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Effect of *Azotobacter* and Phosphate Solubilizing Bacteria on Growth and Yield Parameters of Tomato

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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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Short Research Article

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ABSTRACT

Introduction: Tomato (*Solanum lycopersicum* L.) is a nutritionally rich vegetable crop of global importance, widely cultivated in tropical and semi-arid regions. In 2022–23, worldwide tomato production reached 20 million metric tonnes from 8.64 million hectares, with Maharashtra contributing 0.67 million metric tonnes from 0.18 million hectares.
Problem: Excessive reliance on chemical fertilizers to overcome nutrient deficiencies leads to soil degradation, reduced microbial diversity and environmental concerns. There is a pressing need for eco-friendly alternatives to sustain productivity while maintaining soil health.

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Aim: This study was undertaken to evaluate the effectiveness of beneficial microorganisms, particularly *Azotobacter* and phosphorus-solubilizing bacteria (PSB), in improving growth, yield, and soil nutrient status of tomato, with reduced chemical fertilizer input.
Methods: A pot-culture experiment was conducted using different treatments of *Azotobacter* and PSB, alone and in combination, along with varied levels of recommended N and P fertilizers. Growth, yield attributes, and soil nutrient status were recorded and compared.
Results: The combined treatment of seedling inoculation with *Azotobacter* + PSB along with 75% recommended N & P significantly outperformed other treatments. It recorded the highest number of branches (19.27), plant height (73.73 cm), and root length (22.57 cm). Yield parameters also improved, with minimum days to flower initiation (39.40 days), maximum fruits per plant (13.82), polar diameter (6.13 cm), equatorial diameter (4.99 cm), average fruit weight (73.33 g), fruit yield per plant (1.013 kg), and total yield per hectare (375.32 q). Soil nutrient status after harvest also showed higher available N (282.24 kg/ha) and P (36.47 kg/ha).
Novelty: The study demonstrates that integration of microbial inoculants with reduced fertilizer doses can enhance tomato growth, yield, and soil fertility while lowering chemical input. This highlights the potential of biofertilizers as sustainable tools for nutrient management and eco-friendly tomato cultivation.

Keywords: Tomato; Azotobacter; PSB; growth parameters; yield.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an vegetable crop in different semi-arid and tropical regions of the world with excellent nutraceutical properties. 20 million metric tonnes of tomatoes were produced on 8.64 million hectares of land in the fiscal year 2022-2023 2nd largest producer worldwide. It was grown among the different states of India, such as Madhya Pradesh, Andhra Pradesh, Karnataka, Odisha, Gujarat, West Bengaland Tamil Nadu. Tomato is grown on an area of 55.227 thousand hectares in India with a production of 1.3 million metric tonnes (MSHMPB,2023). Maharashtra cultivated over an area of 0.18 million hectares with a total production of 0.67million metric tonnes (MSHMPB,2023).

Azotobacter is a beneficial microorganism that can be used as a bioinoculant to enhance plant health by converting atmospheric nitrogen into ammonia, which plants can then utilize Tomato growth and development are greatly aided by nitrogen, which influences the rich green colour of the leaves and supports the vegetative stages. Higher tomato yields are the result of applying the proper amount of nitrogen fertilizer to the soil. Ambesh *et al*., (2017) isolated *Azotobacter* from soil samples were inoculated them in Jensen's medium. in their study examined bacterial colonies was gramnegative with bacilli form under a microscope. According to Raut *et al*., (2022) the colony colour was described as spherical or irregular and it was white, creamy or yellowish. Encouraging results after the application of PSB inoculum on tomato together with appropriate fertilizer rate Many microorganisms aid in the solubilization of phosphorus and are essential to the cyclic processes of phosphorus such as the mineralization of organic phosphorus, the dissolution of insoluble inorganic phosphorus and the absorption of phosphorus (Zhu *et al*., 2018; Wise *et al*., 2021). Tomato inoculation with PSB indicated production increment, disease resistance, stress resistance and lessened production cost (Khan *et al*., 2015; Zhang *et al*., 2021). Biofertilizers on the other hand promote plant growth and productivity in an environment friendly manner. They support plant development by enhancing biotic, abioticstress tolerance, as well as boosting plant nutrition through processes such as atmospheric nitrogen fixation and the solubilization of soil nutrients

