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Study on Effect of Plant Growth Regulators (PGR) and Training System on Growth and Yield of Cucumber

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during the *Kharif* season, in 2023 in the Horticulture research field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj, U.P, India. The experiment was laid out in a Randomized Block Design (RBD) with twenty treatments and replicated thrice with four cucumber varieties (TMCU-1107, TMCU-1125, TMCU-3112, SAIRA-934). The observations are vine length, days to first appearance of male flower in 50% plants, days to first appearance of female flower in 50% plants, days to first harvest, average fruit weight, fruit length, fruit diameter, number of fruits per plant, average yield per plant, and yield per hectare. The results showed that viz., vine length (155.53 cm), days to first appearance of male flower in 50% plants (32.73), days to first appearance of female flower in 50% plants (39.20), days to first harvest (52.07), average fruit weight (245.93 g), fruit length (15.67 cm), fruit diameter (4.41 cm), number of fruits per plant (12.73), average yield per

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plant (3.13 kg/plant), yield per hectare (34.77 t/ha), were recorded significantly highest by the application of GA_3 – 30 ppm + NAA – 75 ppm + Single head system (Treatment 3) as compared to rest of the treatments.

Keywords: Cucumber; GA3; NAA; single head system; umbrella system; growth; yield.

1. INTRODUCTION

The cucumber belongs to the *Cucurbitaceae* (gourd family). The cucumber belongs to the genus *Cucumis.* The cucumber is native to the northwest of India and has been cultivated there for at least 3000 years. The cucumber is indigenous to India and likely originated from the foothills of the Himalayan Mountains. Gibberellic acid (GA_3), widely employed as a plant growth regulator, enhances stem elongation, overall plant growth, dry matter accumulation, and crop yield across various species. This compound, a tetracyclic di-terpenoid, functions as a plant hormone, stimulating seed germination and coordinating growth transitions from meristem to shoot, juvenile to adult leaves, and vegetative to flowering stages. It also influences sex expression and grain development, influenced by environmental factors such as light, temperature, and water availability. Naphthalene acetic acid (NAA), belonging to the auxin family, acts as a plant growth hormone mainly employed as a rooting agent for vegetative propagation via stem and leaf cuttings [1-4]. Its use significantly improves plant height, root formation, and total soluble solid content. When paired with gibberellic acid, NAA enhances cellulose fiber development in plants. Moreover, it aids in preventing premature fruit dropping and stem thinning when administered after flowering. Nonetheless, over application can negatively impact plant growth. Dalai et al. [5] observed that the combined application of plant growth regulators, specifically a mixture of GA_3 and NAA yielded significantly higher crop yields and associated characteristics in comparison to individual regulator applications. This combined treatment exhibited superior performance in various aspects, including plant height, number of primary branches, no. of female flowers, and fruit parameters such as no. of fruits per plant (10.34), fruit length, and fruit width at five days. Additionally, it resulted in increased fruit yield per plant (2.27 kg), fruit yield per plot, and fruit yield per hectare (173.60 q), while maintaining a minimal sex ratio (1:65). In the Single head training system, vines are trained onto an overhead wire using a singular approach. All flower buds and lateral branches are systematically pruned from the base of the vines up to a height of 60 cm. Fruits are selectively allowed to develop on the main stem, typically one per axil. As the main vine reaches the overhead wire, it is gently wound around it before being encouraged to continue growing towards the ground. In the Umbrella training system, a meticulous approach is taken to prune all flowers and lateral branches up to a specified height of 60 cm from ground level. This ensures focused growth. One fruit per axil is typically permitted on the stem, extending up to the overhead wire. Upon reaching the wire, the main vines' growing point is pruned, encouraging the development of two robust branches in opposite directions along the wire, each extending approximately 15 cm. These branches are then carefully trained to grow downward, with a fruit allocated to each axil, promoting balanced fruiting and efficient space utilization. Shivaraj et al. [6] revealed that Single head training system reported highest vine length, wider leaf area, more number of fruits per vine, highest fruit yield per vine, yield per plot, yield per hectare, marketable yield and lowest deformed fruits. Therefore, it is recommended that Single Head Training System can be followed in cucumber under protected conditions.

