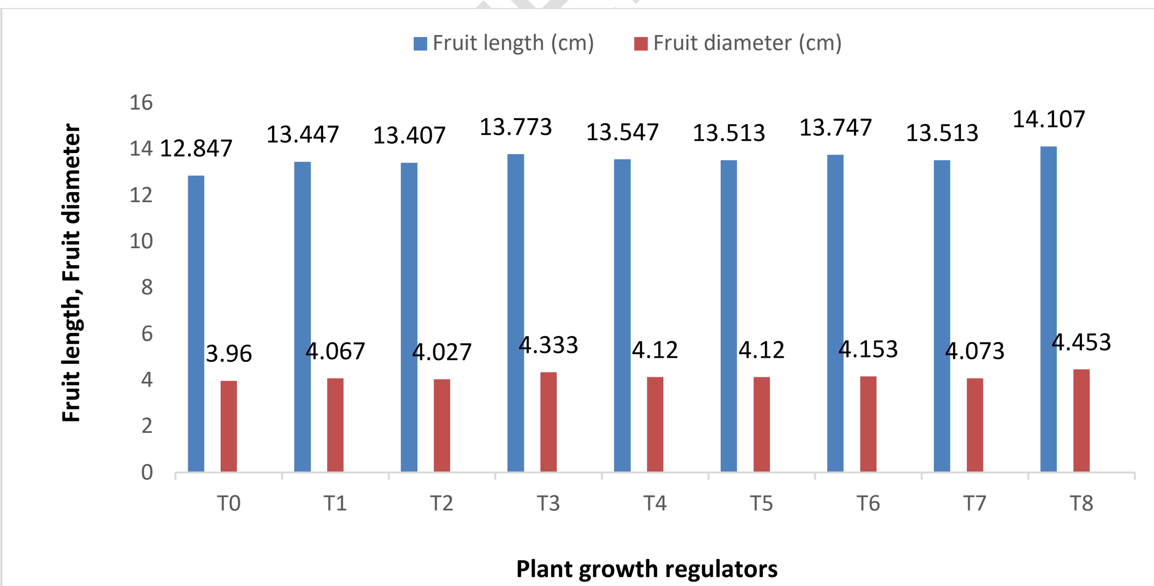

Fig. 6. Effect of GA_3 and NAA on Fruit Length, Fruit diameter of Bitter gourd

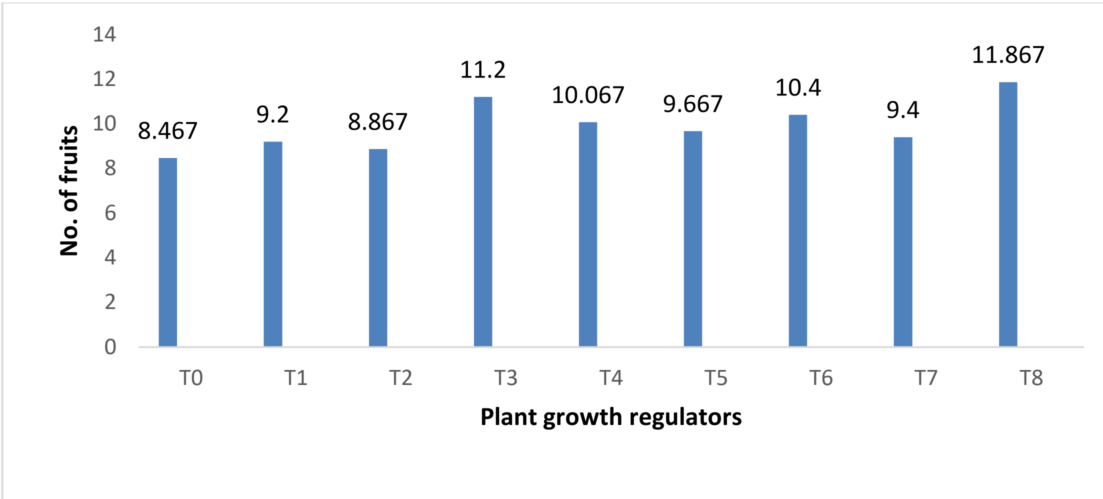

Fig. 7. Effect of GA_3 and NAA on No. of fruits per plant of Bitter gourd

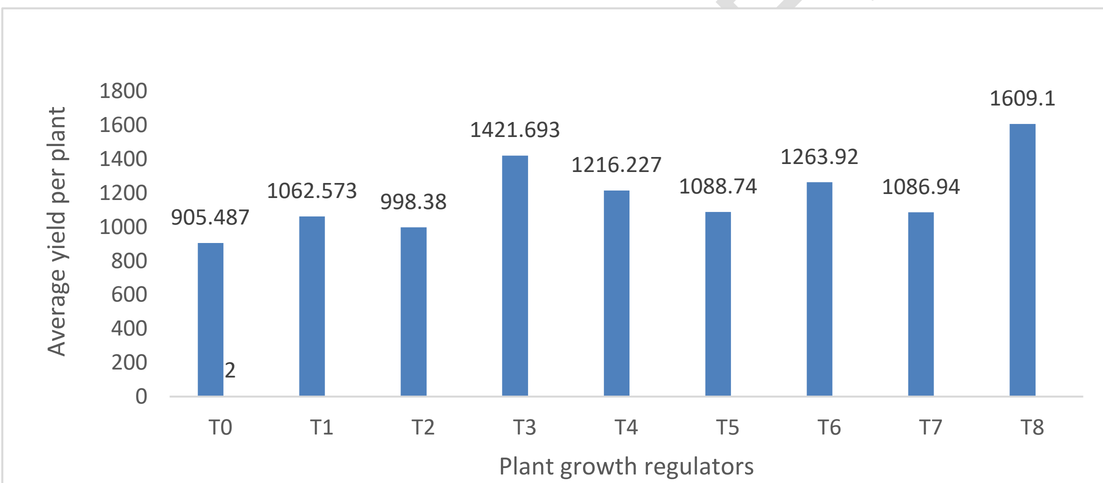

Fig. 8. Effect of GA_3 and NAA on Average yield per plant of Bitter gourd

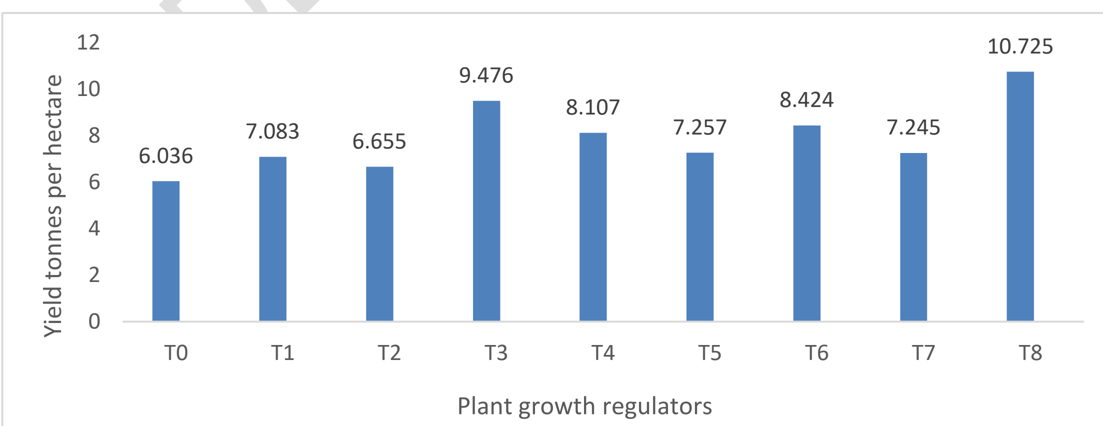

Fig. 9. Effect of GA_3 and NAA on yield tonnes per hectare of Bitter gourd

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4. CONCLUSION

From the results it was concluded that the plant growth regulators treatments rendered their significant effect on the better growth and development of the bitter gourd crop. In treatment T_3 recorded best in vine length at harvest and days to first appearance of male flowers and the treatment with NAA recorded best performance with respect to growth parameters like days to first appearance of female flowers in 50% plants, days to first harvest and yield parameters like average fruit length (cm), average fruit weight (g), fruit diameter (cm), fruit yield per plant (g), yield per hectare 10.72 showed maximum results.

ACKNOWLEDGEMENTS

It is a genuine pleasure to express my deep sense of thanks to my Guide, my inspiration Mr. Deepanshu , Assistant Professor, Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj, To the chairperson Dr. Rajesh singh, Assistant Professor, Department of Agronomy, SHUATS, Co-advisor, Dr. Vijay Bahadur, Associate Professor and Head, Department of Horticulture, SHUATS, members Dr. Anoorag R. Tyade, Assistant Professor Department of Entomology, SHUATS for providing help in various ways and offering valuable suggestions during the course of the research work

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aishwarya, K., Reddy, S.S., P., Syed, S., Ramaiah, M and Srinivasa Rao, G. (2019). Effect of plant growth regulators and stages of application on morphological and yield parameters of bittergourd cv. VK-1 Priya. *International Journal of Chemical Studies,* **7**(4): 2688-2692.

Arvindkumar, P.R., Vasudevan, S.N., Patil, M.G. (2014) Effect of foliar sprays of NAA, tricontanol and boron on growth and seed quality in bitter gourd (*Momordica charantia* L.) *Journal of Horticulture Sciences*, **9**(2):148-152.

