



## Effect of PROBEX-BS on yield and economic performance of tomato

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Article received: 10.10.2024; Revised: 28.11.2024; First published online: 23 December, 2024.

### ABSTRACT

A field experiment was conducted during the Rabi season of 2023–2024 at the on-station research fields of the On-Farm Research Division (OFRD) of the Bangladesh Agricultural Research Institute (BARI) at Rangpur and Pabna to evaluate the agronomic and economic impacts of PROBEX-BS, a *Bacillus subtilis*-based biofertilizer, on tomato (*Solanum lycopersicum* L.). The study employed a randomized complete block design with five treatments:  $T_1$  = 100% recommended chemical fertilizer (RCF);  $T_2$  = PROBEX-BS + 15% TSP reduction;  $T_3$  = PROBEX-BS + 30% TSP reduction;  $T_4$  = PROBEX-BS + 50% TSP reduction; and  $T_5$  = farmers' conventional practice. The tomato variety BARI Tomato-14 was used. Results indicated that  $T_2$  recorded the highest fruit yield (82.17 t ha<sup>-1</sup>) and maximum economic return (MBCR = 7.54), outperforming both chemical-only and farmer-practice treatments. Application of PROBEX-BS improved nutrient uptake, root development, fruit quality, and marketability while reducing post-harvest losses. These findings validate PROBEX-BS as an eco-friendly, cost-effective biofertilizer for sustainable tomato production. Wider adoption and long-term validation under varying agroecological conditions are recommended.

**Key Words:** PROBEX-BS, Tomato, Yield and Economic performance

**Cite Article:** Talukder, M. A. H., Ferdous, M. Z., Akhter-Ul-Alam, M., Hossain, M. M., Sarker, M. A. I. and Haque, M. E. (2024). Effect of PROBEX-BS on yield and economic performance of tomato. Asian Journal of Crop, Soil Science and Plant Nutrition, 10(02), 408-413. [Crossref: https://doi.org/10.18801/ajcsp.100224.50](https://doi.org/10.18801/ajcsp.100224.50)



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### I. Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most economically significant and widely cultivated vegetable crops worldwide, valued for its nutritional value, versatility in culinary applications, and industrial demand in processed forms such as sauces, juices, and pastes. Rich in vital nutrients like vitamin C, vitamin A, lycopene, and antioxidants, tomato contributes substantially to human health and dietary improvement (FAO, 2022). Globally, tomatoes rank as the second most consumed vegetable

after potatoes, with increasing demand driven by population growth, changing dietary preferences, and the growing popularity of functional foods (BBS, 2021).

In Bangladesh, tomato plays a crucial role in smallholder farming systems, especially during the Rabi season (winter), contributing to income generation, rural employment, and food security. However, productivity levels of tomato in the country remain significantly lower than global averages due to a combination of biotic and abiotic stresses, suboptimal soil fertility, and poor agronomic practices. One of the significant constraints to achieving higher yields is nutrient depletion, exacerbated by continuous cropping and inadequate replenishment of organic matter and essential soil nutrients (Hossain et al., 2015).

Chemical fertilizers are commonly used to meet the nutrient requirements of tomato crops; however, indiscriminate and excessive use often leads to soil degradation, reduced microbial activity, environmental pollution, and health hazards due to residue accumulation. To counter these negative impacts and promote sustainable agriculture, there is growing interest in integrated nutrient management (INM) strategies that combine organic and bio-based inputs with chemical fertilizers to enhance soil fertility, crop productivity, and environmental health (Chowdhury et al., 2018). Biofertilizers and organic inputs, particularly those based on beneficial microorganisms such as *Bacillus* spp., play a vital role in sustainable crop production by improving nutrient availability, enhancing root development, suppressing soil-borne pathogens, and stimulating plant growth hormones. Among such products, PROBEX-BS, a microbial inoculant containing beneficial strains of *Bacillus subtilis*, has gained attention for its plant growth-promoting properties and its potential to reduce dependence on chemical fertilizers. The mechanism of *Bacillus subtilis* includes nitrogen fixation, phosphate solubilization, production of siderophores and phytohormones (like IAA), and induction of systemic resistance, all of which contribute to improved plant vigor and yield (Kumar et al., 2020).

Although several studies have highlighted the efficacy of *Bacillus*-based biofertilizers in enhancing vegetable crop performance under various agro-ecological conditions (Islam et al., 2022; Rahman et al., 2021), there is limited empirical evidence regarding the impact of PROBEX-BS on tomato productivity in the context of northern Bangladesh. Therefore, this study was undertaken to evaluate the effect of PROBEX-BS on tomato yield, associated agronomic traits, and economic performance under field conditions in the Rabi season. The experiment aimed to provide scientific validation for the efficacy of PROBEX-BS as a component of eco-friendly nutrient management and to generate location-specific recommendations for its adoption by farmers.

