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Saurav Sheetal
Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Prakhar Khare
Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Akhilesh Kushwaha
Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Saurav Sheetal
Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Effect of TA41 on growth, yield and quality of tomato (*Solanum lycopersicum* L.)

Saurav Sheetal, Vijay Bahadur, Prakhar Khare and Akhilesh Kushwaha

Abstract
This research paper investigates the effect of TA41 on the growth, yield, and quality of tomato (*Solanum lycopersicum* L.). The study was conducted during 2022 which observed various parameters, including plant height, days to first flowering, number of fruits per plant, fruit weight, fruit yield per plant, and fruit yield per hectare. Ten treatments were used, which include control, soil drenching of TA41 at various concentrations, and foliar spray of TA41. The results indicate that the application of TA41 through soil drenching and foliar spray significantly improved the growth, yield, and quality of tomato. The treatment with soil drenching of TA41 at 25 ml/L and foliar spray at 50ml/spray tank showed the highest fruit yield per plant and per hectare, as well as improved plant height and fruit weight. It also gave the highest Benefit - Cost Ratio. These findings suggest that the use of TA41 has great potential to enhance tomato production and may be an effective strategy for tomato farmers.

Keywords: Tomato, plant growth regulator, bacteria, actinomycetes, fungi

1. Introduction
Tomato (*Solanum lycopersicum* L.) is an important agricultural crop, widely grown for its edible fruits that are consumed fresh or processed. It is a member of the Solanaceae family, which also includes other economically important crops such as potato, pepper, and eggplant. Tomatoes are grown in almost every country in the world and are an essential ingredient in many cuisines worldwide.

The agricultural importance of tomatoes stems from their high nutritional value and versatile use. They are a rich source of vitamins A, C, and K, potassium, and antioxidants such as lycopene. Tomatoes are consumed fresh in salads, sandwiches, and as a snack, and are also used in various processed forms such as tomato sauce, paste, juice, ketchup, and canned tomatoes. India is one of the largest producers of tomato in the world, with a production of over 20 million tonnes per year. Uttar Pradesh, the most populous state in India, is also a significant tomato-producing state. The major tomato-growing regions in Uttar Pradesh are the districts of Meerut, Agra, Aligarh, Mathura, and Varanasi [1]. The state has favorable agro-climatic conditions for tomato cultivation, with fertile soils and a warm climate. However, the tomato industry in Uttar Pradesh has faced some challenges, including low productivity, pest and disease infestations, and post-harvest losses [2]. These challenges have been addressed through various measures, including the adoption of better agricultural practices, improved irrigation facilities, and the use of modern technologies.

TA41 is a multifunctional organic growth promoter that takes care of viral, fungal, and sucking pests manufactured by Rayan Farming Solution Pvt. Ltd. TA41 effectively controls and prevents soft-bodied sucking pests such as whiteflies, aphids, mites, scale insects, thrips, mealy bugs, and planthoppers. It is very effective & works quickly against sucking pests. TA41 also helps in retaining soil moisture and prevent soil erosion and develops healthy soil for high yield. TA41 contains bacteria ($19x10^8$cfu/ml), Fungi ($5x10^8$cfu/ml) and Actinomycetes ($9x10^8$cfu/ml). Microorganisms can help to improve soil fertility by fixing atmospheric nitrogen, solubilizing phosphorus, and releasing other nutrients such as potassium and iron, which can improve plant growth and yield [3]. Beneficial microorganisms can produce plant growth-promoting substances such as auxins, gibberellins, and cytokinins, which can stimulate plant growth and development [4, 5]. They also produce antibiotics and other compounds that can protect plants against pathogenic fungi and bacteria, reducing the need for chemical pesticides [6]. Microorganisms can improve soil structure by producing polysaccharides and other substances that can increase soil porosity and water-holding capacity, leading to better soil aeration and drainage [7].

2. Material and Methods

2.1 Experimental Site

Field experiments for studying the effects TA41 on growth, yield and quality of tomato were performed during August to December in 2021 at the Horticultural Research Field, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (25.43° N latitude 81.84° E longitude) India. The soil at the location is Loam and Sandy Loam. Prayagraj district has a sub-tropical climate and the average maximum temperature ranges between 43 °C – 47 °C which may go as high as 48 °C during peak summers. The minimum average temperature is 2-4 °C which may fall as low as 1.5 °C during peak winter months (Dec.-Jan.) The average rainfall of the district is 960 mm and the monsoon season is spread between July-September.

