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Research Article

Exploring the impact of biofertilizers on Tomato crop growth and yield: A comprehensive research study

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ABSTRACT

Experiment was conducted to investigate the effect of different combination of biofertilizers and inorganic chemical fertilizers on the growth and yield parameters of tomato crop. The experiment was designed using a Completely Randomized Design with three replicates and seven treatments, including the sole application of individual strains and their combinations with 75% of recommended dose of fertilizers. The investigation was prompted by the combined effects of inorganic fertilizers and the potential benefits of microbial inoculants. The results revealed that the 100% RDF (T_2) and combined inoculation of 75% RDF with *Azotobacter* + PSB + KSB (T_7) recorded significant increase in the growth and yield parameters of tomato over control (T_1). Further, treatment (T_2) and (T_7) found on par to each other. Tomato plants treated with T_2 exhibited significantly greater plant height (126.8 cm at harvest stage), Number of branches per plant (14.66), Number of leaves per plant (113.33), fresh weight (412.66 g plant^{-1}), and dry weight (133 g plant^{-1}). The study highlights the potential of combined inoculation of inorganic fertilizers and beneficial microbial inoculants promote the growth and yield parameters of tomato plants, this results also suggest that the 75% RDF in combination with Nitrogen fixing, phosphorous and potash solubilising bacteria may helps in reducing the 25% of inorganic chemical fertilizer application and which intern leads to reduce in input cost to the farmers.

KEY WORDS: Tomato; Biofertilizers; *Azotobacter*; Phosphorus solubilisers; Potassium solubilisers

1. Introduction

Tomato (*Solanum lycopersicum*) is a widely cultivated and economically important vegetable crop worldwide (Sadashiva *et al*., 2013; Venema *et al*., 2005). Its nutritional value, versatility in culinary applications, and growing demand make it a significant component of the global agricultural industry. In recent years, there has been a growing emphasis on sustainable agricultural practices that minimize the use of synthetic inputs (Pretty, 2008) while ensuring optimal crop productivity.

The tomato crop in India has not been able to reach its full potential in terms of yield. This can be attributed to various factors, one of which is the inadequate use of fertilizers. In particular, hybrid varieties of tomatoes require higher nutrient levels for optimal growth (Kamal *et al.*, 2018). However, the low utilization of fertilizers and the imbalanced application ratio of nitrogen, phosphorus, and potassium (NPK) contribute to the subpar yield. Relying solely on chemical fertilizers is insufficient to sustain higher yields, and the high cost of inorganic fertilizers often leads to poor profit margins (Ritu and Dash, 2022). To address these challenges, the integration of biofertilizers alongside inorganic fertilizers emerges as a promising solution. Biofertilizers offer several advantages, including their eco-

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friendliness and economic viability, which can help reduce the dependence on chemical fertilizers. These biofertilizers have the ability to fix significant amounts of atmospheric nitrogen in the soil, enhance plant growth through the production of organic acids and growth hormones, and improve nutrient availability for the plants. By incorporating biofertilizers into tomato cultivation practices, farmers can optimize nutrient uptake, stimulate plant growth, and enhance overall crop productivity. In this context, the utilization of biofertilizers has gained attention as a potential alternative to conventional fertilizers for enhancing tomato crop growth, yield, and overall sustainability.

Furthermore, the use of biofertilizers has demonstrated positive effects on the soil ecosystem. The introduction of beneficial microorganisms can help improve soil structure, enhance nutrient cycling, and suppress soil-borne pathogens, thereby reducing the reliance on chemical inputs and promoting sustainable soil health management. However, despite the growing interest in biofertilizers for tomato cultivation, there is still a need for comprehensive research that investigates their efficacy under different environmental conditions, examines their long-term effects on crop growth and yield, and elucidates the underlying mechanisms involved. This research article aims to fill this gap by presenting a comprehensive study that evaluates the effects of various biofertilizers on tomato crop growth and yield performance. Through a combination of field experiments, laboratory analyses, and statistical modeling, this study seeks to provide valuable insights into the potential benefits and practical implications of integrating biofertilizers into tomato production systems.