2. MATERIALS AND METHODS

2.1 Location of Study

The experiment was carried out in the Horticulture research field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P, during the *Kharif* season, 2023. The experiment was laid in a Randomized Block Design (RBD) with 20 treatments and replicated thrice with four cucumber varieties (TMCU-1107, TMCU-1125, TMCU-3112, SAIRA-934).

2.2 Treatments Details

The treatments are 1. GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU 1107 2. GA_3 – 30 ppm + NAA – 100 ppm + Single head system – TMCU-1107 3. GA_3 – 30 ppm + NAA – 75 ppm

+ Single head system – TMCU-1107 4. GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system – TMCU- 1107 5.GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU 1125 6. GA_3 – 30 ppm + NAA – 100 ppm+ Single head system – TMCU-1125 7. GA_3 – 30 ppm + NAA – 75 ppm+ Single head system – TMCU-1125 8.GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system – TMCU-1125 9.GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU-3112 10. GA_3 – 30 ppm + NAA – 100 ppm+ Single head system – TMCU-3112 11.GA_3 – 30 ppm + NAA – 75 ppm+ Single head system – TMCU-3112 12.GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system – TMCU-3112 13. GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – SAIRA 934 14.GA_3 – 30 ppm + NAA – 100 ppm + Single head system – SAIRA-93415.GA_3 – 30 ppm + NAA – 75 ppm + Single head system – SAIRA-934 16.GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system - SAIRA-934 17.Control @ R.D.F – TMCU- 1107 18. Control @ R.D.F – TMCU- 1125 19.Control @ R.D.F – TMCU- 3112 20.Control @ R.D.F – SAIRA-934.

2.3 Sampling Procedure

Five plants were randomly selected for recording observation of the growth and yield parameters of cucumber. The plant growth regulators specified in the treatments were administered as a foliar spray using a sprayer. The foliar application of all treatments was conducted twice: once at the 2 true leaf stage and again at the 4 leaf stage, targeting the surface of the leaves and apical meristems during the morning hours. The solution was prepared by dissolving 30 mg of gibberellic acid in a small quantity of ethyl alcohol. To make it dissolve a magnetic stir use. When complete GA granules dissolved in ethyl alcohol the volume was made to one litre by adding double distilled water to obtain 30 ppm concentration respectively. The 75 ppm and 100 ppm solution of NAA was prepared by dissolving respective amount of NAA granules in small quantity of alcohol and then made it into 1000 ml of distilled water. For making 75 ppm solution, 75 ml was taken from the stock solution and dissolved into 925 ml of distilled water. In a similar manner, 100 parts per million (ppm) of NAA solution were prepared by adjusting the ratio of distilled water for various concentrations.

2.4 Statistical Analysis

The data collected during the investigation were subjected to statistical Analysis of Variance (ANOVA) as described by Fisher (1950).

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The analysis of vine length data revealed a notable difference: Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) exhibited a significantly higher vine length of 155.53 cm at 60 days after sowing, while Treatment 20 (Control @ R.D.F – SAIRA-934) displayed the lowest vine length of 140.37 cm. This variance is likely attributed to the application of GA_3. The positive impact of GA_3 on growth can be attributed to its role in promoting cell division through mitosis and subsequent cell elongation, leading to an increase in cell size and ultimately resulting in enhanced vine length. Dinesh et al. (2016). Observations on the days required for the first appearance of male flowers in 50% of cucumber plants revealed significant differences among treatments. Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) displayed the shortest duration, with male flowers appearing in 32.73 days, closely followed by Treatment 14 (GA_3 – 30 ppm + NAA – 100 ppm + Single head system – SAIRA 934) at 33.13 days. Conversely, Treatment 17 (Control @ R.D.F – TMCU 1107) exhibited a longer period, with male flowers appearing after 35.13 days. This disparity can be attributed to the role of GA_3 in promoting early flowering, especially when applied in optimal concentrations, while higher doses of auxins like NAA tend to delay flowering. This delay is likely due to the enhanced cell division induced by lower doses of NAA, promoting vegetative growth over reproductive growth. The findings of this study are consistent with those reported by Nagamani et al. (2014) in bottle gourd, reinforcing the understanding of hormonal influences on flowering time in cucurbits. Kadi et al. (2018) in cucumber. Effect of Plant Growth Regulators and Training Systems on Days to first appearance of female flower in 50% plants of cucumber - Significantly fewer days taken for first appearance of female flower in 50% plants of cucumber were recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 39.20 days whereas higher days taken for first appearance of female flower in 50% plants of cucumber were recorded in Treatment 19 (Control @ R.D.F – TMCU 3112) 43.53 days. Plant growth regulators applied in a combined dose of GA_3 and NAA recorded more female flowers which might be due to the fact that they are known to increase the metabolization and also reduce sugar thereby

