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Response of bio stimulants and bio pesticides on growth, yield and quality of tomato (*Solanum lycopersicum* L.)

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Abstract
An experiment was carried out on "Response of Biostimulants and Biopesticides on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.) under Malwa Conditions of Madhya Pradesh" at the Experimental field, Department of Horticulture, College of Agriculture, Indore, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the Rabi season 2024-25. The experiment was laid out in randomized block design with nine treatments and three replications. Treatments included bio-stimulants (Amino Acids @ 2 ml/L, Seaweed Extracts @ 2 ml/L), biopesticides (*Bacillus thuringiensis* @ 5 ml/L, *Trichoderma* sp. @ 5 g/L), and their combinations. Results revealed significant differences among treatments for growth, yield, and quality parameters. The combination of Seaweed Extracts + *Trichoderma* sp. (T_8) recorded the highest plant height, number of branches and leaves per plant, internode length, leaf area, and leaf area index at 15, 30, and 45 days after transplanting. T_8 also performed best in terms of early flowering and fruiting, number of flowers per cluster, and flower clusters per plant. Maximum yield per plant (1.91 kg), per plot (30.61 kg), and per hectare (637.84 q) were obtained in T_8, along with highest TSS (5.21 °Brix), titratable acidity (5.57 g/L), ascorbic acid (20.76 mg/g), and lower physiological loss in weight (11.26%). T_8 also showed the lowest disease intensity and pest incidence, and the highest benefit-cost ratio (1:4.8), making it the most effective treatment for enhancing tomato growth, productivity, and quality.

Keywords: Tomato, biostimulants, biopesticides, seaweed extract, *Trichoderma*, *Bacillus thuringiensis*, amino acids

Introduction
Tomato (*Solanum lycopersicum* L.), a member of the Solanaceae family with a chromosome number of 2n = 24, is the second most important vegetable crop globally, valued for its nutritional and economic significance. Native to the Andean region of South America, tomato is widely cultivated for its edible fruit, rich in vitamins A, B, and C, lycopene, flavonoids, and other phytochemicals known for antioxidant, anticancer, and cardiovascular benefits. Despite comprising about 94% water, tomatoes are highly nutritious and commonly referred to as the "poor man's apple." In India, tomato is cultivated over 8.41 million hectares, yielding 20.3 million metric tonnes (NHB, 2023). Madhya Pradesh is one of the leading producers, contributing around 3.5 million tonnes across 1.5 million hectares (Anonymous, 2023) [3]. However, tomato cultivation is often challenged by biotic and abiotic stresses, including pests, diseases, drought, and soil degradation, which adversely affect yield and quality. To address these challenges, biostimulants and biopesticides have emerged as sustainable alternatives to chemical inputs. Biostimulants such as amino acids, seaweed extracts, and *Trichoderma* spp. improve plant metabolism, nutrient uptake, stress tolerance, and overall productivity. They enhance root growth, flowering, fruit set, and nutritional quality, including lycopene and vitamin C content (Yildiz Dasgan *et al.*, 2024; Sharma *et al.*, 2014) [27, 20].

Amino acids support photosynthesis, flowering, and disease resistance, while seaweed extracts supply essential nutrients and natural hormones (auxins, cytokinins, gibberellins), boosting yield and resilience (Colla *et al.*, 2017) [7]. Biopesticides such as *Bacillus thuringiensis* and *Trichoderma* offer effective pest and disease control with minimal

environmental impact. *B. thuringiensis* targets lepidopteran pests like fruit borers, and *Trichoderma* suppresses soil-borne pathogens, promotes root health, and enhances plant defense (Sridhar *et al.*, 2019; Muhorakeye *et al.*, 2024) [21, 16]. These eco-friendly inputs represent vital components of sustainable tomato production, enhancing growth, yield, and quality while reducing dependency on synthetic chemicals.

