



Study on Differential Effect of Biofertilizer on Growth, Yield and Quality Attributes of Cherry Tomato (*Solanum lycopersicum* var *cerasiformae*)

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ABSTRACT

Background: A biofertilizer is a product that contains living microorganisms, which, when applied to soil, plant surfaces, or seeds, establish themselves in the plant's rhizosphere and promote growth by providing essential nutrients. Considered an environmentally friendly alternative to chemical fertilizers, biofertilizers help minimize ecological harm. Moreover, after 3-4 years of consistent use, additional applications are unnecessary, as the original inoculants are sufficient for continued growth and multiplication.

Methods: This study investigates the differential effects of biofertilizers on the growth, yield and quality attributes of Cherry tomato (*Solanum lycopersicum* var. *cerasiformae*) during Rabi 2019 at new horticulture nursery, Jabalpur. Thirteen treatments, incorporating combinations of Azotobacter and Pseudomonas with varying rates of recommended dose of fertilizers (RDF), were arranged in a randomized block design with three replications.

Result: Key findings revealed that the treatment of 75% RDF combined with Azotobacter and Pseudomonas significantly enhanced growth parameters, yielding the highest plant height (35.05 cm at 30 DAT) and number of branches (24.33 at 90 DAT). Additionally, it resulted in superior phenological traits, such as the earliest flowering and highest flower clusters. Yield metrics, including fruit diameter (2.58 cm), fruit weight (11.32 g) and overall yield (1368.33 g per plant), were also maximized under this treatment. Furthermore, economic analysis showed that this combination yielded the highest gross income (Rs 248,880), net income (Rs 189,226.07) and B:C ratio (3.17). Overall, the application of biofertilizers proved beneficial for both agronomic and economic aspects of Cherry tomato cultivation.

Key words: Azotobacter, Biofertilizer, Economics, Pseudomonas, Quality, Yield.

INTRODUCTION

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is native to the Peru-Ecuador region and is likely an ancestor of today's cultivated varieties. Its current form emerged after a lengthy domestication process, which likely began in Central Mexico. The Aztecs referred to it as *tomatl* or *xtomatl* and used it for cooking. It has a chromosome count of $2n=24$. Cherry tomatoes are typically seen as akin to, but not the same as, their wild relatives, the original tomato plants. They were commonly cultivated in Central America when the conquistadors arrived and are now found in regions such as California, Korea, Germany, Mexico and Florida. Tomato is consumed in a variety of ways, raw as salad, cooked in various dishes and as various other processed products like sauce, catch-ups, etc (Shilpa et al., 2021).

Bio-fertilizers are the carrier-based preparations containing mainly effective strains of microorganisms in sufficient number, which are useful for nitrogen fixation solubilizing phosphate, synthesis of growth promoting substances. To maintain crop productivity as well as soil fertility, biofertilizers play a significant role (Maity et al., 2024). Amongst bio-fertilizers *Azotobacter* strains play a key role in harnessing the atmospheric nitrogen through its fixation in the roots. The *Pseudomonas* is one of the most powerful phosphate solubilizing bacteria as inoculants simultaneously increase phosphate uptake by the plant and increase crop

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yield. At the outset, *Pseudomonas* is behaviourally versatile with free living as well as parasitic forms capable of colonizing a wide variety of host organisms and ecological niches within hosts (Sadarahalli et al., 2022). These are known to be less expensive, eco-friendly, sustainable and do not require non-renewable source of their production and it will improve growth and quality of crop. Broad based and careless use of chemical fertilizers, pesticides and fungicides are responsible for degradation of soil health. Even the nutrient requirement of plants is supplemented with organic manures and biofertilizer which will enhance the soil fertility and maintain soil health.

Integrated use of chemical fertilizer as well as bio fertilizer in Cherry tomato can be more efficient than chemical fertilizer alone. Biofertilizers are creating advancement in growing level concern towards environmental safety sustainable agricultural practice. In this present study, different levels of biofertilizers are used to examine the effect on growth, yield and quality attributes of cherry tomato. This experiment was carried out during Rabi season 2019-2020 at new horticulture nursery in adhartal, within the Department of Horticulture, JNKVV Jabalpur (M.P.) with the objective to find out a potential biofertilizer for cherry tomato in commercial use.

