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Effect of TA41 on Growth, Yield and fruit Quality of Hybrid Cucumber (*Cucumis sativus* L.) under Protected Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Protected cultivation provides a means to mitigate abiotic and biotic stresses, enabling crop production even in adverse climates. A field experiment was carried out from March to May 2022 at the Horticulture Research Field in the Department of Horticulture, Naini Agricultural Institutes, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.) India, the effects of the treatment TA41 on hybrid cucumber were investigated. The experiment was entitled as "Effect of TA41 on growth, yield and fruit quality of hybrid cucumber (*Cucumis sativus* L.) under

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protected condition" with randomized block design (RBD) with three replications and ten treatments. The experiment results revealed that hybrid cucumber performed extremely well under protected condition with respect to growth, earliness, yield and quality parameters. While taking the observation it was seen that in growth parameters, earliness and yield parameters, the highest values were recorded significantly maximum in treatment T_8: Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt. while comparing the qualitative parameters the highest values were recorded significantly maximum in treatment T_4: Soil drenching of TA41 @ 15 ml/lt. + Foliar spray of TA41 @ 25 ml/lt. The benefit:cost ratio was obtained highest in treatment T_4 (3.53). Besides, this hybrid also proved to be the best in terms of disease resistance and profitability. This study contributes valuable insights into the benefits of protected cultivation and the potential of TA41 for improving cucumber production. The findings have practical implications for growers, providing them with evidence-based recommendations to enhance their crop yields, quality, disease resistance, and profitability.

Keywords: Benefit cost ratio; earliness; fruit quality; growth; pgr (ta41); yield.

1. INTRODUCTION

The commonly grown vegetables in India such as cucumber, pumpkin, and gourds are known to play an important role in India's farming contributing to about 6.5 million tons of cucurbits which is the highest in South Asia. Though authentic statistical records of area, production and productivity of Cucumber are not available but in the year 2019 India produced approximately 20.3 million tons of cucumbers making it the second-highest producer of cucumbers globally just behind China (FAO, 2019).

The Cucumber (*Cucumis sativus* L.) belongs to the family Cucurbitaceae is an annual plant species and is found to be day neutral, containing 0.4% protein, 2.5% carbohydrates, 1.5mg iron and 2mg of vitamin C per 100g fresh weight, and has eventually emerged as the fourth important vegetable in the world. Basically, it is a monoecious, trailing or climbing vine with angled hirsute or rough stems. They. Cucumber had its origin as well as domestication in India and spread to other parts of the world.

Trichoderma species use different mechanisms for pathogen inhibition, such as mycoparasitism via hydrolytic enzyme secretion, antibiosis via secondary metabolite production, competition for space and nutrients, promoting plant growth, and inducing plant systemic resistance mechanisms [1]. Trichoderma spp. are effective biocontrol agents due to the rapid multiplication or the tolerance of harsh conditions [2]. Trichoderma spp. have effective antagonism and mycoparasitic actions on plant pathogens, allowing them to reduce the incidence of plant diseases, and the key mechanism for Trichoderma species is hyper parasitism opines the earlier reports [3,4]. The Trichoderma colonization of roots causes root hair growth and triggers defense activities, such as significant changes in a variety of metabolic pathways and the activation of genes involved in plant host defines, primarily through signalling pathways involving jasmonic acid and ethylene [5].

Using plant growth regulators can be a great way to improve crop production and increase the number of crops grown. These regulators are substances that can be applied to plants to help them grow faster, stronger and produce more fruit or vegetables. Applying plant growth regulators on plants externally can alter the natural growth and development of plants. This means that farmers can use plant growth regulators to manipulate the physiological processes of plants which can potentially increase their crop yield and better crop quality.

2. MATERIALS AND METHODS

The experiment was conducted in the Horticulture Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.) from March to May 2022. The experiment was conducted on hybrid cucumber (*Cucumis sativus* L.) var. Gurka F1 under protected condition with ten treatments including control (Table 1) and three replications in randomized block design under protected condition. Five plants were randomly selected per treatment for recording the observations.