Materials and Methods

A field experiment on Tomato was conducted at Experimental field, Department of Horticulture, College of Agriculture, Indore, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the Rabi season 2024-25. The spacing between row to row 0.6 m and plant to plant 0.5 m were maintained. The experiment was laid out in randomized block design with nine treatments and three replications. The treatments consist of two Bio stimulants *viz.*, (Amino Acids @ 2 ml/L, Seaweed Extracts @ 2 ml/L), and two Bio pesticides *viz.*, (*Bacillus thuringiensis* @ 5 ml/L, *Trichoderma* sp. @ 5 g/L) sprayed at 15, 30 and 45 DAT. The treatments consists of T_0 (Control), T_1 (Amino Acids @ 2 ml/L), T_2 (Seaweed Extracts @ 2 ml/L), T_3 (*Bacillus thuringiensis* @ 5 ml/L), T_4 (*Trichoderma* sp. @ 5 g/L), T_5 (Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L), T_6 (Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L), T_7 (Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L), and T_8 (Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L). The required amounts of treatments were applied to the corresponding plots, following the specified treatment schedules and at the correct growth stages. Five plants were randomly chosen and tagged in each treatment to record the observations of growth and flowering characteristics.

Results and Discussion

Growth parameters

Data presented in Table 1(a) give idea about the growth parameters such as plant height (cm), number of branches per plant, number of leaves per plant, while Table 1(b) presents the data of internode length (cm), leaf area (cm²), and leaf area index (LAI). It reveals that all are significantly influenced by the topical application of biostimulants and biopesticides. The significantly maximum values for growth parameters such as plant height in cm (35.24, 71.20, 102.02 at 15, 30 and 45 DAT respectively), number of branches per plant (6.00, 13.20, 20.05 02 at 15, 30 and 45 DAT respectively) number of leaves per plant (27.90, 56.73, 80.20 02 at 15, 30 and 45 DAT respectively) were recorded in treatment T_8 (Seaweed extract @ 2 ml/L + *Trichoderma* sp. @ 5 g/L), while the minimum values were observed in treatment T_0 (Control). This enhanced vegetative growth in T_8 may be attributed to the presence of macro-and micronutrients, amino acids, vitamins, and other growth-promoting compounds in seaweed extracts that stimulate cellular metabolism, improve photosynthetic efficiency, and facilitate the translocation of assimilates. Seaweed extracts act synergistically as bio-stimulants, improving physiological and biochemical activities in plants, thereby enhancing vegetative growth. These results are in accordance with the findings of Silva *et al.*, (2019) [22], Soares *et al.*, (2020) [23], and Pohl *et al.*, (2019) [17], who reported improved plant performance through seaweed extract application. Additionally, *Trichoderma* sp. played a crucial role in enhancing nutrient uptake, root development, and phytohormone production, which collectively improved shoot elongation, leaf proliferation, and biomass accumulation. These findings are in line with Li *et al.* (2015) [15], who reported that inoculation with *Trichoderma harzianum* significantly increased plant height and leaf area in tomato.

The significantly maximum internode length in cm (5.03, 6.50, 7.05 02 at 15, 30 and 45 DAT respectively), leaf area in cm² (477.26, 781.34, 1026.31 02 at 15, 30 and 45 DAT respectively), and leaf area index (LAI) (0.177, 0.289, 0.379 at 15, 30 and 45 DAT respectively) were recorded in T_8 (Seaweed extract @ 2 ml/L + *Trichoderma* sp. @ 5 g/L), while the minimum values were observed in treatment T_0 (Control). This is due to the combined application of seaweed extract and *Trichoderma* sp. exhibited a synergistic effect in promoting vegetative growth there by increasing internode length and leaf area, as also observed by Ashmawi (2021) [4] found that foliar spraying of seaweed extract improved plant height and leaf area, while *Trichoderma* spp. promoted root development and phytohormone activity. Fatimah *et al.* (2018) [9], also reported enhanced hypocotyl and root development with foliar application of *Sargassum* sp. extract.