bringing a change in the membrane permeability. These results are in conformity with Dixit et al. (2001) in watermelon. Effect of Plant Growth Regulators and Training Systems on days to first harvest of cucumber - Significantly fewer number days taken for first harvest of cucumber were recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 52.07 days which was at per with Treatment 4 (GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system – TMCU 1107) 53.27 days whereas higher days taken for first harvest of cucumber were recorded in Treatment 19 (Control @ R.D.F – TMCU 3112) 56.33 days.

3.2 Yield Attributes and Yield

Effect of Plant Growth Regulators and Training Systems on average fruit weight of cucumber**-** The maximum average fruit weight of cucumber was recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 245.93 g which was at per with Treatment 9 (GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system– TMCU 3112) 231.93 g whereas minimum average fruit weight of cucumber was recorded in Treatment 19 (Control @ R.D.F – TMCU 3112) 177.93 g. Growth regulators increase the rate of photosynthesis activity, accelerated translocation, and efficiency of utilization of photosynthates, thus resulting in cell elongation and rapid cell division in the growing portion which increases fruit length and girth resulting in increased fruit weight. Promotion of individual fruit weight by the application of GA_3 was also reported by Kadi et al. (2018), Shafeek et al. [7], and Farhana [8] which is parallel to our findings. Effect of Plant Growth Regulators and Training Systems on fruit length of cucumber **-** The significantly highest fruit length of cucumber was recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 15.67 cm whereas the lowest fruit length of cucumber was recorded in Treatment 19 (Control @ R.D.F – TMCU 3112) 13.45 cm. Growth regulators increase the rate of photosynthesis activity, accelerated translocation, and efficiency of utilization of photosynthates, thus resulting in cell elongation and rapid cell division in the growing portion which increases fruit length and girth resulting in increased fruit weight. Promotion of individual fruit weight by the application of GA_3 was also reported by Kadi et al. (2018), Shafeek et al. [7], and Farhana [8] which is parallel to our findings. Effect of Plant Growth Regulators and Training Systems on fruit diameter of cucumber - Significantly highest fruit diameter of cucumber was recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 4.41 cm whereas the lowest fruit diameter of cucumber was recorded in Treatment 17 (Control @ R.D.F – TMCU 1107) 3.61 cm. Growth regulators increase the rate of photosynthesis activity, accelerated translocation, and efficiency of utilization of photosynthates, thus resulting in cell elongation and rapid cell division in the growing portion which increases fruit length and girth resulting in increased fruit weight. The promotion of individual fruit weight by the application of GA_3 was also reported by Kadi et al. (2018), Shafeek et al. [7], and Farhana [8] which is parallel to our findings. Effect of Plant Growth Regulators and Training Systems on number of fruits per plant of cucumber **-** Significantly highest number of fruits per plant of cucumber were recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 12.73 which was at per with Treatment 1 (GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU 1107) 11.80 whereas lowest number of fruits per plant of cucumber were recorded in Treatment 17 (Control @ R.D.F – TMCU 1107) 9.87.Effect of Plant Growth Regulators and Training Systems on average yield per plant of cucumber **-** Significantly highest average yield per plant of cucumber was recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 3.13 kg per plant which was at per with Treatment 9 (GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU 3112) 2.75 kg per plant whereas lowest average yield per plant of cucumber was recorded in Treatment 20 (Control @ R.D.F – SAIRA 934) 1.87 kg per plant. Mostly, in cucurbitaceous vegetables, soon after the flower, anthesis fails to fertilize, combined application of GA_3 and NAA would make the female part of the flower more active and hence reduce the abortion so better fertilization would take place. These findings closely conform with the findings of Aisha et al. [9]. Similarly, Hossain (1974) also reported a gradual increase in the yield per plant with a higher concentration of GA_3. Effect of Plant Growth Regulators and Training Systems on yield tonnes per hectare of cucumber **-** Significantly highest yield tonnes per hectare of cucumber was recorded in Treatment 3 (GA_3 – 30 ppm + NAA – 75 ppm + Single head system – TMCU 1107) 34.77 tonnes per hectare which were at per with Treatment 9 (GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system – TMCU 3112) 30.57 tonnes per hectare whereas lowest yield tonnes per hectare of cucumber was recorded in