MATERIALS AND METHODS

The aim of this research is to examine the differential effects of biofertilizers on the growth, yield and quality attributes of cherry tomatoes. The study was conducted at the New Horticulture Nursery in Adhartal, within the Department of Horticulture at JNKVV Jabalpur (M.P.) during the Rabi season of 2019-2020. The soil at the experimental site was medium black (Vertisol) clayey loam, characterized by uniform topography, good drainage and moderate NPK levels. The experiment was organized in a Randomized Block Design with three replications. The detail of thirteen different treatments viz., T1 (*Pseudomonas*), T2 (*Azotobacter*), T3 (RDF; 90:60:50 Kg/ha), T4 (100% RDF + *Pseudomonas*), T5 (100% RDF + *Azotobacter*), T6 (100% RDF + *Pseudomonas* + *Azotobacter*), T7 (50% RDF + *Pseudomonas*), T8 (50% RDF + *Azotobacter*), T9 (50% RDF + *Pseudomonas* + *Azotobacter*), T10 (75% RDF + *Pseudomonas*), T11 (75% RDF + *Azotobacter*), T12 (75% RDF + *Pseudomonas* + *Azotobacter*) and T13 (Control). The seedlings were grown in pro trays under polyhouse conditions at the nursery. Seeds were sown in the pro trays using a soilless medium at a depth of 2-3 cm. This medium was created by thoroughly mixing sieved farmyard manure (FYM), coco peat and soil in a 1:1:1 ratio before filling the pro trays. Approximately 30-day-old seedlings, featuring 5-6 true leaves, were then transplanted into the experimental plots, following a pre-marked spacing of 60 cm × 50 cm. The fertilizer dosage was determined by the soil's fertility and the amount of organic manure used. For optimal yield, 25 tons of well-decomposed FYM was incorporated into the soil, with the treatment fertilizer calculated and applied accordingly. The calculated amount of RDF for 100% will be nitrogen (90 kg N/ha), phosphorus (50 P₂O₅/ha) and potash (60 kg K₂O/ha), for 75% RDF nitrogen (67.5 kg N/ha), phosphorus (37.5 P₂O₅/ha) and potash (45 kg K₂O/ha) and for 50 % RDF nitrogen (45 kg N/ha), phosphorus (25 P₂O₅/ha) and potash (30 kg K₂O/ha) were applied. These fertilizers supplied through urea (46%), single super phosphate (16%) and muriate of potash (60% K₂O) respectively. Half amount of urea and full dose of SSP and MOP was applied to each plot as basal dressing at transplanting. The remaining half dose of urea was applied around 30 days after transplanting.

In this experiment, *azotobacter* and *pseudomonas* were the two biofertilizers used. *Azotobacter* was applied as a seed treatment by mixing 50 g of *Azotobacter* with 100 ml of water to create a slurry. The seeds were thoroughly mixed with this slurry for even distribution, then dried in the shade before being sown in the pro trays. After one month of transplanting, a foliar application of *Pseudomonas* was conducted. For this, 15 ml of the solution was mixed with 1 liter of water and sprayed onto the respective plots using a hand sprayer.

The analysed data of plant height (cm), number of branches per plant at different days and days to 50% flowering are recorded by randomly selecting five representative plants from each plot of each replication. The yield contributing traits such as number fruit per plant, fruit set percentage (%), fruit length (cm), fruit diameter (cm), fruits weight (g), fruit yield per plant (kg), total fruit yield per hectare (q ha⁻¹) are recorded at physiological maturity as per the standard method whereas fruit length and fruit diameter are measured by using Vernier calliper. In quality attributes, the total soluble solids (p Brix) is collected as per the standard method by using hand refractometer.

RESULTS AND DISCUSSION

Effect on morphological and phenological parameters

Among the different treatment the maximum plant height was found in T12 (35.06 cm) at 30 DAT and T6 (76.06, 125.16 cm) at 60 and 90 DAT. It was followed by T6 (33.40 cm) at 30 DAT and T12 (73.93, 124.23 cm) at 60 and 90 DAT which were statistically at par with each other as illustrated in Table 1. Minimum plant height was recorded in T13 (29.47, 62.46 and 93.96 cm) at 30, 60 and 90 DAT respectively. This increase in plant height is due to the production of more chlorophyll content with the inoculation of nitrogen fixers. The other reason for increased vegetative growth may be the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. In addition, the growth-promoting substances that are produced in high quantities by the action of rhizosphere microorganisms influence the overall morphology and physiology of different crops (Sumbul *et al.*, 2020). Bacteria promote plant growth under both normal and stress conditions using direct mechanisms such as nitrogen fixation, phosphate solubilization, potassium solubilization, phytohormone production, iron sequestration or indirect mechanisms for the protection of plants against various pathogens by antibiotic release, the induction of systemic resistance and competition (Goswami *et al.*, 2020) which is found in conjugation to Pandey *et al.* (2023), Tadesse *et al.* (2021) and Salim *et al.* (2018) in Tomato, Barley and Broccoli.