Phenological Parameters

Data presented in Tables 2 revealed that phenological parameters such as days to first flower initiation, days to first fruit set, days to first picking, number of flowers per clusters and number of flower cluster per plant were significantly influenced by the external application of biostimulants and biopesticides. The significantly earliest flower initiation (22.05 days), fruit set (75.24 days), and days to first picking (36.85 days) were recorded in treatment T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* sp. @ 5 g/L), whereas the minimum values were observed in treatment T_0 (Control). This may be due to to the presence of bioactive compounds in seaweed extract that stimulate hormonal activity, particularly auxins, cytokinins, and gibberellins, which play crucial roles in promoting early flowering and fruit development. Seaweed extracts are also known to enhance enzyme activity, protein synthesis, and nutrient availability, which together accelerate floral initiation and support reproductive growth. These results are supported by Subramaniyan *et al.* (2023) [24], who reported that foliar application of *Ascophyllum nodosum* extract significantly improved flowering traits and fruit yield in tomato.

The significantly maximum number of flowers per clusters (7.00) and number of flower clusters per plant (10.51) were recorded in treatment T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* sp. @ 5 g/L), whereas the minimum values were observed in treatment T_0 (Control). The enhancement of phenological traits under T_8 may be due to the fact as seaweed-based biostimulants enhanced plant growth, number of flowers per clusters and clusters per plant, chlorophyll content, flowers and fruit production as observed by Ali *et al.* (2019) [2]. The synergistic effect of seaweed extract and *Trichoderma* spp. in treatment T_8 likely created favorable physiological and hormonal conditions for early flowering and fruit setting. *Trichoderma* spp. are known to enhance root development, nutrient uptake, and phytohormone production, which positively influence plant vigor and reproductive traits. This is in line with the findings of Harman *et al.* (2004) [10] and Contreras-Cornejo

et al. (2009) [8], who demonstrated that *Trichoderma* species improve plant architecture and stimulate auxin and gibberellin production, leading to earlier floral development and better fruit set. While previous studies focused primarily on individual treatments, the superior performance observed under the combined application in this study highlights its potential as a promising strategy for enhancing reproductive efficiency and yield under open-field conditions.

Yield Parameters

Data presented in Tables 3 showed that yield parameters such as number of fruits per plant, average fruit weight (g), number of fruits per cluster, fruit diameter (cm), yield per plant (kg), yield per plot (kg), and yield per hectare (q) were significantly influenced by the external application of biostimulants and biopesticides. The highest values of number of fruits per plant (34.78), average fruit weight (55.01 g), number of fruits per cluster (3.50), fruit diameter (5.51 cm) were recorded in treatment T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* spp. @ 5 g/L), while the lowest were observed in treatment T_0 (Control), indicating the superior efficacy of the combined treatment in enhancing fruit yield and related attributes. The improvement in yield parameters under T_8 may be attributed to the presence of essential macro-and micronutrients, amino acids, and plant growth-promoting substances in seaweed extracts, which collectively stimulate vegetative and reproductive development. Seaweed-based biostimulants enhance photosynthetic efficiency, chlorophyll content, and assimilate translocation, resulting in an increased number of fruits, greater fruit size, and overall yield. Foliar application of seaweed extracts such as *Sargassum horneri* and *Ascophyllum nodosum* has been reported to improve photosynthetic activity and significantly enhance fruit number, clusters, and yield in tomato (Hussain *et al.*, 2021) [11].

The significantly highest values of number of yield per plot (30.61 kg), and yield per hectare (637.84 q) across all yield-related traits were recorded in treatment T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* spp. @ 5 g/L), while the lowest were observed in treatment T_0 (Control), Colla *et al.* (2014) [7] reported a similar promoting effect of plant-derived protein hydrolysate on tomato, demonstrating that the application of this biostimulant stimulated flowering, fruit setting and final yield through an elicited endogenous phytohormonal biosynthesis. In terms of microbial inoculants, Uddin *et al.* (2016) [25] demonstrated that *Trichoderma* spp. increased tomato yield from 1.4 kg to 3.0 kg per plant by improving nutrient solubilization and plant vigor. Lanzuise *et al.* (2022) [14] similarly demonstrated that co-application of *Trichoderma* strains with medium-long chain fatty acid mixtures resulted in yield increases of up to 90% in tomato, lettuce, and kohlrabi, reinforcing the synergistic effect of microbial consortia and organic biostimulants in enhancing crop productivity and quality.