Table 1. Effect of Plant growth regulators (PGR) and training system on growth parameter of Cucumber

Sl No.	Treatments	Variety	Vine length (cm) 60 DAS	Days to first appearance of male flower in 50% plants	Days to first appearance of female flower in 50% plants	Days to first harvest
1	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	TMCU – 1107	143.77	34.07	41.27	54.07
2	GA_3 – 30 ppm + NAA – 100 ppm + Single head system	TMCU – 1107	142.59	33.33	42.27	54.80
3	GA_3 – 30 ppm + NAA – 75 ppm + Single head system	TMCU – 1107	155.53	32.73	39.20	52.07
4	GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system	TMCU – 1107	144.43	34.47	42.93	53.27
5	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	TMCU – 1125	143.86	33.53	41.73	53.80
6	GA_3 – 30 ppm + NAA – 100 ppm+ Single head system	TMCU – 1125	145.25	34.33	42.60	54.47
7	GA_3 – 30 ppm + NAA – 75 ppm+ Single head system	TMCU – 1125	144.15	33.80	41.60	53.67
8	GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system	TMCU – 1125	145.20	33.93	41.20	53.47
9	GA_3 – 30 ppm + NAA – 75 ppm+Umbrella system	TMCU – 3112	144.37	33.87	41.60	54.33
10	GA_3 – 30 ppm + NAA – 100 ppm+ Single head system	TMCU– 3112	144.89	34.60	42.27	54.07
11	GA_3 – 30 ppm + NAA – 75 ppm+ Single head system	TMCU– 3112	144.09	33.67	42.33	54.47
12	GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system	TMCU– 3112	143.94	33.80	42.27	54.20
13	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	SAIRA – 934	143.70	33.53	41.93	54.27
14	GA_3 – 30 ppm + NAA – 100 ppm + Single head system	SAIRA – 934	145.56	33.13	42.07	54.13
15	GA_3 – 30 ppm + NAA – 75 ppm + Single head system	SAIRA – 934	145.86	33.53	41.87	53.53
16	GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system	SAIRA – 934	144.69	33.80	41.73	53.80
17	Control @ R.D.F	TMCU – 1107	143.29	35.13	41.27	53.53
18	Control @ R.D.F	TMCU – 1125	141.46	34.93	42.93	54.73
19	Control @ R.D.F	TMCU – 3112	141.39	35.33	43.53	56.33
20	Control @ R.D.F	SAIRA – 934	140.37	34.60	41.73	53.60
	F-test		**S**	**S**	**S**	**S**
	SEm(±)		**1.37**	**0.38**	**0.50**	**0.44**
	CD (P=0.05)		**3.91**	**1.10**	**1.43**	**1.25**

Table 2. Effect of Plant growth regulators (PGR) and training system on yield attributes of Cucumber