2. Materials and Methods

The field experiment was conducted to evaluate the impact of different treatments on tomato crop growth and yield. The experiment consisted of seven treatments, which included 75 % and 100 % of the recommended dose of NPK. These treatments were combined with the application of N-fixing bacteria (*Azotobacter*), phosphorus-solubilizing bacteria (PSB) and Potassium solubilizing bacteria (KSB), in addition to a control that does not received any chemical and bio fertilizers.

The experimental design followed a randomized block design, with three replications to ensure statistical validity. Seedlings, aged thirty-eight days, were transplanted into the experimental plots and applications of biofertilizers were imposed as per the respective treatment combinations. All necessary cultural operations were performed in accordance with the specific requirements of the tomato crop across all experimental plots. Plant height measurements were taken at various intervals: 45, 90 days after transplantation (DAT) and at the final harvest.

At the time of the final harvest, the plants were uprooted and their fresh weight was measured. These plants were then subjected to sun drying for a period of 3-4 days, followed by drying in an oven at a temperature of 55 °C for 6-8 days. The dried plants were weighed to obtain the plant dry weight. Additionally, observations were made for the number of primary branches and the number of fruits per plant at the final harvest stage. The total fruit yield (measured in quintals per hectare) was computed based on the yield obtained from each individual plot.

By conducting these measurements and observations, valuable data was collected to assess various parameters of tomato plant growth and yield. This comprehensive analysis allowed for a detailed evaluation of the effects of the experimental treatments on the different plant characteristics, providing insights into the performance and productivity of the tomato crops.

3. Results and Discussion

3.1 Plant height (cm)

In this study, plant height was monitored at various stages of growth, and the effects of microbial inoculants and inorganic chemical fertilizer treatment combinations were recorded. The results showed a continuous increase in plant height from 45 days after transplanting (DAT) until the harvesting stage in all the treatment combination, regardless of the presence of microbial inoculants. However, treatments with 100% RDF (126.8 cm) and 75% RDF with *Azotobacter*, PSB and KSB (125.3 cm) showed significantly greater plant height compared to all other treatments at all stages of plant growth (45, 90 and at harvest stage) (Table 1, Fig. 1). Conversely, the control treatment (T_1) that did not received any chemical fertilizers and microbial inoculants exhibited the lowest plant height (37.5 cm).

These findings highlight the positive impact of specific microbial inoculants combinations in promoting plant height, providing valuable insights for optimizing plant growth in agricultural practices. Similar results were obtained by (Argaw, 2012) who revealed that the parameters like the height of the plant were enhanced by the co-inoculation of PSB and *Azotobacter* than single inoculation.

3.2 Number of branches/plant

The experiment examined the impact of different treatments on the number of branches per plant. The results revealed that Treatment T_2, which involved applying the full recommended dose of fertilizer (100 % RDF), led to the highest average of 14.66 branches per plant. This indicates that providing plants with the complete fertilizer dosage significantly promoted branch development (Table 2, Fig. 2).

Furthermore, Treatment T_7, which combined 75% RDF with *Azotobacter*, PSB, and KSB, demonstrated the second-highest average of 13.33 branches per plant. This suggests that the synergistic effects of microbial inoculants, along with a reduced fertilizer dose, positively influenced branch growth, similar findings were also recorded by (Gajbhiye *et al.*, 2003). In contrast, treatments involving specific microbial inoculants (T_3, T_4, and T_5) resulted in moderate to slightly lower numbers of branches per plant, ranging from 10.33 to 8.00. Finally, Treatment T_1 which is not treated with any biofertilizer and inorganic chemical fertilizer exhibited the lowest average of 4.00 branches per plant.