The experiment was carried out with the objectives to find out the suitable dose of TA41 on growth yield and quality of Tomato, the Pest and Disease incidence in Tomato and to study economics of various treatments.

2.2 Experimental details

The experiment was carried out in open field conditions. The variety used in the experiment was Kashi Abhiman. Plants were sown in nursery beds in the on December 10th, 2022 and transplanted to open field on December 24th, 2022 with a spacing of 45 cm row to row and 45 cm plant to plant. TA4 was made available by Rayan Farming Solution Pvt. Ltd. It is applied as soil drenching and through foliar spray. The experiment was designed in Randomized Block Design with three replications. The application of TA41 was given as per the treatment. Soil drenching was done after 15 and 30 days after transplanting while Foliar application was given after 30 and 45 days after transplanting. The treatments details are given in Table 1.

Table 1: Details of the Treatment

S.no.	Treatment	Treatment Combination
1	T_0	Control
2	T_1	Soil drenching of TA41 @ 1%
3	T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.
4	T_3	Soil drenching of TA41 @1.5%.
5	T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.
6	T_5	Soil drenching of TA41 @ 2%
7	T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.
8	T_7	Soil drenching of TA41 @ 2.5%
9	T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.
10	T_9	Foliar spray @ 0.3%.

The recommended dose of fertilizers was applied to the crop with a dose of Nitrogen at 120 kg/ha, Phosphorus at 60 kg/ha, Potassium at 30 kg/ha. The half dose of nitrogen was applied as a basal dose and rest as soil drenching. FYM at 5 t/ha was applied 15 days before transplanting.

2.3 Observations

Growth Parameters (Plant Height, Number of Branches), Earliness Parameters (Days to 1st Flowering, Days to fruit picking), Yield Parameters (No of fruits per plant, Fruit yield per hectare, Fruit Weight), Qualitative Parameters (Total soluble solids, Ascorbic Acid), Economic Parameters (Cost of cultivation, Benefit Cost Ratio) and disease and pest incidence were observed in the population.

3. Result and Discussion

The performances of tomato under different levels of TA41 as recorded through crop growth and yield were as follows: -

a. Growth parameters

Growth Parameters such as Plant Height and Number of Branches recorded are given in Table 2.

Table 2: Growth Parameters

Treatment	Treatment Combination	Plant height (m)	Number of branches
T_0	Control	88.21	5.7
T_1	Soil drenching of TA41 @ 1%	90.56	8.6
T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.	92.56	7.2
T_3	Soil drenching of TA41 @1.5%.	98.46	6.9
T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.	100.25	7.2
T_5	Soil drenching of TA41 @ 2%	102.45	9.1
T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.	105.86	10.3
T_7	Soil drenching of TA41 @ 2.5%	101.12	8.2
T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.	109.8	10.9
T_9	Foliar spray @ 0.3%.	95.89	9.5

The application of TA41 significantly increased Plant height and Number of Branches in tomato. The treatment Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5% gave the maximum plant height and number of branches (109.8 & 10.9 respectively). Bacteria and actinomycetes are known to fix atmospheric nitrogen, which can be used by plants to synthesize amino acids and other essential compounds. This results in an increase in plant biomass and height. Fungi, on the other hand, form a symbiotic relationship with plant roots, known as mycorrhiza. This relationship enhances nutrient uptake, particularly phosphorus, which is often a limiting nutrient for plant growth. Fungi also produce growth-promoting substances, such as gibberellins and auxins, which can stimulate plant height and no. of branches [8, 9]. These microorganisms are the main constituent of TA41, hence may attribute to increased plant height and number of branches in Tomato.

3.2 Earliness Parameters

Earliness Parameters such as Days to 1st Flowering and Days to fruit picking recorded are given in Table 3.