Sl No.	Treatments	Variety	Average Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruits/ plant (No.)	Average yield/plant (Kg)	Yield (t/ha)
1	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	TMCU – 1107	190.67	13.69	4.01	11.80	2.24	24.88
2	GA_3 – 30 ppm + NAA – 100 ppm + Single head system	TMCU – 1107	187.62	13.84	3.85	11.53	2.17	24.16
3	GA_3 – 30 ppm + NAA – 75 ppm + Single head system	TMCU – 1107	245.93	15.67	4.41	12.73	3.13	34.77
4	GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system	TMCU – 1107	229.50	14.22	3.71	11.73	2.70	29.97
5	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	TMCU – 1125	210.04	13.81	3.75	11.33	2.36	26.26
6	GA_3 – 30 ppm + NAA – 100 ppm+ Single head system	TMCU – 1125	214.72	14.13	3.71	11.47	2.46	27.30
7	GA_3 – 30 ppm + NAA – 75 ppm+ Single head system	TMCU – 1125	191.46	13.53	4.05	12.33	2.36	26.22
8	GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system	TMCU – 1125	189.65	13.91	3.73	12.07	2.27	25.27
9	GA_3 – 30 ppm + NAA – 75 ppm+Umbrella system	TMCU – 3112	231.93	13.84	3.75	11.87	2.75	30.57
10	GA_3 – 30 ppm + NAA – 100 ppm+ Single head system	TMCU– 3112	221.20	14.39	3.65	12.20	2.70	30.01
11	GA_3 – 30 ppm + NAA – 75 ppm+ Single head system	TMCU– 3112	188.53	14.41	3.73	11.47	2.16	24.00
12	GA_3 – 30 ppm + NAA – 100 ppm+ Umbrella system	TMCU– 3112	178.44	14.25	3.77	11.53	2.06	22.90
13	GA_3 – 30 ppm + NAA – 75 ppm+ Umbrella system	SAIRA – 934	212.07	13.66	3.67	10.93	2.32	25.76
14	GA_3 – 30 ppm + NAA – 100 ppm + Single head system	SAIRA – 934	219.60	14.12	3.69	11.20	2.47	27.41
15	GA_3 – 30 ppm + NAA – 75 ppm + Single head system	SAIRA – 934	198.86	14.13	3.75	11.27	2.24	24.90
16	GA_3 – 30 ppm + NAA – 100 ppm + Umbrella system	SAIRA – 934	204.40	14.25	3.68	11.47	2.34	26.01
17	Control @ R.D.F	TMCU – 1107	195.20	14.07	3.61	9.87	1.92	21.35
18	Control @ R.D.F	TMCU – 1125	192.13	13.99	3.63	10.53	2.04	22.66
19	Control @ R.D.F	TMCU – 3112	177.93	13.45	3.65	10.73	1.91	21.23
20	Control @ R.D.F	SAIRA – 934	183.40	13.87	3.63	10.13	1.87	20.74
	F-test		**S**	**S**	**S**	**S**	**S**	**S**
	SEm(±)		**13.55**	**0.33**	**0.05**	**0.33**	**0.17**	**1.84**
	CD (P=0.05)		**38.78**	**0.94**	**0.15**	**0.95**	**0.47**	**5.27**