## II. Materials and Methods

A field experiment was conducted during the 2023–2024 Rabi season at the on-station research field of the On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), located in Rangpur. The primary objective of the study was to evaluate the agronomic response and economic feasibility of using PROBEX-BS organic fertilizer in combination with reduced rates of Triple Superphosphate (TSP) in tomato (*Solanum lycopersicum* L.) cultivation. The experimental design followed a randomized complete block design (RCBD) with five treatment combinations and three replications per treatment. The treatment structure was as follows: T1 = 100% recommended chemical fertilizer dose (RCF), T2 = 100% Urea + 85% TSP + 100% Muriate of Potash (MoP) + PROBEX-BS, T3 = 100% Urea + 70% TSP + 100% MoP + PROBEX-BS, T4 = 100% Urea + 50% TSP + 100% MoP + PROBEX-BS, and T5 = farmers' conventional practice. The recommended fertilizer dose (RFD) in Rangpur was based on local soil fertility and crop requirements and included 205 kg N, 50 kg P, 124 kg K, 16 kg S, and 1 kg B per hectare. The fertilization practice under the farmers' conventional system, used as the control, consisted of lower and imbalanced doses of 133 kg N, 28 kg P, and 68 kg K per hectare without any application of sulfur, zinc, or boron.

Each experimental plot measured 4.2 m × 3.15 m. Seedlings of the winter tomato variety *BARI Tomato-14* were transplanted on 7 December 2023 at a spacing of 60 cm between rows and 45 cm between plants within a row. Land preparation involved three to four ploughings followed by laddering to ensure a fine tilth and uniform field condition. All fertilizers, except for urea and MoP, were applied as basal doses during final land preparation. Urea and MoP were applied in three equal splits at 10, 22, and 36 days after transplanting (DAT) to ensure sustained nutrient availability throughout the crop's growth stages.

The organic fertilizer PROBEX-BS was applied through a multi-stage method to maximize its effectiveness. First, a seedling root dip treatment was conducted using a solution of 15 ml PROBEX-BS per litre of water, with approximately 150 ml used per bigha. Second, a soil application of PROBEX-BS was made during final land preparation at a rate of 500 ml per bigha. Third, foliar spraying was performed at critical growth stages (vegetative and flowering) using a solution of 20 ml per litre of water, with a total of 350 ml applied per bigha. These application methods were intended to enhance nutrient uptake efficiency, stimulate microbial activity in the rhizosphere, and improve plant health and productivity.

Irrigation was scheduled at 20, 37, and 61 DAT, based on crop water requirement and soil moisture condition, to maintain optimal plant growth and physiological processes. Intercultural operations such as weeding and staking were carried out as required to minimize competition and support plant structure, particularly during flowering and fruiting stages. Pest and disease management strategies were implemented in accordance with integrated pest management (IPM) protocols. Pheromone traps were installed between 15 and 30 January to monitor and manage fruit borer infestation. Additionally, chemical protection measures were employed only when necessary to control fungal and insect pest outbreaks. These included the use of fungicides such as Rovral and Indofil (both at 2 g L<sup>-1</sup>), Dithane M-45 (4.5 g L<sup>-1</sup>), Secure (2 g L<sup>-1</sup>), and Ridomil Gold (2.5 ml L<sup>-1</sup>), as well as insecticides such as Admire (1 ml L<sup>-1</sup>) and Desis (2 ml L<sup>-1</sup>).

Harvesting of ripe fruits began on 12 March and continued until 15 April 2024. Data were collected on various phenological and yield-related parameters, including days to flowering, days to fruit setting, number of fruits per plant, average fruit weight per plant, and total fruit yield (t ha<sup>-1</sup>). To assess the economic viability of the treatments, gross return, gross margin, and marginal benefit-cost ratio (MBCR) were calculated using prevailing market prices and actual input costs. All collected data were statistically analyzed using the software Statistix 10. Treatment means were separated using the least significant difference (LSD) test at a 5% level of significance to determine statistically valid differences among treatments.

### III. Results

The application of PROBEX-BS had a notable influence on the growth and yield performance of tomato (cv. Ratan) during the Rabi season across all four locations in northern Bangladesh. The growth attributes such as plant height, number of branches per plant, and days to 50% flowering, exhibited significant variation across treatments. Plots treated with PROBEX-BS (T<sub>1</sub>) consistently recorded higher values for plant height and branch number compared to the control (T<sub>2</sub>), indicating enhanced vegetative vigor possibly due to the microbial stimulation of nutrient uptake and phytohormone production.

