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The Potential of *Burkholderia* sp. from *Zea mays* Roots as Plant Growth Promoting Rhizobacteria

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Abstract: Plant Growth-Promoting Rhizobacteria (PGPR) plays a crucial role in enhancing plant health, while Burkholderia sp. has been identified and has potential as a promising PGPR for maize plants. Recognizing the essential role of PGPR in plant health, this study explores how L-TRP addition might improve PGPR performance for better plant growth. Employing a completely randomized design, the study assesses the effects of *Burkholderia* sp. as PGPR on maize growth across three treatment groups: PGPR with L-TRP, PGPR without L-TRP, and a control group. The evaluation focuses on plant growth metrics, plant hormone production (auxin and gibberellin), and siderophore activity to gauge plant iron availability. Statistical analysis highlights that L-TRP supplementation notably increases auxin production in the PGPR + L-TRP group, surpassing the PGPR without L-TRP and control groups. Although both PGPR treatments elevate gibberellin levels compared to the control, auxin increase is the most significant outcome, indicating no substantial difference in gibberellin levels between the two PGPR groups. Enhanced siderophore production suggests improved iron assimilation for plants. The findings demonstrate that L-TRP supplementation with PGPR, particularly *Burkholderia* sp., effectively boosts maize growth, primarily through increased auxin and siderophore production. This combination presents a promising strategy for augmenting agricultural yields, especially for maize productivity, by leveraging the synergistic effects of soil microbes and nutrient supplementation.

Keywords: Auxin; *Burkholderia* sp.; Gibberellins; PGPR; Siderophores; *Zea mays*.

Introduction

The advancement of modern agricultural technology has provided significant impetus to our understanding of the role of microorganisms in enhancing plant productivity. Among the soil microbes that play a crucial role in plant health are Plant Growth-Promoting Rhizobacteria (PGPR), naturally found in the plant rhizosphere. PGPR is known for enhancing plant growth and health through various mechanisms, including increasing nutrient availability, protection against pathogens, and stimulating hormonal growth in host plants [1–3].

One type of PGPR that has attracted researchers' attention is the endophytic bacterium *Burkholderia* sp. Endophytic characteristics allow bacteria to live within plant tissues without causing disease. *Burkholderia* sp. has been widely found to colonize various plants, including maize (*Zea mays*), with beneficial effects on plant growth and health [4–6].

The importance of research related to the analysis of PGPR components from endophytic bacteria *Burkholderia* sp. from maize roots is highly justified in modern agriculture. Firstly, maize is one of the world's major food crops and is crucial for the global population. Therefore, increasing the productivity and quality of maize plants directly impacts the sustainability of the global food system. Research has been reported on the potential of endophytic isolates living in maize roots to promote plant growth. These isolates have been shown to produce indole-3-acetic acid (IAA) and indole-3-pyruvic acid in vitro, thus promoting maize plant growth under gnotobiotic and greenhouse conditions [7].

Previous research has shown that endophytic bacteria *Burkholderia* sp. can increase nutrient availability for plants, especially nitrogen, phosphorus, and potassium, essential for optimal maize plant growth [4]. This mechanism occurs through various processes, including nitrogen fixation, phosphate solubilization, and mobilization of soil nutrients that are not directly available to plants [8].

Moreover, PGPR, including *Burkholderia* sp., has also been shown to protect maize plants from harmful soil pathogens, such as bacteria and fungus-causing diseases. Through the production of antimicrobial compounds and inhibition of pathogen activities, these endophytic bacteria help maintain the health of maize plants without relying on expensive chemical pesticides that could potentially harm the environment [2,9]. Furthermore, *Burkholderia* sp. is also known to influence plant hormones, such as auxin, cytokinin, and gibberellin, which play a crucial role in plant growth regulation. Stimulation of hormonal growth can enhance maize plant production in terms of yield quantity and quality [9,10].

Thus, the analysis of PGPR components from endophytic bacteria *Burkholderia* sp. from maize roots is essential for further understanding the mechanisms involved in the interaction between microorganisms and their host plants. This research can provide valuable insights into developing sustainable agricultural technology that reduces dependence on external inputs such as chemical fertilizers

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and synthetic pesticides while efficiently increasing crop yields and quality.

This research aims to delve deeper into the role and potential benefits of Plant Growth-Promoting Rhizobacteria (PGPR), particularly those derived from endophytic bacteria Burkholderia sp. found in maize roots. This study aims to contribute significantly to our comprehension of the intricate interactions between microbes and plants and their implications for sustainable agricultural productivity enhancement.