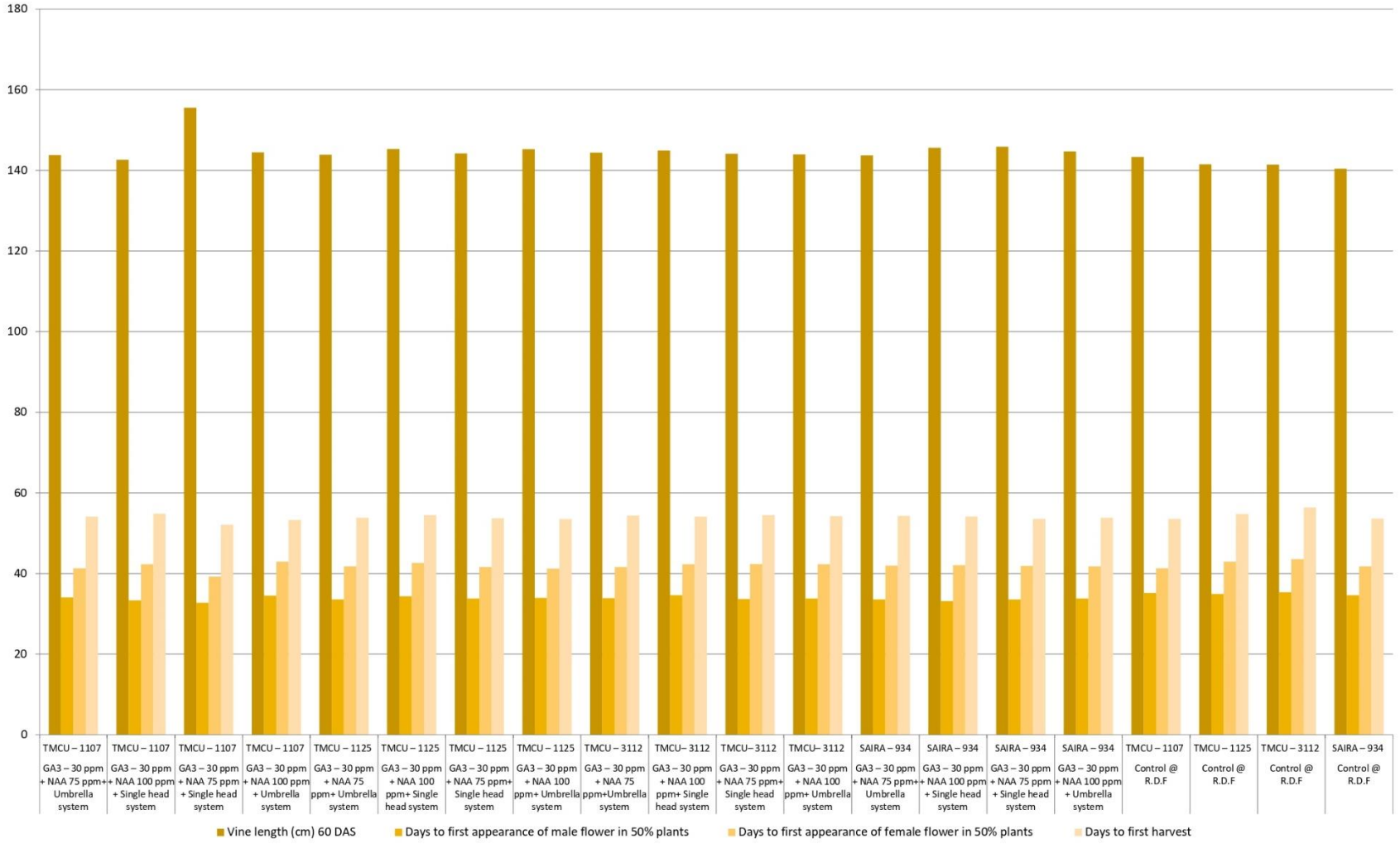

Chart 1. Effect of Plant growth regulators (PGR) and training system on growth parameter of cucumber