2. MATERIALS AND METHODS

The experiment was undertaken at Plant Pathology Section, RCSM College of Agriculture, Kolhapur and on the instructional cum research horticulture farm, Kolhapur, during the year 2024. Seven isolates of *Azotobacter* and three PSB were isolated from tomato rhizosphere of Kolhapur District. All isolates were identified on the basis of morphological (gram staining, cell shape), microscopic observations and different biochemical test *viz*. catalase, methyl red, indole, nitrate, gelatine, H_2S, oxidase and starch hydrolase N fixing and P solubilizing ability respectively (Jain *et al*., 2022,) On the basis of N fixing ability, the most effective isolate 6 of *Azotobacter* were designated as (*Azo*VI 12.62 mg/g^{-1} of sucrose) and in case of PSB, on the

basis of maximum solubilization index most effective isolate of PSB was designated as (PSB I) were selected for pot culture. Raut et al., (2022) The experiment was laid out in RBD with three replications and eight treatments. The tomato seedlings of variety Ansal required for field experiment 25 days old seedlings were used to transplanting. these seedlings were treated with *Azotobacter* and Phosphate solubilizing bacterial inoculums using seedling root dip method. As per the plan of layout treated seedlings transplanted in respective pots Raut et al., (2022). Data are recorded and analyzed statistically to express the yield. Raut et al., (2022)

3. RESULTS AND DISCUSSION

The experimental results (Table 1) revealed that, growth and yield parameters of tomato significantly increased when seedlings were treated with *Azotobacter* and phosphate solubilizing bacteria as compared to uninoculated control. The results concern with growth parameters revealed that, the plants inoculated with treatment T5, 75% N & P+ Reference *Azotobacter* + Efficient isolate of PSB showed the highest number of branches (19.27), highest plant height (73.73 cm), highest root length (22.57cm), maximum days to flower initiation (39.40 days), maximum number of fruits per plant (13.82), maximum polar diameter (6.13cm), maximum equatorial diameter (4.99cm), average fruit weight (73.33 gm), fruit yield per plant (1.013 kg) and total yield per ha (375.32 qt) which was found superior to rest of the treatment. Treatment T_3, 75% RDF of N & P + efficient isolate of *Azotobacter* & PSB showed the highest number of branches (18.20), plant height (70.28 cm), root length (15.87 cm), days to flower initiation (40.46),number of fruits per plant (13.15), polar diameter of fruits(6.03 cm), equatorial diameter(4.42 cm), average fruit weight (69.46 gm), fruit yield per plant (0.913 kg) and total yield per ha (338.29 qt) was found statistically at par with treatment T_6,100% RDF + Reference of *Azotobacter* and PSB showed the number of branches (18.00), plant height (67.87cm), root length (13.18 cm), days to flower initiation (40.60 days), number of fruits per plant (12.91), polar diameter of fruits (5.91 cm), equatorial diameter of fruits (4.34 cm), average fruit weight (68.06 gm), fruit yield per plant (0.878 kg) and total yield per ha (325.37 qt).

The minimum number of branches (13.93), plant height (67.87 cm),root length (6.00 cm), days to flower initiation(45.20 days), number of fruits per plant (11.96), polar diameter of fruits (3.70 cm), equatorial diameter of fruits (3.12 cm), average fruit weight (41.66 gm), fruit yield per plant (0.498 kg) and total yield per ha (184.53 qt) was appeared in treatment T_8, absolute control. Similar results were found by Yadav *et al*., (2023) and Pandey *et al*., (2023) in tomato. Maximum plant height (156.40cm) and (77.83 cm) respectively of tomato atharvest after application of *Azotobacter* + PSB compared to rest of the treatment. Similar trend of result was observed in case of yield parameters.