Table 1. Treatment details of different concentrations & method to apply PGR (TA41) on cucumber

Treatment	Treatment Combination
T_0 (control)	Without any treatment of TA41.
T_1	Soil drenching of TA41 @ 10 ml/lt.
T_2	Soil drenching of TA41 @ 10 ml/lt. + Foliar spray of TA41 @ 5 ml/lt.
T_3	Soil drenching of TA41 @ 15 ml/lt.
T_4	Soil drenching of TA41 @ 15 ml/lt. + Foliar spray of TA41 @ 25 ml/lt.
T_5	Soil drenching of TA41 @ 20 ml/lt.
T_6	Soil drenching of TA41 @ 20 ml/lt. + Foliar spray of TA41 @ 35 ml/lt.
T_7	Soil drenching of TA41 @ 25 ml/lt.
T_8	Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.
T_9	Foliar spray of TA41 @ 15 ml/lt.

2.1 Statistical Analysis

The data recorded throughout the course of investigation was subjected to Statistical analysis by using analysis of variance (ANOVA) for randomized block design (RBD) by Fischer and Yates (1963). Whenever 'F' test was found significant for comparing the means of two treatments, a critical difference (C.D. at 5%) was worked out.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant Height

At 60 days after transplanting, the maximum plant height was recorded in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 103.97 cm while treatment T_0 (control) shows the minimu vbm plant height which was 91.57 cm.

This might be due to the fact that Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt. act as a nutrilink to plants increasing hormonal concentration, nutritional condition, enzyme activation and these may have contributed to a considerable extent for better plant height and number of nodes. Similar results were also reported by Saptari RT et al., [6] who reported that TA41 can promote the activity of xyloglucan endotransglucosylase which cause loosening of cell wall and increases cell permeability. Similar result was found in brinjal by Meena and Dhaka [7].

The general positive effect of these bio stimulants was proportional to their concentrations i.e., more plant height was recorded under higher concentrations of these growth eliciting substances.

3.1.2 Number of nodes

At 60 days after transplanting, the maximum number of nodes was recorded in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 21.13 while treatment T_0 (control) shows the minimum number of nodes which was 18.33.

The marked increase in number of nodes might be due to the possible stimulation of meristematic tissues by auxin accelerating greater cell division and cell enlargement in growing portions. Findings are in accordance with the findings of Viradia et al*.,* [8] and El-Soad et al*.,* [9].

Biofertilizers also produced the growth promoting substances like auxins, gibberellins and cytokinins potentially leading to increased branching and node formation. Similar result was found in chilli and capsicum by Raj et al*.,* [10].

3.2 Earliness Parameters

3.2.1 Days to first flowering (Female)

Data analysis showed that the days to first flowering (female) was recorded maximum in treatment T_0 (control) which was 24.73 while the minimum was found in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 19.60.

More intensive flower setting was elicited by improved endogenous components, especially gibberellic acid (GA_3). They stimulate shoot elongation and induce flowering in many plant species. Similar result was found in cucumber by Dalai et al*.,* [11] who concluded foliar application of GA3 influenced phenological requirement in cucumber.

3.2.2 Days to first fruit setting

Data analysis showed that the days to first fruit setting was recorded maximum in treatment T_0 (control) which was 28.67 while the minimum was found in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 23.47.

This could be attributed to enhanced photosynthetic activity, increased production and accumulation of carbohydrates and favourable effect on vegetative growth and retention of flowers which increased fruit set percentage and decreasing days to first fruit setting. These results are in accordance with the findings of Baliyan et al*.,* [12] in tomato and Das et al*.,* [13] in bell pepper.

3.2.3 Days to first fruit picking

Data analysis showed that the days to first fruit picking was recorded maximum in treatment T_0 (control) which was 38.73 while the minimum was found in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 33.67.

This could be attributed to enhanced photosynthetic activity, increased production and accumulation of carbohydrates and favourable effect on vegetative growth and retention of flowers which increased fruit set percentage and decreasing days to first fruit picking. TA41 also has a potential to check flowers and fruits drops. These results are in accordance with the findings of Baliyan et al*.,* [12] in tomato and Das et al*.,* [13] in bell pepper.

3.2.4 Node number bearing first female flower

Data analysis showed that the node number bearing first female flower was recorded maximum in treatment T_0 (control) which was 1.67 while the minimum was found in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 1.13.

This might be due to the combined effect of gibberellins and auxin which induces early flowering at lower nodes. Early flowering of treated plants may be due to induction of tendency of femaleness in the plant and increased levels of auxin might have resulted in the early induction of flowers. Similar findings were obtained by Mia et al*.,* [14] in bittergourd.

3.3 Yield Parameters

3.3.1 Number of female flowers / plant

Data analysis showed that the number of female flowers / plant was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 27.00 while the minimum was found in treatment T_0 (control) which was 21.67.