Quality Parameters

Data presented in Tables 4 revealed that quality parameters such as total soluble solids (TSS °Brix), titratable acidity (g/L), physiological loss in weight (%), and ascorbic acid content (mg/g) were significantly influenced by the external application of biostimulants and biopesticides. The significantly highest values of total soluble solids (TSS 5.21°Brix), titratable acidity (5.57 g/L), physiological loss in weight (11.26 %), and ascorbic acid content (20.76 mg/g) were recorded in treatment T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* spp. @ 5 g/L), while the lowest were observed in treatment T_0 (Control). The significant improvement of quality parameters under T_8 may be attributed to the presence of essential nutrients and bioactive compounds in seaweed extracts that promote carbohydrate accumulation, enhance metabolic activity, and stimulate the biosynthesis of sugars. *Ascophyllum nodosum* seaweed extract application enhances tomato fruit quality by increasing TSS, vitamin C, and flavor index. Soil drenching with the extract is especially effective under water-deficit conditions, improving ascorbic acid content and reducing physiological weight loss. (Jalali *et al.*, (2022) [12] and Ahmed *et al.*, (2022) [1]. The inclusion of *Trichoderma* sp. in the treatment further contributed to improved fruit quality by enhancing nutrient uptake, promoting root health, and increasing the plant's physiological activity as observed by Khan *et al.* (2017) [13] that increased antioxidant compounds such as ascorbic acid, lycopene and β-carotene in ripe tomato fruits due to the application of 100% *Trichoderma* bio-compost in field conditions. The combined effects of seaweed extract and *Trichoderma* sp. thus resulted in improved ascorbic acid content and reduced physiological loss in weight, as reflected in the present study.

Disease and Pest Incidence Parameters

Data presented in Tables 5 revealed that disease and pest incidence parameters, including Percent Disease Intensity (PDI %) and Percent Pest Incidence (PPI %), were significantly influenced by the external application of biostimulants and biopesticides. Among all treatments, the lowest values of Percent Disease Intensity (18.86 %) and Percent Pest Incidence (15.11 %), were recorded by T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* sp. @ 5 g/L) indicating its strong suppressive effect on both disease and pest pressure in tomato plants. In contrast, the maximum incidence of disease and pest attack was observed in the untreated control (T_0) due to Seaweed-based formulations are rich in polysaccharides, phytohormones, and other bioactive compounds that activate plant immune responses. Ramesh *et al.* (2022) [18] reported that foliar spraying of seaweed extracts in tomato effectively reduced early blight severity and fruit borer infestation due to stimulated plant defense responses. The addition of *Trichoderma* sp. further enhanced disease and pest suppression through biological control mechanisms such as competition, mycoparasitism, and the secretion of hydrolytic enzymes. *Trichoderma* spp. are well-documented antagonists of soil-borne pathogens like *Fusarium oxysporum*, *Pythium*, and *Rhizoctonia*. Muhorakeye *et al.* (2024) [16] reported that T. *asperellum* significantly reduced *fusarium wilt* severity and nematode infestation in tomato by degrading pathogen cell walls and promoting rhizosphere colonization. Likewise, Brotman *et al.* (2022) [5] found that *T. atroviride* enhanced resistance to insect pests in tomato by inducing systemic defense responses and modifying volatile emissions that deter pest activity. The synergistic effect of seaweed extract and *Trichoderma* sp. contributed not only to disease and pest resistance but also to improved nutrient uptake and root development, creating an environment less favorable for pathogen and pest establishment. These findings are supported by Du Jardin (2015), who highlighted that seaweed-based formulations improve stress tolerance and

nutrient assimilation through their rich composition of polysaccharides, amino acids, and phytohormones.

