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Effects of Mimosa Pudica Root-Derived PGPR on Tomato Growth and Fruit Set**Fatima Dina Moniz, Ade Irma Sulistiani*, Nelly Selvia Tongkeles, Toar Daniel Malingkas**

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Abstract. Plant growth-promoting rhizobacteria (PGPR) may serve as biological inputs for tomato cultivation, but the responses to different concentrations of root-derived preparations require evaluation under local growing conditions. This study assessed the effects of a fermented preparation originating from *Mimosa pudica* roots on plant height, stem diameter, time to 50% flowering, and fruit number per cluster in tomato (*Solanum lycopersicum*). The greenhouse experiment was conducted in Belu Regency, East Nusa Tenggara, Indonesia, from April to May 2026. A completely randomized design comprised four treatments: no PGPR preparation (D0), 100 mL/L (D1), 150 mL/L (D2), and 200 mL/L (D3), with three replicate experimental units per treatment and seven plants per unit. Plant height and stem diameter were recorded at 14, 21, 28, and 35 days after planting; flowering time and fruits per cluster were also assessed. The study reported treatment effects based on analysis of variance followed by Tukey's honestly significant difference test at the 5% level. At 35 days, D3 produced the greatest mean plant height (127.14 cm), while flowering occurred earliest under D3 (37.00 days versus 41.00 days for D0). D3 also had the highest reported mean fruit count per cluster (5.05 versus 3.30 for D0). Within the tested concentration range, D3 showed the most favorable overall response. These findings concern measured growth and fruit-set indicators rather than total marketable yield.

Keywords: Fermentation; Fruit set; *Mimosa pudica*; Plant growth-promoting rhizobacteria; Tomato.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is an important horticultural crop for fresh consumption and processing, and sustainable approaches to maintaining its vegetative development and reproductive performance remain of practical interest. The agronomic outcomes of biological fertilizers are often evaluated through distinct indicators, including plant height, flowering, fruit number, and yield; these responses should not be treated as interchangeable (Katsenios et al., 2021; Quintarelli et al., 2025; Sharmin et al., 2026). A recent meta-analysis also highlighted substantial variation in tomato responses to *Bacillus*-based biofertilizers

across experimental conditions (Ogugua et al., 2025).

Plant growth-promoting rhizobacteria (PGPR) can influence the plant-soil interface through nutrient mobilization, root colonization, and microbial or plant signalling, but the expression of these functions depends on strain identity, host genotype, and cultivation conditions (Chieb & Gachomo, 2023; Rehan et al., 2023; Haile et al., 2024). Studies involving *Bacillus* and related rhizobacteria have documented changes in tomato root growth, rhizosphere communities, and plant performance (Sarti et al., 2024; Shao et al., 2025; Chen et al., 2026). The demonstrated capacity of bacterial

inoculants to colonize tomato roots also depends on the carrier, formulation, and application route (Oyoque-Salcedo et al., 2025; Warthen et al., 2026).

Tomato experiments using bacterial inoculants or microbial consortia have reported changes in plant height, physiological status, fruit development, or harvest performance, but the outcomes are context-specific. Evidence includes field and greenhouse studies using distinct inoculants and nutrient-management combinations (Gashash et al., 2022; Nemeskéri et al., 2022; Cirillo et al., 2023; Manzano-Gómez et al., 2025). Photosynthetic bacteria and cyanobacterial formulations have likewise affected tomato production in studies with identified inoculants (Lee et al., 2022; Hakkoum et al., 2025). The response can differ among cultivars, grafting combinations, or microbial preparations, as shown by Al Achkar et al. (2026).

Research on tomato inoculation under saline conditions further illustrates that microbial responses are not automatically transferable among soils or stress regimes (Nakahara et al., 2022; Abdelkefi et al., 2024; Yang et al., 2026). The combined use of bacterial inoculants and other biostimulants can also influence physiological processes and fruit production, although such responses require formulation-specific interpretation (Benito et al., 2025). Recent research on *Bacillus*-associated tomato rhizospheres reinforces the importance of identifying the microorganisms and their activity when explaining the mechanism of a biological product (Lu et al., 2026).