Table 3: Earliness Parameters

Treatment	Treatment Combination	Days to 1st Flowering	Days to fruit picking
T_0	Control	46.5	94.6
T_1	Soil drenching of TA41 @ 1%	45.2	93.4
T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.	44.7	92.5
T_3	Soil drenching of TA41 @1.5%.	45.9	93.6
T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.	43.5	91.4
T_5	Soil drenching of TA41 @ 2%	42.3	90.2
T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.	40.2	88.6
T_7	Soil drenching of TA41 @ 2.5%	43.1	92.3
T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.	38.5	87.4
T_9	Foliar spray @ 0.3%.	41.5	89.6

The application of TA41 significantly decreased days to first flowering and days to fruit picking in tomato. The treatment Soil drenching with TA41 @ 2.5% + foliar spray @ 0.5% has minimum number of days to first flowering and days to fruit setting (38.5 & 87.4 respectively).

Soil microorganisms produce plant growth-promoting hormones and other compounds that can stimulate plant growth and development. Some bacteria produce auxins, which can promote cell elongation and stem growth in plants. This can lead to earlier flowering and fruiting in tomato plants, which would result in shorter days to first flowering and days to first picking. They can produce antibiotics and other compounds that can inhibit the growth of harmful pathogens in the soil, reducing the risk of infection in plants. This can also promote healthier and more vigorous plant growth, leading to earlier flowering and fruiting [10, 11]. As a prime constituent of TA41, these microorganisms may attribute to earliness in Tomato.

3.3 Yield Parameters

Yield Parameters such, Number of fruits per plant, fruit weight and Fruit yield per hectare (t/ha) were observed and listed in Table 4.

Table 4: Yield Parameters

Treatment	Treatment Combination	No of fruits per plant	Fruit weight (g)	Yield/ha (t/ha)
T_0	Control	33.4	62.9	89.5
T_1	Soil drenching of TA41 @ 1%	35.5	70.6	104.5
T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.	38.4	72.8	117.9
T_3	Soil drenching of TA41 @1.5%.	39.4	75.6	124.1
T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.	36.4	79.5	113
T_5	Soil drenching of TA41 @ 2%	37.9	76.1	119.1
T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.	42.7	80.3	143.7
T_7	Soil drenching of TA41 @ 2.5%	40.8	78.6	133.7
T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.	45.5	85.6	162.9
T_9	Foliar spray @ 0.3%.	41.2	77.4	132.9

Application of TA41 significantly increased the Yield Parameters such as Number of fruits per plant, Fruit weight (g) and Fruit yield per hectare (t/ha). Maximum Number of fruits per plant, Fruit weight and Fruit yield per hectare was observed in treatment of Soil drenching with TA41 @ 2.5%+foliar spray @ 0.5% (45.5, 85.6 & 162.9 tons/ha respectively). Microorganisms play an important role in breaking down organic matter in the soil, making nutrients available to plants [12]. They help decompose organic matter, which then releases essential nutrients like nitrogen, phosphorus, and potassium. Certain microorganisms can promote root growth and development, which can help increase the uptake of nutrients and water by the tomato plants [13]. Microorganisms can also help improve soil structure by producing substances like polysaccharides and glomalin, which can improve soil aggregation, water retention, and aeration [14]. Some bacteria and fungi can produce antibiotics and other compounds that help suppress plant diseases [15]. Since, these microorganisms are the main constituent of TA41, these factors may attribute to increased yield in Tomato.

3.5 Qualitative Parameters

Qualitative Parameters such as TSS (°Brix) and Ascorbic Acid (mg/100g) were recorded and give in Table 5.

Table 5: Qualitative Parameters

Treatment	Treatment Combination	TSS (°Brix)	Ascorbic Acid (mg/100 g)
T_0	Control	4.01	15.31
T_1	Soil drenching of TA41 @ 1%	4.50	20.34
T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.	4.32	18.12
T_3	Soil drenching of TA41 @1.5%.	4.46	21.43
T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.	4.29	19.31
T_5	Soil drenching of TA41 @ 2%	4.59	20.98
T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.	4.62	22.12
T_7	Soil drenching of TA41 @ 2.5%	4.13	17.43
T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.	4.80	23.23
T_9	Foliar spray @ 0.3%.	4.39	18.32

Application of TA41 resulted in more Total soluble solids and Ascorbic Acid content in the tomato fruit. Maximum TSS and Ascorbic Acid content was observed in the treatment of Soil drenching with TA41 @ 2.5% + foliar spray @ 0.5% (4.80 and 23.23 respectively). Beneficial microorganisms can increase the availability of essential nutrients, such as nitrogen and phosphorus, to the tomato plants. Ascorbic acid is known to be positively correlated with the availability of these nutrients, so increasing their availability through the action of microorganisms can result in higher levels of ascorbic acid [16].