It is evident from data shown in Table 2 that biofertilizer treatment had found statistically insignificant influence on number of branches per plant at 45 DAT and significant at 90 DAT. Minimum number of branches per plant recorded in control (8.93, 19.80) at 45 and 90 DAT. Whereas maximum number of branches per plant was found in T12 (11.73) at 45 DAT and T6 (24.33) at 90 DAT followed by T6 (10.56) at

45 DAT and T12 (23.2.) which were statistically at par with each other. Nagoni *et al.* (2017) in their research revealed that application of 75 per cent RDF along with biofertilizer increase the number of branches over control. This also confirms the previous studies of Shahram Sharafzadeh, (2012) and Salim *et al.* (2018) in tomato and Broccoli. This biological fertilizer increases the availability of nitrates, nitrites and phosphates in the roots and leaves of the R. serpentina plant. This formulation also increases the alkaloid content in the roots of this plant which leads to cell enlargement, cell division and ultimately resulting in increased plant growth (Elita *et al.*, 2022).

It was observed from the data illustrated in Table 2 that the biofertilizer had significant influence on days to 50% flowering. Treatment T12 -75% RDF + *Azotobacter* +

Pseudomonas takes significantly the minimum days to 50% flowering (44.00) followed by treatment T6-100% RDF + *Azotobacter* + *Pseudomonas*, whereas control takes the maximum days to 50% flowering (51.66). The present research reveals that there had been a significant increase in number of flowers per plant by organic manures and bio-fertilizers treatments by Meena *et al.* (2017). These findings are in conformity with the reports of Meena *et al.* (2017) and Sharma *et al.* (2022). The effect of biofertilizer on phenological parameter may be due to more vegetative growth consequently increased translocation of photosynthesis towards reproductive organs. Earliness in cherry tomato could be due to its higher capacity to make available assimilates to the apex during the sensitive phase before initiation as reported by Prema *et al.* (2011).

Table 1: Effect of biofertilizer application on plant height (cm) at different days after transplanting (DAT).

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
T1- <i>Pseudomonas</i>	32.13	66.40	97.63
T2- <i>Azotobacter</i>	30.53	63.07	97.57
T3- RDF	32.33	65.00	110.58
T4-100% RDF+ <i>Pseudomonas</i>	31.96	69.33	113.16
T5- 100% RDF + <i>Azotobacter</i>	31.40	66.61	119.30
T6- 100% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	33.40	76.06	125.17
T7- 50% RDF + <i>Pseudomonas</i>	32.00	69.25	109.40
T8- 50% RDF + <i>Azotobacter</i>	32.46	70.27	109.80
T9- 50% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	31.90	68.91	110.26
T10- 75% RDF + <i>Pseudomonas</i>	32.47	64.90	119.10
T11- 75% RDF + <i>Azotobacter</i>	31.86	67.17	119.86
T12- 75% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	35.06	73.93	124.23
T13- Control	29.46	62.47	93.96
C.D	2.58	6.98	8.28
SE(m)±	0.88	2.37	2.82

Table 2: Effect of biofertilizer application on No. of branches per plant at different days and days to 50% flowering.

Treatments	Number of branches per plant		Day to 50% flowering
	45 DAT	90 DAT	
T1- <i>Pseudomonas</i>	9.56	20.40	49.00
T2- <i>Azotobacter</i>	9.46	19.76	50.33
T3- RDF	9.20	21.46	49.33
T4-100% RDF+ <i>Pseudomonas</i>	9.66	21.53	45.33
T5- 100% RDF + <i>Azotobacter</i>	9.46	22.06	46.66
T6- 100% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	10.56	24.33	46.00
T7- 50% RDF + <i>Pseudomonas</i>	9.33	21.30	48.00
T8- 50% RDF + <i>Azotobacter</i>	9.50	20.96	47.33
T9- 50% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	9.16	20.50	49.00
T10- 75% RDF + <i>Pseudomonas</i>	9.9	20.80	46.00
T11- 75% RDF + <i>Azotobacter</i>	9.73	21.56	47.66
T12- 75% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	11.73	23.20	44.00
T13- Control	8.93	19.80	51.66
C.D	N S	2.403	4.101
SE(m)±	0.563	0.818	1.975