Economic Parameters

Data presented in Table 6 indicated that economic parameters, specifically the Benefit:Cost (B:C) ratio, were significantly influenced by the application of biostimulants and biopesticides. Among all treatments, T_8 (Seaweed Extract @ 2 mL/L + *Trichoderma* sp. @ 5 g/L) recorded the highest B:C ratio (1:4.8), reflecting its superior economic viability and profitability under treated conditions. In contrast, the control treatment (T_0) exhibited the lowest B:C ratio. The higher profitability observed in T_8 may be attributed to the combined effects of increased yield, improved quality parameters, and reduced incidence of pests and diseases, which together contribute to greater marketable produce and reduced input losses. Foliar application of *A. nodosum* extract significantly reduced bacterial spot and early blight incidence in tomato by up to 50% compared to untreated controls. Similarly, Sanap *et al.* (2019) [19] reported that the use of *Opteine* (a seaweed-based extract) effectively reduced pest populations and disease progression, thereby improving overall plant vigor and final yield. In terms of economic returns, the application of seaweed extracts has also demonstrated positive impacts. Yao *et al.* (2023) [26] observed that seaweed extract derived from *Sargassum horneri* improved tomato yield by 4.6% to 6.9%, largely due to enhanced photosynthetic efficiency. The highest yield was achieved at an application rate of 60 kg·hm². Additionally, the treatment shortened the ripening period, enabling harvest during more favorable market windows, thereby increasing net economic returns by up to 13.6% compared to untreated plots. Building upon these findings, the present study confirms that the combined use of seaweed extract and *Trichoderma* sp. further improves economic outcomes by enhancing productivity, reducing crop cycle duration, and boosting resilience under field conditions.

Table 1(a): Response of biostimulants and biopesticides on growth parameters in tomato

Treatments		Plant height (cm)			Number of leaves/plant			Number of branches/plant		
		15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T_0	Control	30.36	64.45	95.1	5.11	11.31	18.26	23.10	50.20	75.58
T_1	Amino Acids @ 2 ml/L	32.43	67.32	97.90	5.41	12.19	19.26	25.37	54.07	77.31
T_2	Seaweed Extracts @ 2 ml/L	33.08	69.38	98.79	5.57	12.37	19.50	25.93	54.70	77.82
T_3	*Bacillus thuringiensis* @ 5 ml/L	31.14	65.60	95.43	5.22	11.54	18.69	23.73	52.62	76.10
T_4	*Trichoderma* sp. @ 5 g/L	31.97	66.55	96.53	5.35	12.04	19.09	24.53	53.22	76.52
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	33.20	69.87	99.8	5.65	12.60	19.63	26.30	55.18	78.31
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	33.87	70.12	100.72	5.76	12.78	19.70	26.77	55.40	78.88
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	34.66	70.74	101.25	5.85	12.97	19.93	27.00	56.20	79.48
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	35.34	71.20	102.02	6.00	13.20	20.05	27.90	56.73	80.20
SEm ±		2.84	0.32	0.14	0.19	0.17	0.21	0.19	0.27	0.26
C.D. (at 5%)		8.28	0.93	0.40	0.54	0.50	0.62	0.54	0.78	0.76

Table 1(b): Response of biostimulants and biopesticides on growth parameters in tomato