Biradar, G., C. M. Nawalagatti, M. B. Dodaamani and M. B. Cheti. (2010). Effect of plant growth regulator on morphological parameters and yield in bitter gourd. Int. J. Agril. Sci. **6** (2):504-507.

Choudhury, B. and N. Singh. 1970. Chemical sex modification and its effect on fruit of cucumber (Cucumis sativus L) at three locations. Indian J. Hort**. 27** (3/4): 180-183.

Dixit, A., Rai, N and Kumar, V. (2001). Study on the effect of plant growth regulators in watermelon *(Citrullus janatus*) cv. Sugar Baby. *Indian Journal Agriculture Research*, **35**(1): 13-17.

Dostogir, H., MA Karim., MHR Pramanik and AAMS Rehman. (2006). Effect of gibberellic acid (GA3) on flowering and fruit development of bitter gourd (Momordica charantia L.).

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

Ghani, M.A., Amjad, M., Iqbal, Q., Nawaz, A., Hafeez, O.B.A., Abbas, M. and Ahmad, T. 2013. Efficacy of plant growth regulators on sex expression, earliness and yield components in bitter gourd. Pakistan Journal of Life and Social Science, **11**: 218-224.

Hossain, D. M., Abdul Karim, M., Pramanik, H.R., A. A.M. and Rahaman, S. (2006). Effect of Gibberellic Acid (GA_3) on Flowering and Fruit development of Bitter Gourd (*Momordica charantia L*.). *International Journal of Botany.,* **2**(3): 329-332.

Hilli, J.S., Vyakarnahal, B.S., Hunje, R. (2010). Effect of growth regulators and stages of spray on growth, fruit set and seed yield of ridge gourd (*Luffa acutangula L. Roxb*). *Karnataka Journal of Agriculture Sciences* **23**: 239–42.

Khatoon, R., Moniruzzaman, M. (2019). Effect Of Foliar Spray Of Ga3 And Naa On Sex Expression And Yield Of Bitter Gourd. *Bangladesh Journal of Agricultural Research*, **44**(2): 281-290.

Kumar, S., Dixit, S.K., and Mishra, H.R. (2006). Effect of plant growth regulators on yield and yield attributing characters of bottle gourd. *Advances of Plant Science*, **19** (2): 419-421.

Kumari, K., Kamalkant, Kumar, R., Singh V.K. (2019) Effect of Plant Growth Regulators on Growth and Yield of Bottle Gourd (*Lagenaria siceraria (Mol.) Standl.*). *International Journal of Current Microbiology and Applied Science,* **8**(7):1881-1885.

Mangal JL, Pandita ML, Singh GR. (1981). Effect of various chemicals on growth, flowering and yield of bittergourd. *Indian Journal of Agriculture Research.,* 15(3):185-188.

Marbhal, SK., AM Musmade., NV Kashi., MS Kamble and PV Kamthe. (2005). Effect of growth regulators and picking sequence on seed yield of bitter gourd. Haryana Journal of Horticultural Sciences, 34: 323-326

Mangave, B.D., Dekhane, S.S., Patel, D.J., And Dumbre, R.B. (2017). Effect Of Plant Growth Regulators on Growth and Sex Expression of Bitter Gourd. *Advance Research Journal of Crop Improvement*, **8**(2): 183-185.

Melissa, F., Tolentino and Nina, M., Cadiz. (2005). Effects of Naphthaleneacetic Acid (NAA) and Gibberellic Acid (GA3) On Fruit Morphology, Parthenocarpy, Alkaloid Content and Chlorophyll Content in Bitter gourd (*Momordica charantia* L*.). The Philippine Agricultural Scientist*, **88** (1): 35-39.

Nagamani, S., Basu, S., Singh, S., Lal, S.K., Behera, T.K., Chakrabarty, S.K. And Akshay Talukdar. (2015). Effect of plant growth regulators on sex expression, fruit setting, seed yield and quality in the parental lines for hybrid seed production in bitter gourd (Momordica charantia L.). *Indian Journal of Agricultural Sciences*, **85** (9): 1185–91.

Rafeekher, M., Nair, S. A., Sorte, P. N., Hatwal, G. P. and Chandhan, P. M. (2002). Effect of growth regulators on growth and yield of summer cucumber. *Journal Soils Crops*, **12:** 108-110.

Rudich J, 1983. Conference on the Biology and Chemistry of Cucurbitaceae. *Cornell University, Ithaca. New York August*.

Wang, Q.M. and Zeng, G.W. 1996. Effects of gibberellic acid and cycocel on sex expression of Momordica charantia. *Journal of Zhejiang Agriculture University*, **22**: 541-546.

Wang, Q.M. and Zeng, G.W. 1997. Morphological and histochemical study on sex differentiation on Momordica charantia. *Journal of Zhejiang Agriculture University*, **23:** 149-153.