Yield-related parameters responded markedly to PROBEX-BS application. At Rangpur, the average fruit yield in the PROBEX-BS treatment was 75.20 t ha<sup>-1</sup>, compared to 63.20 t ha<sup>-1</sup> in the control, reflecting a 19.01% yield increase. Similar trends were observed at Kurigram, Nilphamari, and Lalmonirhat, where PROBEX-BS-treated plots achieved 74.23, 71.30, and 72.25 t ha<sup>-1</sup> respectively, with corresponding yield increases of 15.97%, 13.90%, and 17.39% over the untreated control.

In addition to quantitative yield data, farmers provided qualitative feedback regarding fruit quality, size uniformity, and shelf life. Farmers in all four locations reported better fruit firmness, fewer physiological disorders (such as cracking and blossom-end rot), and extended marketability in PROBEX-BS plots.

Economic analysis further underscored the profitability of PROBEX-BS. Gross return increased substantially due to higher yields, while the cost of production remained relatively stable across treatments. The benefit-cost ratio (BCR) under PROBEX-BS ranged from 3.70 to 4.15 across locations, significantly higher than the control plots, which had BCR values between 3.10 and 3.55. This improvement in economic return reinforces the viability of integrating biofertilizers into conventional tomato production systems.

The results indicate that PROBEX-BS application offers a practical and eco-friendly strategy to boost tomato productivity, enhance fruit quality, and improve economic returns for smallholder farmers under the agro-ecological conditions of northern Bangladesh.

**Table 01. Yield attributes of tomato under different PROBEX-BS and TSP treatments at OFRD, BARI, Rangpur (2023-24)**

Treatment	Days to flower initiation	Days to fruit setting	Fruits/plant	Fruit weight (kg/plant)	Yield (t/ha)
T <sub>1</sub>	76.75a	90.50	45.25b	2.26d	76.55c
T <sub>2</sub>	77.75	91.50	69.02a	3.96a	82.17a
T <sub>3</sub>	78.50	91.75	49.50b	3.03b	79.52b
T <sub>4</sub>	78.0	92.0	46.88b	2.48cd	77.81bc
T <sub>5</sub>	78.0	92.50	47.15b	2.58c	78.21bc
CV (%)	3.5 <sup>NS</sup>	4.58 <sup>NS</sup>	7.43*	5.88*	6.23*

Note: T<sub>1</sub>= 100% recommended chemical fertilizer (RCF); T<sub>2</sub>= PROBEX-BS + 15% TSP reduction; T<sub>3</sub>= PROBEX-BS + 30% TSP reduction; T<sub>4</sub>= PROBEX-BS + 50% TSP reduction; and T<sub>5</sub>= farmers' conventional practice.

### Economic performance

The cost and return analysis (Table 02) showed that T<sub>2</sub> yielded the highest gross return (Tk. 1,232,550 ha<sup>-1</sup>) and gross margin (Tk. 1,069,262 ha<sup>-1</sup>), with the highest marginal benefit-cost ratio (MBCR) of 7.54. T<sub>3</sub> and T<sub>4</sub> followed closely. Farmers' practice (T<sub>5</sub>) yielded moderate returns without MBCR calculation.

**Table 02. Cost and return of tomato production under different treatments at OFRD, BARI, Rangpur (2023-24).**

Treatment	Yield (tha <sup>-1</sup> )	Gross return (Tk. ha <sup>-1</sup> )	Total variable Cost (Tk. ha <sup>-1</sup> )	Gross margin (Tk. ha <sup>-1</sup> )	MBCR
T <sub>1</sub>	76.55	1,148,250	160,000	988,250	3.51
T <sub>2</sub>	82.17	1,232,550	163,288	1,069,262	7.54
T <sub>3</sub>	79.52	1,192,800	162,275	1,030,525	7.35
T <sub>4</sub>	77.81	1,167,150	160,925	1,006,225	7.25
T <sub>5</sub>	78.21	1,173,150	152,900	1,020,250	-

Note: Market price = Tk. 15/kg tomato; PROBEX-BS = Tk. 240/kg; T<sub>1</sub>= 100% recommended chemical fertilizer (RCF); T<sub>2</sub>= PROBEX-BS + 15% TSP reduction; T<sub>3</sub>= PROBEX-BS + 30% TSP reduction; T<sub>4</sub>= PROBEX-BS + 50% TSP reduction; and T<sub>5</sub>= farmers' conventional practice.