Table 1: Effect of biofertilizers on plant height (cm) at various stages of crop growth

Treatment	Plant Height (cm)		
	45 DAT	90 DAT	At final harvest
T_1 – Control	18.2	32.4	37.5
T_2 – 100% RDF	76.1	117.3	126.8
T_3 – 75% RDF + *Azotobacter*	70.4	112.2	121.7
T_4 – 75% RDF + PSB	69.5	109.5	120.4
T_5 – 75% RDF + KSB	69.0	108.1	119.6
T_6 – *Azotobacter* + PSB + KSB	55.9	91.7	116.2
T_7 – 75% RDF + *Azotobacter* + PSB + KSB	74.3	116.2	125.3
S.Em ±	0.82	1.21	1.12
CD at 5%	2.41	3.60	3.31

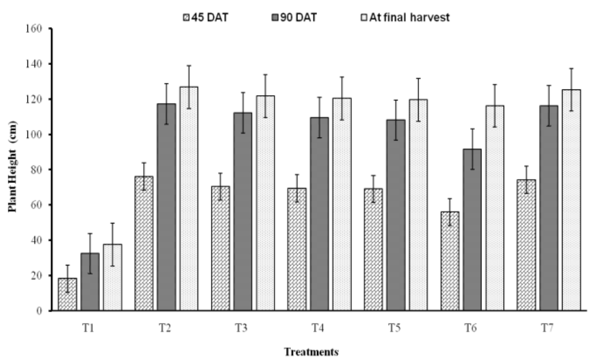

Fig. 1 Effect of biofertilizers on plant height (cm) at various stages of crop growth

3.3 No. of leaves/plant

The results of the experiment suggest significant differences in the number of leaves per plant among certain treatments. Treatment T_2, applying the full recommended dose of fertilizer (100% RDF), demonstrated a significantly higher leaf count with an average of 113.33 compared to the control group (Treatment T_1) with 51.00 leaves per plant. Similarly, Treatment T_7, combining 75% RDF with *Azotobacter*, PSB, and KSB, exhibited a significantly higher leaf count with an average of 109.66. However, treatments T_3, T_4, T_5, and T_6, which involved combinations of microbial inoculants and reduced RDF, showed non-significant differences in leaf count compared to T_2 and T_7. Nonetheless, these treatments still displayed improved leaf development compared to the control (Table 2, Fig. 2). Overall, the results indicate that the full RDF application and the combined use of microbial inoculants with a reduced RDF had significant positive effects on leaf growth, while the other treatments showed non-significant differences but still contributed to enhanced leaf development, in an another research conducted by (Mamatha and Bagyaraj, 2003) demonstrated the similar results.

3.4 Fresh weight/plant (g)

The results showed that, fresh weight per plant across different treatments, revealing both significant and non-significant differences. Treatment T_2, involving the application of the full recommended dose of fertilizer (100% RDF), displayed a significantly higher fresh weight per plant with an average of 412.66 g, compared to the control (T_1) with 195.33 g. Similarly, Treatment T_7, combining 75% RDF with *Azotobacter*, PSB, and KSB, exhibited a significantly higher fresh weight per plant with an average of 410.33 g, results obtained were similar to the research done by (Mahdi *et al.*, 2011) who investigated the effect of *Azotobacter chroococum*, was more than *Pseudomonas putida* and the combined inoculation produced the higher results than the control or sole application of either inoculants.. The findings demonstrate that the full RDF application and the combined use of microbial inoculants with a reduced RDF had significant positive effects on plant weight (Table 2, Fig. 2).

3.5 Dry weight/plant (g)

The analysis of dry weight per plant among the different treatments revealed that, Treatment T_2 which received the full recommended dose of fertilizer (100% RDF), exhibited a significantly higher dry weight per plant with an average of 133 g compared to the control group (T_1) with 42.66 g. Similarly, Treatment T_7, combining 75% RDF with *Azotobacter*, PSB, and KSB, displayed a significantly higher dry weight per plant with an average of 129.66 g, our results are in accordance with (Singh *et al.*, 2004). In contrast, treatments T_3, T_4, T_5, and T_6, which involved combinations of microbial inoculants with a reduced RDF, showed non-significant differences in dry weight

