



Studies on Synergistic Effects of Rhizobacteria and Organic Mulches on Growth and Yield in Tomato

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Abstract

Plant Growth-Promoting Rhizobacteria (PGPR) and organic mulches have been increasingly recognized as eco-friendly interventions capable of enhancing crop performance through improved nutrient dynamics, moisture conservation, and disease suppression. Nevertheless, their synergistic role in horticultural production systems remains inadequately explored. The present investigation evaluated the interactive effects of PGPR inoculation and organic mulching on growth attributes, yield parameters, and soil health under field conditions across diverse horticultural crops. Findings demonstrated that the integration of PGPR with organic mulches significantly enhanced vegetative vigor, reproductive performance, and fruit yield, while concurrently stimulating soil microbial activity and improving soil quality indices. These results underscore the potential of PGPR–mulch combinations as a sustainable and environmentally sound strategy to optimize horticultural crop productivity.

INTRODUCTION

The rapid intensification of horticultural production systems has considerably increased the reliance on synthetic fertilizers and agrochemicals. Although such inputs have contributed to enhanced yields and improved crop performance, their indiscriminate and prolonged use has raised critical concerns regarding environmental sustainability, soil quality degradation, and potential risks to human health. This has necessitated the exploration of alternative, eco-friendly strategies that can maintain crop productivity while ensuring long-term environmental safety.

Among the promising options, Plant Growth-Promoting Rhizobacteria (PGPR) and organic mulches have gained significant attention as

sustainable interventions in horticulture. PGPR comprise a diverse group of beneficial soil microorganisms that improve plant growth through multiple mechanisms, including biological nitrogen fixation, solubilization of phosphorus and other nutrients, production of phytohormones such as indole-3-acetic acid (IAA), gibberellins, and cytokinins, as well as suppression of plant pathogens via induction of systemic resistance. These mechanisms not only enhance nutrient acquisition but also improve plant tolerance to biotic and abiotic stresses.

In parallel, organic mulches contribute to soil fertility and crop performance by modifying the soil microclimate, conserving soil moisture, regulating temperature fluctuations, suppressing

weed growth, and gradually releasing nutrients through decomposition. In addition, mulching improves soil structure and stimulates microbial activity, thereby supporting overall soil health and resilience.

Although the independent roles of PGPR and organic mulches in enhancing crop performance are well established, their combined use in field-based horticultural systems has received comparatively little attention. Emerging evidence suggests that the integration of PGPR with organic mulching may generate synergistic benefits by fostering a favorable rhizosphere microbiome, improving nutrient cycling, and enhancing crop productivity. Such integration represents a promising avenue for reducing the dependence on synthetic inputs and advancing sustainable horticultural practices.

Therefore, the present study was undertaken to investigate the interactive effects of PGPR inoculation and organic mulching on plant growth, yield attributes, and soil health under field conditions. The findings are expected to provide valuable insights into developing integrated, eco-friendly management practices that can contribute to sustainable horticultural production systems.

Materials and Methods

2.1 Experimental Design

The field experiment was carried out during the Rabi season at the Horticulture Research Farm, Sanjeevane Mahavidyalay Chapoli Tq. Chakur Dist. Latur (M.S.), employing a randomized block design (RBD) with five treatment combinations, each replicated three times.

- **T1:** Control (no PGPR, no mulch)
- **T2:** Organic mulch only (sugarcane trash @ 5 t/ha)
- **T3:** PGPR only (consortium of *Azospirillum*, *Bacillus*, and *Pseudomonas*)
- **T4:** PGPR + organic mulch
- **T5:** Recommended dose of fertilizer (RDF)

2.2 Crop Selection

Tomato (*Solanum lycopersicum* L.) was chosen as the test crop owing to its high economic importance

and demonstrated responsiveness to bio-based inputs.

2.3 Data Collection

Growth parameters: were assessed in terms of plant height (cm), number of primary branches per plant, and leaf area index (LAI). **Yield attributes** included the number of fruits per plant, mean fruit weight (g), and total fruit yield expressed as tonnes per hectare ($t\ ha^{-1}$). **Soil analysis** focused on key biological and chemical indicators, namely microbial biomass carbon (MBC), dehydrogenase enzyme activity (DHA), and soil organic carbon (SOC) content.

Observations and Measurements

Growth and yield attributes of tomato were systematically recorded at appropriate growth stages. Growth parameters included plant height (cm), number of primary branches per plant, and leaf area index (LAI), which collectively provided insights into vegetative development and canopy architecture. Yield attributes were quantified in terms of the number of fruits per plant, average fruit weight (g), and total fruit yield expressed as tonnes per hectare ($t\ ha^{-1}$), thereby reflecting the overall productivity and economic potential of the crop.