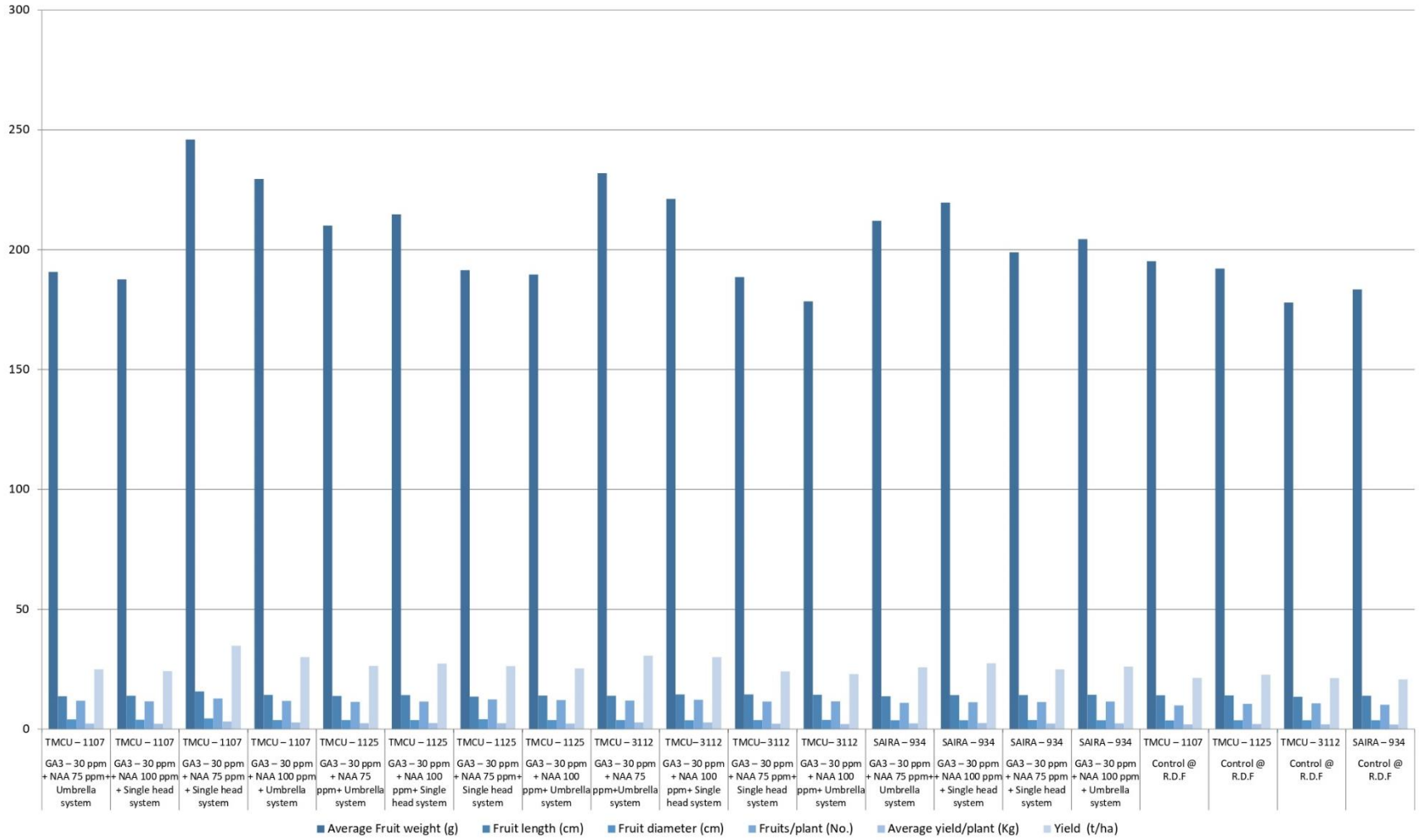

Chart 2. Effect of Plant growth regulators (PGR) and training system on yield attributes of cucumber

Treatment 20 (Control @ R.D.F – SAIRA 934) 20.74 tonnes per hectare. An increase in fruit yield in treated plants may be attributed to the reason that plants remain physiologically more active to build up sufficient sources for the developing female flowers and fruits, ultimately leading to higher fruit yield in cucumbers. These results confirmed the finding of Imamsaheb and Hanchimani [10] in bitter gourd [11-16].