Data on yield parameter revealed that, the plants inoculated with Azotobacter and PSB. Present finding of days required for flower initiation was reported by Yadav *et al*., (2023) who observed that, Treatment comprising *Azotobacter* + PSB has the earliest blossom appearance. In case of number of fruits per plant findings are conformity with Sayed *et al*., (2024) the Vermicompost + *Azotobacter* + PSB treatment produced the maximum fruits per plant (99.94) and Yadav *et al*., (2023) study revealed that maximum fruits per plant (20.60) in the *Azotobacter* + PSB treatment. For polar and equatorial diameter of fruits results are in close agreement with Siddhaling *et al*., (2017) who stated that, tomato plants inoculated with *Azotobacter* and PSB along with 75% RDF produced higher polar and equatorial fruit diameter. The results of present investigation are in accordance with the results of Brar *et al*., (2015)found that, the application of vermicompost along with *Azotobacter* and PSB significantly enhanced the average fruit weight compared to the control with the highest average fruit weight reported as 67.67 g. Similarly, fruit yield per plant is in conformity with who found that treatment T_7 (Vermicompost + *Azotobacter* + PSB) produced the maximum fruit yield per plant 3.05 kg. The lowest yield per plant (2.23 kg/plant) is shown by treatment T_0 (control). However, total yield per ha of tomato was in agreement of Arpitha *et al*., (2024) who reported that tomato fruit yield significantly increased with the inoculation of *Azotobacter* and PSB in combination with 75% RDF (T_7). The maximum available N after harvesting of tomato (282.24 Kg/ha) was recorded in soil collected from in treatment T5, which was found superior over rest of the treatment. Treatment T3 recorded 249.83 kg/ha N was statistically at par with the treatment T6, (247.60 Kg/ha). The lowest available N recorded in treatment T8 to the tune of 178.75 Kg/ha. The maximum available P in soil after harvesting of tomato was observed in treatment

Table 1. Effect of *Azotobacter* and phosphate solubilizing bacteria on yield and quality of tomato

Tr. No.	Treatment Details	Number of branches	Plant height (cm)	Root length (cm)	Days to flower initiation (In days)	Number of fruits per plant	Polar diameter Of fruits (cm)	Equatorial diameter of fruits (cm)	Av. Fruit weight (gm)	Fruit yield per plant (kg)	Total yield (in qt)	Available N (kg/ha)	Available K (kg/ha)
T_1	Seedling treatment of Reference strain of MPKV	14.60	50.78	7.07	44.67	12.23	4.21	3.25	44.80	0.549	203.45	181.88	30.91
T_2	Seedling treatment of *Azotobacter*& PSB + 50% N & P	15.27	54.40	8.87	43.86	12.25	4.54	3.64	49.40	0.605	224.11	197.56	31.82
T_3	Seedling treatment of *Azotobacter* & PSB + 75% N & P	18.20	70.28	15.87	40.46	13.15	6.03	4.42	69.46	0.913	338.29	249.83	35.34
T_4	Seedling treatment of *Azotobacter*& PSB + 100% N & P	17.53	65.20	12.20	41.93	12.69	5.75	4.24	66.66	0.846	312.73	245.02	34.62
T_5	Seedling treatment of Reference *Azotobacter*& PSB + 75% N & P	19.27	73.73	22.57	39.40	13.82	6.13	4.99	73.33	1.013	375.32	282.24	36.47
T_6	Seedling treatment of Reference *Azotobacter*& PSB + 100% N & P	18.00	67.87	13.18	40.60	12.91	5.91	4.34	68.06	0.878	325.37	247.60	35.07
T_7	Control	16.07	59.87	10.47	42.86	12.59	5.21	3.89	54.13	0.681	252.36	210.11	32.70
T_8	Absolute	13.93	44.17	6.00	45.20	11.96	3.70	3.12	41.66	0.498	184.53	178.75	29.90
	S.E.±	0.18	1.12	0.43	0.34	0.92	0.05	0.03	0.94	0.01	5.66	0.88	0.24
	C.D. at 5%	0.55	3.41	1.32	1.04	2.79	0.18	0.11	2.87	0.04	17.1	2.67	0.74

T5, (36.47 Kg/ha) which was superior over the rest of the treatments. Treatment T3 recorded 35.34 kg/ha available P was found statistically at par with the treatment T6, (35.07 Kg/ha) The lowest available P was recorded intreatment T8, (29.90 Kg/ha) (Table 1).

4. CONCLUSION

The results indicate that the treatment T5, 75% RDF + ReferencAzotobacter& PSB showed highest growth, yield parameters and available N, P in soil after harvest. The combined application of *Azotobacter* and Phosphate solubilizing bacteria along with recommended dose of fertilizer leads to significant increase in growth and yield parameters of tomato. The combined use of *Azotobacter* and phosphate solubilizing bacteria had better effect on growth and yield parameters of tomato than single.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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