Effect on yield parameter

As shown in Table 3 and 4, the maximum number of fruits per plant (136.63) and highest fruit length (4.36 cm) was recorded by treatment T6-100% RDF + *Azotobacter* + *Pseudomonas* and also maximum fruit diameter (2.58 cm), fruit set percentage (69.66%), fruit weight (11.31 g) fruit yield/plant (1368.33 g) and highest fruit yield (311.10 q/ha) were observed in treatment T12-75% RDF + *Azotobacter* + *Pseudomonas*, whereas the minimum number of fruits per plant (95.17), fruit length (3.52 cm), fruit diameter (1.98 cm), fruit set percentage (60.00%), fruit weight (7.64 g), fruit yield/plant (856.33 g) and lowest fruit yield (197.73 q/ha) were observed in T13 - control. The morphological parameters like number of fruits per plant, fruit weight, fruit diameter, plant yield per plant and fruit yield (t/ha) were highly

significant similar work was reported by Meena *et al.* (2017). The incorporation of *Azotobacter* in integrated nutrient module leading to better growth and yield confirms the previous studies of Shahram Sharafzadeh, (2012). The increase in yield might be due to increased fruit set per plant, due to the fact that nitrogen fixers and phosphorous solubilizers (Singh and Singh, 2009) which is in adherence to Baba *et al.* (2018) in Tomato. Similar results were reported by Poonia and Dhaka, (2012). Nagoni *et al.* (2017) revealed that application of 75 per cent RDF along with biofertilizer had stimulatory effect of biofertilizers especially *Azotobacter* and phosphate solubilizing bacteria for the development of photosynthetic structures like size of the chloroplast and the number of grana mm⁻². Shukla *et al.* (2009) reported that the supply of essential nutrients to tomato, their availability,

Table 3: Effect of biofertilizer application on yield attributes.

Treatments	No. of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit set percentage (%)
T1- <i>Pseudomonas</i>	105.35	3.83	2.05	62.66
T2- <i>Azotobacter</i>	101.96	3.84	2.09	61.33
T3- RDF	115.47	3.86	2.23	62.66
T4-100% RDF+ <i>Pseudomonas</i>	120.39	3.99	2.12	66.67
T5- 100% RDF + <i>Azotobacter</i>	122.90	3.96	2.15	65.00
T6- 100% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	136.63	4.36	2.26	68.67
T7- 50% RDF + <i>Pseudomonas</i>	120.65	3.79	2.23	61.00
T8- 50% RDF + <i>Azotobacter</i>	119.73	3.85	2.00	61.33
T9- 50% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	121.31	3.95	2.11	62.67
T10- 75% RDF + <i>Pseudomonas</i>	124.03	4.05	2.21	62.00
T11- 75% RDF + <i>Azotobacter</i>	119.64	4.04	2.19	63.66
T12- 75% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	133.17	4.18	2.58	69.67
T13- Control	95.17	3.52	1.98	60.00
C.D	13.439	0.372	0.287	4.507
SE(m)±	4.577	0.127	0.098	1.535

Table 4: Effect of biofertilizer application on yield and quality attributes.

Treatments	Fruits weight (g)	Fruit yield per plant (g)	Total fruit yield per hectare (q/ha)	TSS (° Brix)
T1- <i>Pseudomonas</i>	8.07	968.33	219.83	5.21
T2- <i>Azotobacter</i>	8.28	996.66	228.71	5.27
T3- RDF	9.24	951.66	239.05	5.27
T4-100% RDF+ <i>Pseudomonas</i>	9.65	976.33	254.44	5.45
T5- 100% RDF + <i>Azotobacter</i>	9.99	985.67	253.33	5.33
T6- 100% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	11.04	1316.67	304.44	6.13
T7- 50% RDF + <i>Pseudomonas</i>	9.34	925.66	231.10	5.50
T8- 50% RDF + <i>Azotobacter</i>	9.13	983.67	232.88	5.47
T9- 50% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	9.81	948.31	246.18	5.73
T10- 75% RDF + <i>Pseudomonas</i>	10.21	1071.67	285.10	5.61
T11- 75% RDF + <i>Azotobacter</i>	10.40	1058.33	286.66	5.48
T12- 75% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	11.32	1368.33	311.10	6.21
T13- Control	7.64	856.33	197.73	4.78
C.D	1.65	251.38	51.957	0.711
SE(m)±	0.562	85.165	17.695	0.242

Table 5: Economic analysis of different treatments.