Roots of *Mimosa pudica* have been used locally as a starter material for fermented preparations described as PGPR products. However, a root-derived fermentation made with multiple nutrient-rich ingredients is not necessarily equivalent to a taxonomically identified or microbiologically quantified PGPR inoculant. The source experiment did not provide a bacterial isolation,

identification, or viable-count dataset for the finished product. Its contribution is therefore a concentration-based evaluation of the complete fermented preparation under local greenhouse conditions, rather than a test of a defined bacterial strain or mechanism. This distinction avoids attributing effects to unmeasured microbes.

This study aimed to compare four application concentrations of a *Mimosa pudica* root-derived fermented preparation on tomato plant height, stem diameter, time to 50% flowering, and number of fruits per cluster in Belu Regency, East Nusa Tenggara, Indonesia. The study evaluated response patterns within the concentrations tested, without claiming total marketable yield or a universally optimum rate.

MATERIAL AND METHODS

Study Area and Duration

The experiment was conducted from April to May 2026 in the greenhouse at the Ben Mboi Polytechnic campus, Defense University of the Republic of Indonesia, Kakuluk Mesak District, Belu Regency, East Nusa Tenggara, Indonesia.

Materials and Preparation

Tomato seeds of the Servo F1 variety were raised to approximately 14 days of age or the stage of four to six true leaves. The planting medium consisted of soil, burned rice husk, and manure at a volumetric ratio of 1:1:1 and was placed in 40 × 40 cm polybags. The root-derived preparation was made using a fermentation mixture reported to contain rice bran (4 kg), clean water (30 L), tofu-processing wastewater (130 L), shrimp paste (1 kg), commercial seasoning (16 sachets), palm sugar (4 L), lime (4 tablespoons), and a *M. pudica* root-derived starter (300 g). The mixture was fermented for 14 days in a 200 L container. Garlic and betel leaves were also listed as



ingredients for a botanical pesticide in the original study.

The original methods identify the fermentation duration and ingredients but do not specify the inoculum preparation in microbiological terms, the application date(s), the frequency of application, or the volume applied per experimental unit. These operational details must be confirmed against the study records before submission; no additional preparation or application procedure is assumed here.

Experimental Design and Treatments

A completely randomized design (CRD) was used with four treatments and three replicate experimental units per treatment (12 independent experimental units in total). Each experimental unit comprised seven tomato plants, giving 84 plants overall. For statistical analysis, the seven plant observations in each unit were averaged to produce one unit-level value. The 12 units were randomly arranged in the greenhouse. The treatment concentrations are summarized in Table 1.

Table 1. Concentrations of the root-derived preparation evaluated in the greenhouse experiment

Code	Application concentration
D0	Control: no PGPR preparation
D1	100 mL preparation per liter of water
D2	150 mL preparation per liter of water
D3	200 mL preparation per liter of water

Note: Concentrations are reported as dilution volumes of the prepared fermentation product. The source manuscript does not specify microbial cell concentrations.

Measurements

Plant height and stem diameter were measured at 14, 21, 28, and 35 days after planting (DAP). Plant height was measured from the surface of the growing medium to the apical growing point. Stem diameter was measured using a caliper approximately 2–3 cm above the medium surface. The time to 50% flowering was reported as the number of days after planting until half of the plants within an experimental unit displayed fully open

flowers. Fruits per cluster were recorded at harvest and averaged at the experimental-unit level. The observation dates follow the source manuscript's HST notation (days after planting); the exact starting event should be verified against field records.

Data Analysis

The source study reports analysis of variance (ANOVA) for the CRD, performed in SPSS, followed by Tukey's honestly significant difference (HSD) procedure at $\alpha = 0.05$ when treatment effects were significant. The reported inferential comparisons are retained descriptively in the discussion; the original unit-level observations, ANOVA tables, measures of dispersion, and complete post hoc grouping outputs were not provided in the manuscript. Consequently, only reported treatment means are plotted, and no unreported p-values, confidence intervals, or error bars have been generated.

RESULTS AND DISCUSSION

Results

Plant Height

Plant height increased across observation dates in all treatments. Treatment D3 consistently had the largest reported means, reaching 127.14 cm at 35 DAP, compared with 101.90 cm for D2, 81.38 cm for D1, and 60.85 cm for the control (Figure 1). The original text reports a treatment effect at each observation date ($p < 0.05$). At 35 DAP, however, the narrative indicates that D3 was not statistically distinguishable from D2; therefore, the largest mean should not be interpreted as proof that D3 was superior to every other treatment at that final date.