Table 2: Effect of biofertilizers on growth and yield parameters of tomato crop

Treatment	No. of branches/Plant	No. of leaves/Plant	Fresh weight/Plant (g)	Dry weight/Plant (g)	Number of fruits/Plant	Yield (q/ha)
T_1 – Control	4.00	51.00	195.33	42.66	14.66	238.71
T_2 – 100% RDF	14.66	113.33	412.66	133.00	53.00	712.46
T_3 – 75% RDF + *Azotobacter*	10.33	102.00	386.00	103.33	41.33	624.35
T_4 – 75% RDF + PSB	9.66	98.66	383.66	101.00	38.00	617.97
T_5 – 75% RDF + KSB	8.00	96.00	379.33	94.66	35.66	613.52
T_6 – *Azotobacter* + PSB + KSB	7.66	92.33	322.00	63.00	26.33	413.53
T_7 – 75% RDF + *Azotobacter* + PSB + KSB	13.33	109.66	410.33	129.66	51.66	697.34
S.Em ±	0.76	2.37	6.23	8.16	2.82	13.28
CD at 5%	2.25	7.08	18.64	24.45	8.41	39.81

compared to T_2 and T_7 (Table 2, Fig. 2). However, these treatments still contributed to increased dry weight relative to the control.

3.6 Number of fruits/plant

The analysis of the number of fruits per plant revealed significant differences among the treatments. Treatment T_2, which applied the full recommended dose of fertilizer (100% RDF), exhibited a significantly higher fruit count per plant compared to the control (T_1). Similarly, Treatment T_7, combining 75% RDF with *Azotobacter*, PSB, and KSB, demonstrated a significant increase in fruit production. In contrast, when compared to T_2 and T_7, treatments T_3, T_4, T_5, and T_6, which employed combinations of microbial inoculants with a reduced RDF, did not exhibit statistically significant disparities in fruit count. However, these treatments still contributed to an enhanced number of fruits per plant (Table 2, Fig. 2).

3.7 Fruit yield/plant

The analysis of the fruit yield per plant (q/ha) across various treatments showed that the Treatment T_2, which involved the application of the full recommended dose of fertilizer (100% RDF), displayed a significantly higher fruit yield per plant compared to the control (T_1) and which was followed by the treatment T_7 which received combined application 75% RDF with Azotobacter, PSB, and KSB. These results are in agreement with the findings of (Dhanasekaran and Bhuvaneswari, 2005). Notably, Treatment T_1 which does not received inorganic fertilizer and biofertilizers demonstrated the lowest fruit yield among the treatments (Table 2, Fig. 2).

From this study, it was concluded that the significant variations in various plant growth and yield parameters. Treatments involving the full recommended dose of fertilizer (100% RDF) consistently demonstrated superior performance across multiple metrics. Specifically, T_2 displayed increased plant height, a higher number of leaves, branches and fruits per plant, as well as greater fresh and dry weights, similar results were also obtained by (Sengupta *et al.*, 2002). Additionally, Treatment T_7, combining 75% RDF with microbial inoculants, showcased notable improvements in plant height, number of branches, fresh weight, and fruit yield (Rama and Naik, 2017).