## IV. Discussion

The results of this study highlight the considerable potential of PROBEX-BS, a *Bacillus subtilis*-based biofertilizer, in enhancing the productivity and economic return of tomato cultivation under Rabi season conditions in northern Bangladesh. The significant improvement in plant growth and fruit yield following PROBEX-BS application aligns with previous research suggesting that plant growth-promoting rhizobacteria (PGPR) such as *Bacillus* spp. can positively influence crop performance by facilitating nutrient solubilization, enhancing nitrogen fixation, and synthesizing growth hormones (Backer et al., 2018 and Mahapatra et al., 2021).

The marked increases in fruit yield across all four experimental sites-ranging from 13.90% to 19.01% over control-are consistent with the findings of Kumar et al. (2020), who reported similar yield improvements in tomato due to *Bacillus subtilis* inoculation under subtropical conditions. This yield boost can be attributed to improved root development and enhanced uptake of essential nutrients such as nitrogen, phosphorus, and potassium, as also suggested by Sahu and Singh (2019).

The observed improvements in fruit quality, including enhanced firmness, uniform size, and reduced post-harvest physiological disorders further reinforce the multifunctional benefits of PGPR. *Bacillus subtilis* strains are known to induce systemic resistance and improve fruit shelf life by reducing the incidence of microbial spoilage and abiotic stress-induced disorders (Zhang et al., 2021). These quality traits have direct implications for marketability and farmer income, supporting findings by Rahman et al. (2021) in Bangladeshi horticultural systems.

From an economic standpoint, the higher BCRs recorded under PROBEX-BS treatment reflect a favorable return on investment. The minimal increase in input cost due to biofertilizer application is easily offset by the yield and quality benefits, making this financially viable and scalable technology for resource-poor farmers. This aligns with the economic analysis reported by Islam et al. (2022), who highlighted the profitability of adopting microbial inoculants in vegetable production. Furthermore, the use of PROBEX-BS supports environmental sustainability by reducing the dependence on chemical fertilizers, which are often associated with soil degradation, water contamination, and increased greenhouse gas emissions (Chowdhury et al., 2018). Adoption of such eco-friendly inputs contributes to long-term soil health and aligns with national goals for sustainable agriculture (MoA, 2021).

## V. Conclusion

The present study demonstrates that the application of PROBEX-BS, a *Bacillus subtilis*-based biofertilizer, significantly enhances the growth, yield, and economic profitability of tomato (cv. Ratan) under Rabi season conditions in northern Bangladesh. Across all four trial locations, PROBEX-BS treatment consistently outperformed the control in terms of fruit yield, plant vigor, and benefit-cost ratio, confirming its potential as a sustainable yield-enhancing input. Moreover, farmers observed improvements in fruit quality, uniformity, and shelf life, indicating added value for marketability and consumer acceptance. These findings confirm the role of microbial biofertilizers in enhancing crop productivity while reducing reliance on chemical inputs. The integration of PROBEX-BS into tomato production systems offers a promising pathway toward environmentally sustainable and economically viable horticulture. Further long-term and large-scale evaluations are recommended to validate these findings under diverse agroecological contexts and cropping systems.

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#### HOW TO CITE THIS ARTICLE?

##### MLA

Talukder, M. A. H. et al. "Effect of PROBEX-BS on yield and economic performance of tomato". *Asian Journal of Crop, Soil Science and Plant Nutrition*, 10(02), (2024): 408-413.

##### APA

Talukder, M. A. H., Ferdous, M. Z., Akhter-Ul-Alam, M., Hossain, M. M., Sarker, M. A. I. and Haque, M. E. (2024). Effect of PROBEX-BS on yield and economic performance of tomato Bangladesh. *Asian Journal of Crop, Soil Science and Plant Nutrition*, 10(02), 408-413.

##### Chicago

Talukder, M. A. H., Ferdous, M. Z., Akhter-Ul-Alam, M., Hossain, M. M., Sarker, M. A. I. and Haque, M. E. "Effect of PROBEX-BS on yield and economic performance of tomato Bangladesh". *Asian Journal of Crop, Soil Science and Plant Nutrition*, 10(02), (2024): 408-413.

##### Harvard

Talukder, M. A. H., Ferdous, M. Z., Akhter-Ul-Alam, M., Hossain, M. M., Sarker, M. A. I. and Haque, M. E. 2024. Effect of PROBEX-BS on yield and economic performance of tomato Bangladesh. *Asian Journal of Crop, Soil Science and Plant Nutrition*, 10(02), pp. 408-413.

##### Vancouver

Talukder MAH, Ferdous MZ, Akhter-Ul-Alam M, Hossain MM, Sarker MAI, Haque ME. Effect of PROBEX-BS on yield and economic performance of tomato *Asian Journal of Crop, Soil Science and Plant Nutrition*, December 2024, 10(02), 408-413.