Soil quality assessments were conducted post-harvest to determine the impact of treatments on biological and chemical properties. Microbial biomass carbon (MBC) was estimated as an indicator of soil microbial activity and nutrient turnover, while dehydrogenase enzyme activity (DHA) was measured to evaluate overall microbial oxidative activity and functional capacity. Soil organic carbon (SOC) content was also analyzed to assess changes in soil organic matter status, which is crucial for maintaining soil fertility and long-term sustainability.

2.4 Statistical Analysis

The data were analyzed using ANOVA, and mean comparisons were performed using Duncan's Multiple Range Test at $p < 0.05$.

3. Results and Discussion

3.1 Growth Parameters

The combined application of PGPR and organic mulch (T₄) exhibited a marked influence on vegetative growth, as evidenced by a significant increase in plant height (84.2 cm), number of primary branches, and leaf area index when compared with the control (T₀) and individual applications of PGPR (T₂) or mulch (T₃). This synergistic response highlights the complementary mechanisms contributed by both inputs. PGPR inoculation is known to stimulate root proliferation, enhance nutrient solubilization, and improve uptake efficiency through the production of phytohormones and bioactive metabolites. Concurrently, organic mulch plays a pivotal role in conserving soil moisture, regulating soil temperature, and suppressing evaporative losses, thereby creating a favorable rhizosphere environment that further supports microbial activity and root functioning. The integration of these two practices thus fosters improved plant vigor and canopy development, ultimately establishing a robust physiological foundation for higher reproductive efficiency and yield potential in tomato.

3.2 Yield Attributes

Treatment T₄, comprising the combined application of PGPR and organic mulch, recorded the highest fruit yield (37.8 t ha⁻¹), closely followed by the recommended dose of fertilizers (RDF, 36.4 t ha⁻¹), and significantly outperformed the individual applications of PGPR (T₂) and mulch (T₃). The superior yield performance under T₄ can be attributed to the cumulative benefits of improved vegetative growth, enhanced photosynthetic efficiency, and favorable soil microclimatic conditions provided by mulch cover, which collectively minimized physiological stress during critical growth stages. Mulching not only conserved soil moisture but also moderated soil temperature, thereby sustaining plant metabolic activity under fluctuating field conditions.

In addition, the role of PGPR in promoting hormonal balance, particularly through the production of indole-3-acetic acid (IAA), gibberellins, and cytokinins, likely contributed to improved floral initiation, fruit set, and retention. Furthermore, the capacity of PGPR to solubilize essential nutrients such as phosphorus and

potassium, along with enhanced nitrogen fixation, ensured a steady nutrient supply throughout the crop cycle. The interactive effect of these mechanisms under T₄ thus established an optimal growth–yield continuum, underscoring the potential of integrating PGPR and organic mulching as a sustainable alternative to sole reliance on chemical fertilizers in tomato production systems.

3.3 Soil Health Indicators

Soil biological properties responded positively to the combined application of PGPR and organic mulch (T₄). Microbial biomass carbon (MBC) and dehydrogenase activity (DHA) were significantly higher under T₄ compared to the control and individual treatments, indicating a more active and functionally diverse microbial community. The increase in microbial biomass can be attributed to the dual effect of PGPR inoculation, which introduces beneficial microbial populations into the rhizosphere, and the gradual addition of organic matter from mulching, which serves as a substrate for microbial proliferation. Enhanced DHA activity further reflects the improved metabolic potential of soil microbes, highlighting greater oxidative activity and nutrient turnover under integrated management.

In addition, soil organic carbon (SOC) content showed a marginal but consistent increase under T₄, suggesting the gradual improvement of soil organic matter status. Although short-term gains in SOC are often modest, the incorporation of organic residues through mulching is likely to contribute to long-term soil fertility, structural stability, and nutrient cycling. Together, these results demonstrate that the combined use of PGPR and organic mulching not only improves plant growth and yield but also exerts a positive influence on soil health, thereby reinforcing the sustainability of the production system.

4. Conclusion

The present investigation clearly demonstrates that the integration of Plant Growth-Promoting Rhizobacteria (PGPR) with organic mulching exerts a synergistic influence on both crop performance and soil health. The combined treatment not only enhanced vegetative growth

parameters and yield attributes of tomato but also significantly improved soil microbial biomass and enzymatic activity, indicating a more functionally active rhizosphere environment. The enrichment of soil organic carbon under integrated management further underscores its potential contribution to long-term soil fertility and sustainability.

These findings highlight that the PGPR–mulch combination offers an effective low-input strategy capable of reducing the dependence on synthetic fertilizers while maintaining or even surpassing conventional yield levels. Such practices are particularly relevant in the context of sustainable horticulture, where productivity must be balanced with ecological stability and soil health conservation.

Future research should focus on crop-specific optimization of PGPR strains and mulch types, along with evaluating the long-term ecological and economic impacts of this integrated approach under diverse agro-climatic conditions. Moreover, studies addressing the scalability and farmer-level adoption of PGPR–mulch technology will be critical for its practical implementation in sustainable horticultural production systems.

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