This might be due to the higher levels of endogenous auxin which leads to the initiation and maintenance of more floral meristems, resulting in an increased number of female flowers. Also, endogenous auxin helps in the growth and differentiation of carpels, promoting the development of more female flowers. Similar results were also reported by Yamasaki et al*.,* [15] in cucumber.

3.3.2 Number of fruits / plant

Data analysis showed that the number of fruits / plant was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 26.00 while the minimum was found in treatment T_0 (control) which was 20.33.

Proper nutrients promote vigorous growth of cucumber plant, which ultimately increases the number of fruits per plant, which confirm the observation of Waseem et al*.,* [16] for cucumber.

The number of fruits per plant is an important determination of yield in brinjal due to providing efficiency part and hormonal balance in the plant system [17]. Similar results were reported by Choudhury et al*.,* [18].

3.3.3 Fruit yield / plant (kg)

Data analysis showed that the fruit yield / plant was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 4.50 while the minimum was found in treatment T_0 (control) which was 2.78.

The possible reason for increased fruit yield might be associated to better inorganic nitrogen utilization in the presence of bio fertilizers, which enhanced biological nitrogen fixation, better development of root system and possible higher synthesis of plant growth hormones. Similar

results were also reported by Gajbhiye et al., [19].

Proper nutrients promote vigorous growth of cucumber plant, which ultimately increases the number of fruits per plant increasing fruit yield / plant (kg). Similar results were also reported by Waseem et al., [16] in cucumber.

3.3.4 Fruit yield / plot (kg)

Data analysis showed that the fruit yield / plot was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 36.00 while the minimum was found in treatment T_0 (control) which was 22.21.

An increase in fruit yield in treated plants may be attributed to the reason that plants remain physiologically more active to build up sufficient source for the developing flowers and fruits, ultimately leading to higher yield. Similar results were also reported by Kalantar et al., [20] and Mia et al., [14].

Proper nutrients promote vigorous growth of cucumber plant, which ultimately increases the number of fruits per plant, which confirm the observation of Waseem et al., [16] for cucumber.

3.3.5 Fruit yield / 250 sq. m. (q)

Data analysis showed that the fruit yield / 250 sq. m. was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 62.50 while the minimum was found in treatment T_0 (control) which was 38.56.

An increase in fruit yield in treated plants may be attributed to the reason that plants remain physiologically more active to build up sufficient source for the developing flowers and fruits, ultimately leading to higher yield. Similar results were also reported by Kalantar et al., [20] and Mia et al., [14].

The possible reason for increased fruit yield might be associated to better inorganic nitrogen utilization in the presence of bio fertilizers, which enhanced biological nitrogen fixation, better development of root system and possible higher synthesis of plant growth hormones. Similar results were also reported by Gajbhiye et al., [19].

3.3.6 Average Fruit Weight (gm)

Data analysis showed that the average fruit weight was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 173.23 while the minimum was found in treatment T_0 (control) which was 136.74.

It was due to the content level of nitrogen, phosphorus and potassium in TA41 having higher nutrients than other treatments which play a vital role in fruit growth and development especially at cell division stage, consequently affecting size and weight of fruit. Similar results were reported by Kumaran et al., [21] and Solanki et al., [22].

3.3.7 Fruit length (cm)

Data analysis showed that the fruit length was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 14.11 while the minimum was found in treatment T_0 (control) which was 11.83.

Fruit development is highly affected by auxin formation in the growing seeds and other parts of the fruit to supply food reserves in order to increase fruit development. Moreover, microorganisms that produce auxin are VAM and Azospirillum sp. as microbe, which attaches nitrogen and plays as growth regulator. Similar results were reported by Sam et al., [23] in brinjal.

3.3.8 Fruit Girth (mm)

Data analysis showed that the fruit girth was recorded maximum in treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) which was 32.95 while the minimum was found in treatment T_0 (control) which was 25.33.

Fruit development is highly affected by auxin formation in the growing seeds and other parts of the fruit to supply food reserves in order to increase fruit development. Moreover, microorganisms that produce auxin are VAM and Azosprillium sp. as microbe, which attaches nitrogen and plays as growth regulator. Similar results were reported by Sam et al., [23] in brinjal.