4. CONCLUSION

Based on the findings of the study, GA_3 30 ppm + NAA 75 ppm along with a single head system (Treatment 3), recorded highest yield of 34.77 t/ha.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Guchhait P, Varma S, Banerjee D, Kumar S, Halder R, Dahiya A. Plant growth regulators and rooting media: A viable approach for growth and performance of citrus. J. Exp. Agric. Int. [Internet]. 2024 Mar. 26 [cited 2024 Jun. 10];46(5):366-78. Available:https://journaljeai.com/index.php/JEAI/article/view/2387
2. Jain S, Nidhi N, Kale S, Rathod M, Dhurve L, Mehara H, Baidya BK, Shivani. A comprehensive review on role of bio-regulators in the growth and development of fruit and vegetable crops. Int. J. Environ. Clim. Change. [Internet]. 2023 Nov. 14 [cited 2024 Jun. 10];13(11):2879-92. Available:https://journalijecc.com/index.php/IJECC/article/view/3458
3. Giannakoula AE, Ilias IF, Maksimović JJ, Maksimović VM, Živanović BD. The effects of plant growth regulators on growth, yield, and phenolic profile of lentil plants. Journal of Food Composition and Analysis. 2012 Nov 1;28(1):46-53.
4. Lopez-Lauri F. Plant growth regulators. Postharvest Management Approaches for Maintaining Quality of Fresh Produce. 2016 Feb 24:125-39.
5. Dalai S, Singh MK, Soni S. Yield and yield traits of cucumber (*Cucumis sativus L.)* as influenced by foliar application of plant growth regulators. *Int. J. Curr. Microbiol. App. Sci.* 2020;9(3):121-126.
6. Shivaraj, Prasanth P, Lakshminarayana D, Ramesh T. Studies on the effect of training systems on cucumber (*Cucumissativus*L.) cv. malini grown under protected conditions. Current Journal of Applied Science and Technology. 2020;39(48): 539-544.
7. Shafeek MR, Helmy YI, Ahmed AA, Ghoname AA. Effect of foliar application of growth regulators (GA_3 and Ethereal) on growth, sex expression, and yield of summer squash plants (*Cucurbita pepo* L.) under plastic house condition. International Journal of Chem Tech Research. 2016; 9(6):70-76.
8. Farhana U. Effects of plant growth regulators on flowering behavior and yield of cucumber. M.Sc. (Ag.) Thesis, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh; 2015.
9. Aisha S, Chaudhary NY. GA_3 improves flower yield in some cucurbits treated with lead and mercury. African Journal of Biotechnology. 2006;5:149-153.
10. Imamsaheb SJ, Hanchinmani CN. Effect of different levels of fertilizers and growth regulator on growth, yield, and economy of bitter gourd under north eastern transition zone. Plant Archives. 2014;14(2):871-874.
11. Vedigeri BG, Madalgeri BB, Sheelavantar MN. Effect of ethrel and gibberellic acid on yield and quality of two cucumber varieties. Karnataka J. Agric. Sci. 2001;14(3): 727-730.

12. Mukesh Thappa, Satesh Kumar, Romisa Radiq. Influence of plant growth regulators on morphological, floral and yield of cucumber (*Cucumis sativus* L.). *Kasetsart J. (Nat. Sci*.) 2010;45:177-188.
13. Shoko Hikosaka, Nobuo Sugiyama. Effects of exogenous plant growth regulators on yield, fruit growth, and concentration of endogenous hormones in gynoecious parthenocarpic cucumber (*Cucumis sativus* L.). The Horticulture Journal. 2015;84(4):342–349.
14. Ajay KS, Asati KP, Swathi B, Tulasigiri RG. Effect of different plant growth regulators on growth, yield and quality parameters in cucumber. Int. Curr. Microbiol. App. Sci. 2018;7(4): 2319-7706.
15. Dinesh P, Prasanth D, Lakshminarayana K, Nagaraju, Gouthami P. Efficacy of plant growth regulators on growth and flowering of cucumber (*Cucumissativus L.)* cv. malini under shade net conditions. Int. J. Curr. Microbiol. App. Sci. 2019;8(9): 313-317.
16. Sapkota, Dhital M, Shrestha B, Tripathi KM. Effect of plant growth regulators on flowering and fruit yield of cucumber (*Cucumissativus*cv. Malini) in Chitwan, Nepal. Journal of Agriculture and Forestry University. 2020;4:161-167.

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