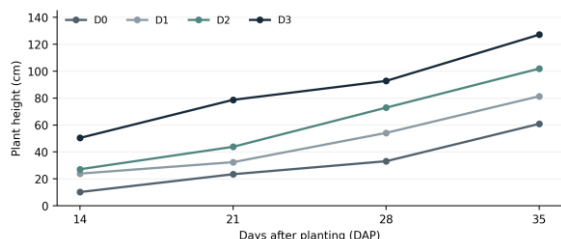


Figure 1. Mean plant height of tomato under four concentrations of a *Mimosa pudica* root-derived preparation at 14, 21, 28, and 35 days after planting.

Note: Points are means transcribed from the source graph. The original manuscript did not provide standard deviations or standard errors for these observations.

Stem Diameter

The source data indicate increasing stem diameter over time under all four treatments (Figure 2). D3 had the highest recorded mean at 35 DAP (13.64 in the units printed in the original manuscript), whereas D0 had the lowest (7.08). The original narrative reports significant treatment effects and a higher final mean under D3 than under the other treatments. The reported measurement unit must be verified against the caliper records before these values are used for formal publication.

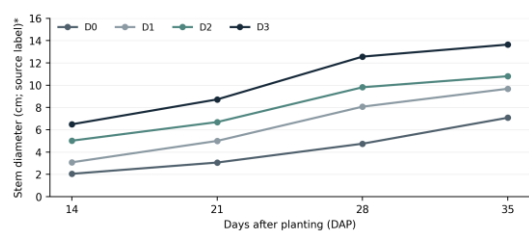


Figure 2. Reported mean stem diameter for tomato plants at 14, 21, 28, and 35 days after planting under four treatments.

Note: The original source labels stem diameter in centimeters. The unit is retained provisionally and must be checked against the original caliper records.

Time to 50% Flowering

The mean time to 50% flowering decreased numerically with increasing concentration of the preparation (Figure 3). The control reached this stage at 41.00

DAP, compared with 39.67 DAP under D1, 38.67 DAP under D2, and 37.00 DAP under D3. The source narrative reports that D1 and D2 were not significantly different according to its Tukey comparisons, whereas D3 flowered earlier than the other reported treatments.

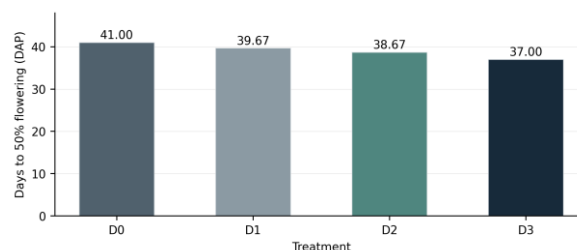


Figure 3. Reported mean time to 50% flowering of tomato plants for four treatment concentrations.

Note: Means follow the textual values in the source manuscript. The full Tukey grouping table was not available for independent validation.

Fruit Number per Cluster

The mean number of fruits per cluster increased numerically from D0 to D3 (Figure 4). The source narrative reports mean values of 3.30 for D0, 3.99 for D1, 4.35 for D2, and 5.05 for D3. These observations describe a fruit-number component; they do not quantify total yield per plant or marketable fruit weight. The figure follows the explicitly reported mean values, which should be checked against the original data before final submission.

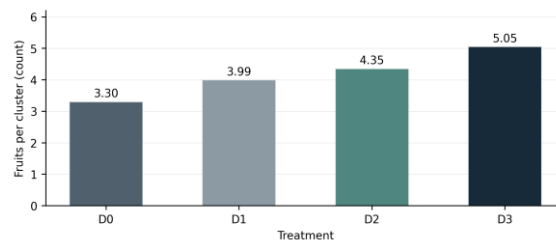


Figure 4. Reported mean number of fruits per cluster of tomato under four concentrations of the root-derived preparation.

Note: Mean fruit counts were transcribed from the results narrative. The source chart data series requires verification before submission.

Discussion

The reported concentration gradient was accompanied by higher mean plant height and stem diameter and an earlier mean flowering date at the greatest tested concentration. Similar vegetative responses have been reported after inoculation with characterized bacterial strains in tomato production (Katsenios *et al.*, 2021; Gashash *et al.*, 2022; Rehan *et al.*, 2023; Haile *et al.*, 2024). Field-based investigations have also documented effects on plant physiology and agronomic traits, although the response depends on the inoculant and environmental setting (Nemeskéri *et al.*, 2022; Cirillo *et al.*, 2023). Thus, the direction of the present mean responses is broadly consistent with the literature, but the studies do not establish equivalent microbial composition or mode of action.