Table 2. Effect of TA41 on growth, earliness, yield and quality parameters on hybrid cucumber

Treatment	Plant Height (cm)	Number of Nodes	Days to 1st Flowering (Female)	Days to 1st Fruit Setting	Days to 1st Fruit Picking	Node Number Bearing 1st Female Flower	Number of Female Flowers/ Plant	Number of Fruits/ Plant	Fruit Yield per Plant (kg)	Fruit Yield per Plot (kg)	Fruit yield per 250 sq. m (q)	Average Fruit Weight (gm)
T_0	91.57	18.33	24.73	28.67	38.73	1.67	21.67	20.33	2.78	22.21	38.56	136.74
T_1	98.13	19.83	20.53	24.13	34.2	1.4	23.67	22.67	3.66	29.31	50.87	161.75
T_2	100.4	20.27	20.27	24.27	34.4	1.4	23	22	3.64	29.09	50.5	166.48
T_3	100.53	20.07	20.6	24.47	34.73	1.33	22.67	21.33	3.34	26.75	46.43	157.15
T_4	102.5	20.33	19.8	23.67	33.87	1.2	26	24.67	4.23	33.84	58.74	171.83
T_5	100.97	19.9	20.13	24.2	34.13	1.27	24.67	23.33	3.55	28.37	49.26	152.79
T_6	101.9	20.13	20.2	23.93	33.8	1.47	25	24	3.77	30.13	52.31	157.17
T_7	102	19.97	19.87	24	34	1.27	22	20.67	3.45	27.6	47.91	167.2
T_8	103.97	21.13	19.6	23.47	33.67	1.13	27	26	4.5	36	62.5	173.23
T_9	101.23	19.87	20	24	34.67	1.53	23.67	22.67	3.54	28.35	49.21	156.67
F Test	S	S	S	S	S	NS	S	S	S	S	S	S
S. Ed. (±)	1.01	0.48	0.63	0.72	0.71	0.22	1.12	1	0.15	1.21	2.11	7.49
CD (5%)	2.11	1.02	1.31	1.5	1.49	0.46	2.35	2.09	0.32	2.55	4.43	15.73
CV	1.23	2.97	3.72	3.58	2.5	19.69	5.73	5.36	5.1	5.1	5.1	5.73

Table 3. Fruit Length, Fruit Girth, TSS, Vitamin C and Juice Percentage against different treatments

Treatment	Fruit Length (cm)	Fruit girth (mm)	TSS (°Brix)	Vitamin C (mg/100 g)	Juice Percentage
T_0	11.83	25.33	3.24	5.4	78.3
T_1	12.11	31.32	3.54	5.43	82.6
T_2	12.75	25.57	3.33	5.7	80.73
T_3	13.46	29.74	3.6	5.97	79.9
T_4	13.97	31.62	4.72	6.47	88.37
T_5	13.59	28.56	3.82	5.7	83.7
T_6	12.9	26.68	3.54	6.03	84.73
T_7	13.32	28.65	3.47	5.87	84.77
T_8	14.11	32.95	4.05	6.17	86.87
T_9	13.18	28.35	3.57	5.8	85.5
F Test	S	S	S	NS	S
S. Ed. (±)	0.35	0.36	0.27	0.31	0.64
CD (5%)	0.74	0.75	0.57	0.64	1.35
CV	3.27	1.51	9.03	6.41	0.95

3.4 Qualitative Parameters

Application of TA41 resulted in more total soluble solids, ascorbic acid and juice percentage in the cucumber. Maximum TSS, ascorbic acid and juice percentage was observed in the treatment T_4 (Soil drenching of TA41 @ 15 ml/lt. + Foliar spray of TA41 @ 25 ml/lt.) which was 4.72, 6.47 & 88.37 respectively while least was observed in treatment T_0 (control) which is 3.24, 5.4 & 78.3 respectively.

Adding bio-fertilizer and nutrients like nitrogen, phosphorus, and potassium can improve the quality of plants. This is because it boosts the plant's ability to make food (photosynthesis) and use nutrients (metabolism) resulting in more acids, compounds and sugar being produced by the plant. These results are in conformity with Kamili et al*.,* [24] in brinjal. Similar results were reported by Kumaran SS and Natarajan S. [21] in tomato.

4. CONCLUSION

On the basis of present investigation, it is concluded that the treatment T_8 (Soil drenching of TA41 @ 25 ml/lt. + Foliar spray of TA41 @ 45 ml/lt.) is proved as a best combination of TA41 for growth, earliness and yield traits, however, treatment T_4 (Soil drenching of TA41 @ 15 ml/lt. + Foliar spray of TA41 @ 25 ml/lt.) significantly enhances the quality traits of hybrid cucumber var. Gurka F1 under protected condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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