Treatments		Internode length (cm)			Leaf Area (cm²)			Leaf Area Index (LAI)		
		15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T_0	Control	4.07	5.06	6.07	320.23	623.10	821.20	0.119	0.232	0.304
T_1	Amino Acids @ 2 ml/L	4.48	5.73	6.55	383.88	680.42	910.49	0.129	0.249	0.336
T_2	Seaweed Extracts @ 2 ml/L	4.53	5.90	6.64	397.29	694.74	930.64	0.131	0.253	0.344
T_3	*Bacillus thuringiensis* @ 5 ml/L	4.13	5.10	6.29	340.53	630.66	841.84	0.123	0.238	0.319
T_4	*Trichoderma* sp. @ 5 g/L	4.28	5.48	6.32	364.12	652.22	870.63	0.127	0.245	0.325
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	4.69	6.04	6.72	400.56	718.06	957.16	0.138	0.259	0.350
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	4.73	6.10	6.80	429.00	748.70	980.30	0.153	0.265	0.367
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	4.94	6.37	6.90	452.77	761.20	1006.22	0.162	0.274	0.370
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	5.03	6.50	7.05	477.26	781.34	1026.31	0.177	0.289	0.379
SEm ±		2.84	0.12	0.24	0.20	10.84	8.54	6.05	0.01	0.01
C.D. (at 5%)		8.28	0.34	0.71	0.57	31.52	24.81	17.58	0.02	0.03

Table 2: Response of biostimulants and biopesticides on phenological parameters in tomato

Treatments		Days to first flower initiation	Days to first picking	Days to first fruit set	Number of flowers/clusters	Number of flowers clusters/plant
T_0	Control	25.12	81.55	39.21	6.07	9.08
T_1	Amino Acids @ 2 ml/L	24.11	79.70	38.26	6.43	9.50
T_2	Seaweed Extracts @ 2 ml/L	23.79	78.49	38.03	6.67	9.71
T_3	*Bacillus thuringiensis* @ 5 ml/L	24.78	80.98	38.94	6.18	9.18
T_4	*Trichoderma* sp. @ 5 g/L	24.59	80.11	38.53	6.26	9.36
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	23.37	77.94	37.80	6.72	9.89
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	23.13	77.52	37.43	6.85	10.05
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	22.87	76.46	37.13	6.90	10.37
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	22.05	75.24	36.85	7.00	10.51
SEm ±		0.36	0.31	0.20	0.08	0.21
C.D. (at 5%)		1.05	0.91	0.58	0.22	0.62

Table 3: Response of biostimulants and biopesticides on yield parameters in tomato.

Treatments		Number of fruits/plant	Average fruit weight/fruit (g)	Number of fruits/cluster	Fruit diameter (cm)	Yield/plant (kg)	Yield/plot (kg)	Yield/hectare (q)
T_0	Control	25.34	50.11	3.03	4.50	1.27	20.27	422.42
T_1	Amino Acids @ 2 ml/L	29.12	52.98	3.23	4.70	1.44	24.64	507.41
T_2	Seaweed Extracts @ 2 ml/L	31.88	53.27	3.30	4.85	1.56	25.32	551.11
T_3	*Bacillus thuringiensis* @ 5 ml/L	27.80	51.82	3.13	4.58	1.33	22.26	461.09
T_4	*Trichoderma* sp. @ 5 g/L	28.35	52.37	3.20	4.66	1.37	23.52	479.92
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	32.41	53.80	3.37	5.08	1.63	26.57	556.99
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	35.35	54.40	3.41	5.16	1.67	27.49	600.00
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	33.90	54.92	3.45	5.31	1.72	29.47	620.00
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	34.78	55.01	3.50	5.51	1.91	30.61	637.84
SEm ±		0.29	0.29	0.08	0.21	0.21	0.12	0.30
C.D. (at 5%)		0.85	0.85	0.24	0.61	0.61	0.35	0.87

Table 4: Response of biostimulants and biopesticides on quality parameters in tomato

Treatments		TSS (ºBrix)	Titrable acidity (g/l)	Physiological loss in weight (%)	Ascorbic acid (mg/g)
T_0	Control	3.37	4.08	18.16	18.03
T_1	Amino Acids @ 2 ml/L	4.37	4.52	14.65	19.00
T_2	Seaweed Extracts @ 2 ml/L	4.59	4.78	14.00	19.55
T_3	*Bacillus thuringiensis* @ 5 ml/L	3.68	4.22	16.92	18.53
T_4	*Trichoderma* sp. @ 5 g/L	4.11	4.43	15.54	18.86
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	4.68	4.99	13.59	19.89
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	4.89	5.26	12.70	20.02
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	5.14	5.38	12.30	20.32
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	5.21	5.57	11.26	20.76
SEm ±		0.35	0.27	0.69	0.49
C.D. (at 5%)		1.03	0.79	2.01	1.42