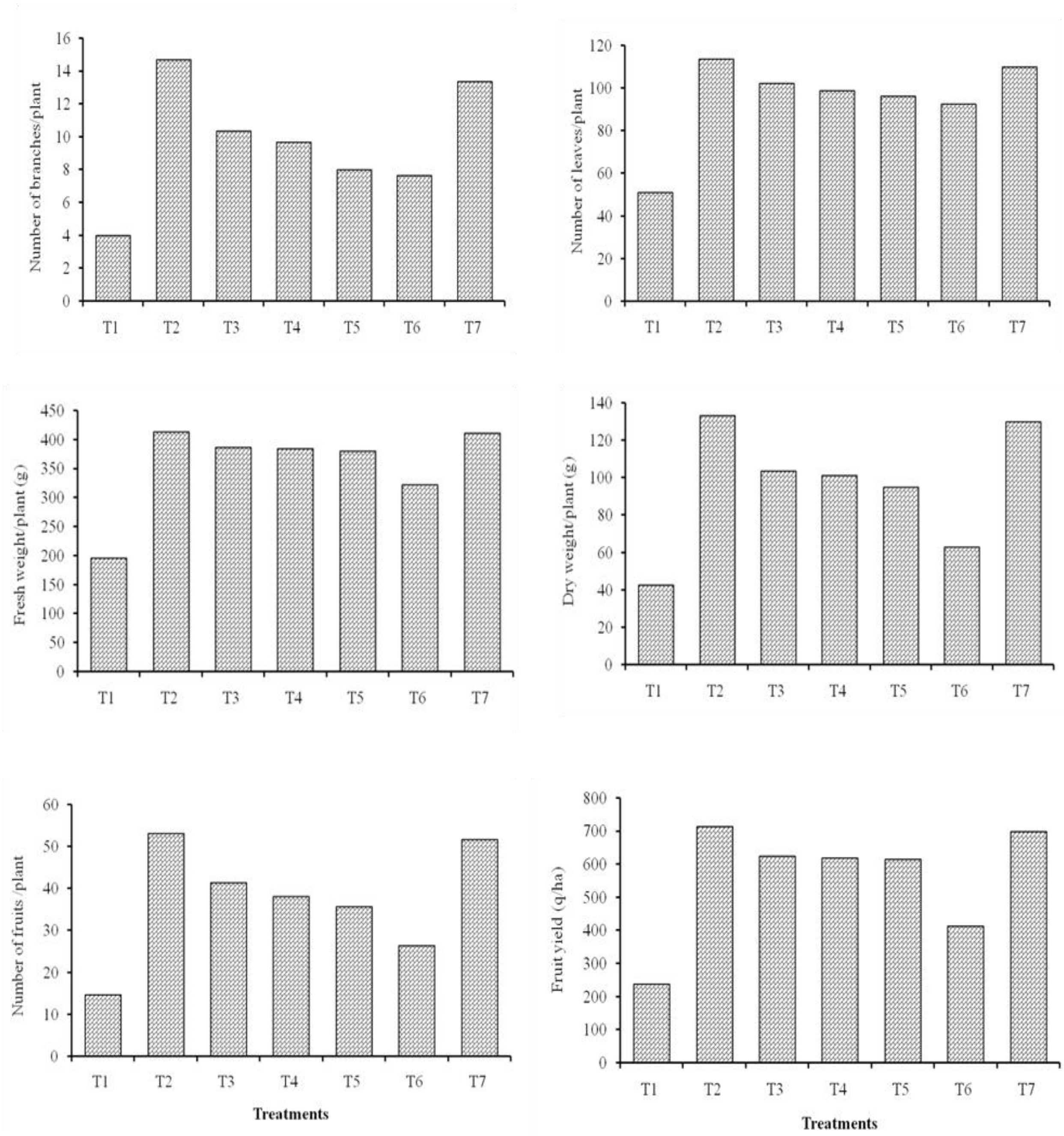

Fig.2 Effect of biofertilizers on growth and yield parameters of tomato crop

While treatments with reduced RDF and microbial inoculants (T_3, T_4 and T_5) did not yield statistically significant differences in various growth and yield parameters of tomato, they still exhibited positive effects compared to the control (T_1).

The observed enhancements in all the plant growth and yield parameters may be attributed to various factors. One potential contributor is the secretion of ammonia into the rhizosphere, which can have a positive impact on plant growth (Harikrishna *et al.*, 2002). Another factor that could play a role is the accelerated movement of photosynthates facilitated by root exudates.

The presence of beneficial microorganisms in the soil might also contribute to the observed improvements. These microorganisms may engage in various biological activities that enhance the soil's condition, transforming it into a fertile zone capable of readily supplying essential nutrients to the plant's root system. Similar positive outcomes were documented in studies conducted on coriander (Subramanian and Vijayakumar, 2001) and maize (Rama *et al.*, 2015). Collectively, these findings offer valuable insights for improving growth and yield parameters of tomato by adapting different treatment combinations to reduced the use of inorganic chemical fertilizers.

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5. Conflict of Interest

None declared. The authors affirm no financial or personal relationships that could influence the objectivity or interpretation of the findings.

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