The original manuscript reported flowering at 37.00 days after planting for D3, approximately four days earlier than the untreated control. Earlier reproductive development may be agronomically relevant, but flowering time alone does not demonstrate increased final yield. Other tomato biofertilization experiments have independently measured flowering, fruits per cluster, fruits per plant, and fruit weight, thereby illustrating the need to distinguish these outcomes (Quintarelli *et al.*, 2025; Sharmin *et al.*, 2026). The current trial did not provide total yield per plant or marketable yield; its strongest supported reproductive endpoint is the reported mean number of fruits per cluster.

The highest reported mean fruits per cluster occurred under D3 (5.05), compared with the control (3.30). In studies using identified bacterial strains, fruit responses have varied substantially with microbial species, formulation, and cultivation environment (Lee *et al.*, 2022; Manzano-Gómez *et al.*, 2025; Al Achkar *et al.*, 2026). The meta-analysis of *Bacillus*-based tomato biofertilizers similarly identified dose, bacterial count,

and application mode as important sources of variation (Ogugua *et al.*, 2025). Consequently, the present numerical trend should be described as a response within the tested dilution series rather than as evidence of a generally optimum concentration.

Several mechanisms discussed in the PGPR literature could explain positive plant responses, including improved nutrient availability, microbial colonization, and changes in growth-related biochemical signalling. For example, root-associated *Bacillus* strains have been investigated for their effects on rhizosphere communities, nutrient dynamics, or root colonization (Sarti *et al.*, 2024; Shao *et al.*, 2025; Chen *et al.*, 2026; Lu *et al.*, 2026). Formulation studies show that how beneficial bacteria are delivered can affect their persistence or performance on tomato roots (Oyoque-Salcedo *et al.*, 2025; Warthen *et al.*, 2026). Nevertheless, these studies are mechanistic comparisons only. This experiment did not identify active organisms in its preparation or quantify plant hormones, photosynthesis, nutrient uptake, or microbial establishment; none of these mechanisms can be claimed as directly demonstrated here.

The presence of multiple fermentation components is especially relevant when interpreting this experiment. In addition to root-derived starter material, the preparation contained nutrient-rich inputs, so an observed plant response cannot be isolated to one bacterial taxon or one physiological pathway. Experiments with mixed microbial and non-microbial biostimulants have shown that combined inputs can influence tomato development and stress responses (Benito *et al.*, 2025; Hakkoum *et al.*, 2025). Similarly, responses in salt-affected systems have been shown to depend on soil conditions and the microbial strains used (Nakahara *et al.*, 2022; Abdelkefi *et al.*, 2024; Yang *et al.*, 2026). These comparisons support a



cautious, formulation-level interpretation of the present data.

The greenhouse setting, three independent experimental units per treatment, restricted application range, and lack of a characterized microbial inoculum limit broad recommendations. The available manuscript does not contain full replicate-level observations, ANOVA tables, complete Tukey grouping outputs, or measures of variability. Although its narrative describes significant differences, numerical differences in plotted means should not be presented as statistically significant beyond the comparisons explicitly reported in the source. At 35 days after planting, for example, D3 and D2 were not significantly different for height according to the original text. The discrepancy between the original fruit chart cache and displayed fruit-number labels and the uncertain diameter units must be verified before journal submission. These are reporting and source-data checks rather than grounds to fabricate additional analyses or experiments.

CONCLUSION

In the greenhouse experiment in Belu Regency, the 200 mL/L treatment (D3) produced the most favorable overall numerical response among the four tested concentrations of a *Mimosa pudica* root-derived preparation. D3 had the greatest reported plant height at 35 days after planting, the earliest mean time to 50% flowering, and the highest mean number of fruits per cluster. Its numerical advantage was not statistically distinguishable from every lower concentration for every endpoint or observation date. Thus, the findings support a concentration-dependent pattern for the indicators measured under these experimental conditions, but not a general optimum concentration, a verified microbial mechanism, or an increase in total marketable tomato yield. Subsequent

work may characterize the fermentative preparation and assess yield and quality under more diverse growing conditions.

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