Table 5: Response of biostimulants and biopesticides on Disease intensity PDI (%) and pest incidence PPI (%) in tomato

Treatments		Disease intensity PDI (%)	Pest incidence PPI (%)
T_0	Control	25.43	20.76
T_1	Amino Acids @ 2 ml/L	23.11	17.21
T_2	Seaweed Extracts @ 2 ml/L	22.14	16.88
T_3	*Bacillus thuringiensis* @ 5 ml/L	24.70	19.55
T_4	*Trichoderma* sp. @ 5 g/L	24.19	18.53
T_5	Amino Acid @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	21.26	16.30
T_6	Amino Acid @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	20.32	15.72
T_7	Seaweed Extracts @ 2 ml/L+ *Bacillus thuringiensis* @ 5 ml/L	19.89	15.39
T_8	Seaweed Extracts @ 2 ml/L+ *Trichoderma* sp. @ 5 g/L	18.86	15.11
SEm ±		1.19	1.00
C.D. (at 5%)		3.47	2.90

Table 6: Response of biostimulants and biopesticides on economic parameters in tomato

S. No.	Cost of cultivation (Rs.)			Yield/hectare (q)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C
	Common cost	Extra cost	Total cost				
T_0	1,03,000	0	1,03,000	422.42	4,22,240	3,19,240	1:3.1
T_1	1,03,000	2480	1,05,480	507.41	5,07,410	4,01,930	1:3.8
T_2	1,03,000	2530	1,05,530	551.11	5,51,110	4,55, 580	1:4.2
T_3	1,03,000	3970	1,06,970	461.09	4,61,090	3,54,120	1:3.3
T_4	1,03,000	4020	1,07,020	479.92	4,97,920	3,90,900	1:3.6
T_5	1,03,000	6450	1,09,450	556.99	5,66,990	4,75,540	1:4.1
T_6	1,03,000	6500	1,09,500	600.00	6,00,000	4,90,500	1:4.4
T_7	1,03,000	6800	1,09,800	620.00	6,20,000	5,10,200	1:4.6
T_8	1,03,000	6500	1,09,500	637.84	6,37,840	5,28,340	1:4.8

Conclusion

The present investigation demonstrated that the combined application of Seaweed Extract @ 2 mL/L and *Trichoderma* sp. @ 5 g/L had a significant and positive influence on the growth, phenological, yield, quality, disease and pest resistance, and economic performance of tomato (*Solanum lycopersicum*). Among all treatments, T_8 consistently recorded the best results across all observed parameters, including plant height, leaf area, flowering, fruit setting, fruit yield, total soluble solids (TSS), ascorbic acid content, and reduced Percent Disease Intensity (PDI%) and Percent Pest Incidence (PPI%). The synergistic action of bioactive compounds present in seaweed extract and the beneficial effects of *Trichoderma* sp. contributed to enhanced nutrient uptake, improved plant physiology, stimulated defense mechanisms, and increased crop productivity. These outcomes not only enhanced tomato growth and yield but also improved fruit quality and minimized losses caused by biotic stress. Economically, the highest Benefit:Cost (B:C) ratio was recorded, indicating its superior profitability compared to other treatments. This suggests that the integration of seaweed extract and *Trichoderma* sp. can serve as a sustainable and eco-friendly alternative to conventional chemical inputs in tomato cultivation. Based on these findings, it can be concluded that the combined use of seaweed extract and *Trichoderma* sp. offers a promising strategy for improving the productivity, quality, and profitability of tomato under open-field conditions.

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