3.6 Economic Parameters

Economic Parameters such as Gross Return, Net Income/Return, Benefit Cost Ratio were calculated and listed in Table 6.

Table 6: Economic Parameters

Treatment	Treatment Combination	Gross Return (₹)	Net Return (₹)	Benefit Cost Ratios
T_0	Control	2,68,740	183311	2.15
T_1	Soil drenching of TA41 @ 1%	313740	227511	2.64
T_2	Soil drenching of TA41 @1%+foliar spray @ 0.2%.	353730	265901	3.03
T_3	Soil drenching of TA41 @1.5%.	372480	285851	3.30
T_4	Soil drenching of TA41 @ 1.5%+foliar spray @ 0.3%.	339000	249971	2.81
T_5	Soil drenching of TA41 @ 2%	357480	270451	3.11
T_6	Soil drenching of TA41 @ 2%+foliar spray @ 0.4%.	431250	341021	3.78
T_7	Soil drenching of TA41 @ 2.5%	401250	314021	3.60
T_8	Soil drenching of TA41 @ 2.5%+foliar spray @ 0.5%.	488730	397501	4.36
T_9	Foliar spray @ 0.3%.	398370	310901	3.54

The application of TA41 as Soil drenching @ 2.5% + foliar spray @ 0.5% gave more Net and Gross returns as compared to other treatments. Maximum Benefit Cost ratio was obtained in the treatment of TA41 as Soil drenching @ 2.5%+foliar spray @ 0.5%.

3.7 Disease and Pest Incidence

Leaf Curl and Fruit Borer are one of the prominent disease and pest of tomato in Prayagraj region. Thus, incidence of both were observed and calculated and given in Table 7.

Table 7: Disease and Pest Incidence

Treatment	Treatment Combination	Leaf curl (%)	Fruit borer (%)
T_0	Control	44.34	33.34
T_1	Soil drenching of TA41 @ 1%	33.34	14.67
T_2	Soil drenching of TA41 @ 1% + foliar spray @ 0.2%.	18.34	11.12
T_3	Soil drenching of TA41 @1.5%.	33.34	14.67
T_4	Soil drenching of TA41 @ 1.5% + foliar spray @ 0.3%.	18.34	11.12
T_5	Soil drenching of TA41 @ 2%	18.34	14.67
T_6	Soil drenching of TA41 @ 2% + foliar spray @ 0.4%	14.67	11.12
T_7	Soil drenching of TA41 @ 2.5%	14.67	14.67
T_8	Soil drenching of TA41 @ 2.5% + foliar spray @ 0.5%.	14.67	11.12
T_9	Foliar spray @ 0.3%.	18.34	14.67

It was observed that treatments with Soil drenching of TA41 @ 2% + foliar spray @ 0.4%, Soil drenching of TA41 @ 2.5% and Soil drenching of TA41 @ 2.5% + foliar spray @ 0.5% recorded the minimum Leaf curl incidence (14.67%). The treatments with application of TA41 as soil drenching and foliar spray both, gave minimum incidence of Fruit borer in Tomato. Beneficial microorganisms present in TA41 can trigger the plant's natural defence mechanisms, which can result in increased resistance to disease. When the plant is exposed to certain microorganisms, it can stimulate the production of phytohormones and other defence-related compounds that help protect the plant against pathogens [17, 18]. The beneficial microorganisms can produce insecticidal compounds, which can kill or repel insect pests such as fruit borers when applied directly to the leaves [19]. Due to which foliar application was more efficient than soil drencing. Microbial treatments can alter the chemical composition of the plant's surface, making it less attractive to fruit borers and other pests [20]. These factors attributed to less disease and pest incidence in tomato.

4. Conclusion

The results indicated that, application of TA41 significantly increased the growth, quality and yield while attributing to earliness and less disease and pest incidence. The treatment Soil drenching of TA41 @ 2.5% + foliar spray @ 0.5% was found best in the terms of Growth, Earliness, Yield and Qualitative parameters. The disease and pest incidence was also found less in the treatment of TA41 as Soil drenching @ 2.5% + foliar spray @ 0.5% could be recommended for a better tomato crop.

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