Treatments	Gross monetary returns (Rs/ha)	Total cost of cultivation (Rs/ha)	Net monetary returns (Rs/ha)	B: C ratio
T1- <i>Pseudomonas</i>	175864	53305	122559	1:2.29
T2- <i>Azotobacter</i>	182968	51738	131230	1:2.53
T3- RDF	191240	59524.9	131715.1	1:2.21
T4-100% RDF+ <i>Pseudomonas</i>	203552	61131.9	142420.1	1:2.25
T5- 100% RDF + <i>Azotobacter</i>	202664	59564.9	143099.1	1:2.39
T6- 100% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	243552	61171.9	182380.1	1:2.98
T7- 50% RDF + <i>Pseudomonas</i>	184880	58085.95	126714.05	1:2.18
T8- 50% RDF + <i>Azotobacter</i>	186304	56528.95	129775.05	1:2.29
T9- 50% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	196944	58125.95	138818.05	1:2.38
T10- 75% RDF + <i>Pseudomonas</i>	228080	59613.93	168466.07	1:2.82
T11- 75% RDF + <i>Azotobacter</i>	229358	58056.93	171301.07	1:2.95
T12- 75% RDF + <i>Pseudomonas</i> + <i>Azotobacter</i>	248880	59653.93	189226.07	1:3.17
T13- Control	158184	51698	106486	1:2.05

acquisition, mobilization and influx into the plant tissues increased and thus improved growth and yield components.

Effect on quality parameters

In accordance to the data observed in Table 4, differential response of *Azotobacter* and *Pseudomonas* treatment had significant influence on total soluble solids. The lowest TSS reading (4.78°Brix) was recorded by treatment Control. Where the highest TSS reading (6.21°Brix) was observed with treatment T12 -75% RDF + *Azotobacter* + *Pseudomonas*. However, T6 - 100% RDF + *Azotobacter* + *Pseudomonas* which was at par. Kourosh Ordookhani and Mahdi Zare, (2011) observed in the *Pseudomonas* + *Azotobacter* treatment which had differed significantly from other treatments. Meena *et al.* (2017) postulated 75 % RDF along with 25% FYM and *Azospirillum* treatment combinations were highly significant. Similar results on cherry tomato found by Prema *et al.* (2011), Islam *et al.* (2012) and Sharma *et al.* (2022). Higher TSS might be due to the enhanced deposition of solids and more conversion of organic acids to sugars.

Economic parameters

The recorded data illustrated in Table 5 shows the maximum gross return (Rs 295545) was reported in T12 treatment and net return (Rs 225705.97) was noted by treatment T12- (75% RDF + *Azotobacter* + *Pseudomonas*) due to which an improved B:C ratio (3.23) was obtained. Whereas the minimum gross return (Rs 187843.5) and net return (Rs124142.4) was found in Control (T13). Higher market price and less cost of cultivation are desirable characters for getting higher returns. The net realization was worked out from the yield of tomato by taking into consideration the prevailing prices of tomato fruits harvested during the experimentation. *Azotobacter* @ 2 kg/ha+75% N + full dose of PK + full dose of FYM treatment combination significantly increased growth, yield and quality characters over RDF or organic manures alone thereby a saving of 25% chemical nitrogen application

during the year of study also the maximum net returns to the tune of Rs. 148089/- and highest B:C ratio of 1:2.51 was recorded with the same treatment.

CONCLUSION

In light of the experimental findings summarized above, it may be concluded that among various treatment 75% RDF + *Azotobacter* + *Pseudomonas* showed better response with respect to plant height, number of branches, minimum days to flowering, minimum days to 50% flowering, number of flowers per cluster, fruit diameter, fruit set percentage, average fruit weight, yield per plant, total yield per hectare and TSS. Besides it boost soil health minimized soil pollution and was also economical. Even though 100 % RDF + *Azotobacter* + *Pseudomonas* was at par with 75% RDF + *Azotobacter* + *Pseudomonas* keeping the fact of highest gross income and B:C ratio 75% RDF + *Azotobacter* + *Pseudomonas* concluded as the best of all other treatment.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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