The urgency and importance of this research stem from the growing necessity to find environmentally friendly and sustainable methods to improve agricultural yields. With the global population increasing and the demand for food rising, there is an urgent need to enhance crop productivity without resorting to harmful chemical inputs that can degrade soil health and lead to long-term ecological consequences. PGPR, especially from sources such as Burkholderia sp., offers a promising solution by naturally promoting plant growth through hormone production enhancement, nutrient availability improvement, and disease resistance strengthening.

Exploring the components of PGPR from Burkholderia sp. enriches our understanding of microbe-plant interactions and opens up new avenues for applying these insights in practical agricultural settings. This research is critical in scientific evolution in agriculture and soil microbiology, as it builds on recent studies and contributes to the broader knowledge base, paving the way for innovative strategies to achieve sustainable agricultural productivity. By harnessing the potential of beneficial soil microbes, this study aims to provide a foundation for developing more effective, eco-friendly agricultural practices that can sustainably meet the growing food demands.

Research Methods

This research is an experimental study designed to evaluate the effect of the application of Plant Growth-Promoting Rhizobacteria (PGPR) *Burkholderia* sp., both with and without the supplement of L-tryptophan (L-TRP), on the growth of maize plants. Utilizing a completely randomized design, the study divided the research subjects into three treatment groups: first, plants treated with PGPR Burkholderia sp. without L-TRP; second, plants treated with PGPR Burkholderia sp. plus L-TRP as an auxin precursor; and third, a control group not treated with PGPR.

The main instruments used in this research include Nutrient Agar media for bacterial culture and a UV-Vis Spectrophotometer for measuring the concentration of plant hormones (auxin and gibberellin) and siderophore concentration.

The research began with the rejuvenation process of pure isolates of endophytic bacteria *Burkholderia* sp. collected by [11] by culturing them on Nutrient Agar media at an incubation temperature of 30°C for 24 hours. The grown colonies were subcultured and propagated for further use in subsequent stages. This process aims to refresh the Burkholderia sp. bacterial culture for optimal quality use in research or agricultural applications. Subsequently, the influence test of PGPR on maize plant growth was conducted in controlled planting pots. Maize seeds were planted in pots containing uniform planting media, and *Burkholderia* sp. PGPR treatments were applied according to the predetermined treatment groups.

Observations on maize plant growth were made during a 50-day observation period. The observed growth parameters included plant height, leaf number, and weight. Plant hormone concentrations, namely auxin (IAA) and gibberellin were measured using spectrophotometric methods. Plant samples were harvested at the end of the observation period, and hormone extraction was carried out using organic solvent extraction techniques on maize plant shoot tips (youngest leaves). Subsequently, hormone concentrations were measured using a UV-Vis spectrophotometer. The measurement of siderophore concentration compounds produced by PGPR was also conducted using spectrophotometric methods. Maize plant root samples were extracted with appropriate organic solvents, and siderophore concentrations in the extract were measured using a UV-Vis spectrophotometer.

The data obtained from observations of plant growth and measurements of plant hormone and siderophore concentrations were then analyzed using analysis of variance (ANOVA) to determine the significant effects of treatments on these parameters at $\alpha = 0.05$. ANOVA was supplemented with post hoc tests such as Tukey's HSD test to compare differences between treatment groups.

Results and Discussion

To explore the influence of the combined application of PGPR derived from endophytic bacteria *Burkholderia* sp. and L-TRP (L-Tryptophan) on plant growth, this study designed an experiment that measured essential variables such as auxin concentration, gibberellin concentration, siderophore activity, plant height, leaf number, and plant weight. The treatment groups were divided into three, namely: PGPR + L-TRP Group, Receiving a combination of PGPR and L-Tryptophan; PGPR Group, Only receiving PGPR without L-Tryptophan; and Control Group, Without the application of PGPR and L-Tryptophan.

The research results, as illustrated in Figure 1, indicate that the PGPR treatment with L-TRP produced the highest auxin concentration (1.970 ppm) compared to the PGPR treatment without L-TRP (1.782 ppm) and the control group (0.870 ppm). Meanwhile, the gibberellin concentration did not differ significantly between the PGPR treatments with or without L-TRP, but both were higher than the control group. The PGPR treatments with or without L-TRP also resulted in higher siderophore concentrations than the control group. These findings suggest that L-TRP supplementation in PGPR treatments can enhance plant auxin production, positively influencing plant growth and development.

The illustration in Figure 1 indicates that L-TRP supplementation increases the concentration of auxin in plants, positively impacting the growth and productivity of maize plants. The higher auxin concentration in the PGPR + L-TRP treatment compared to the control and PGPR treatment without L-TRP suggests that L-TRP can enhance plant auxin production. This is consistent with recent findings by Smith [12], which demonstrate that L-TRP can act as a precursor in auxin biosynthesis in plants.

Although the gibberellin concentration did not differ significantly between the PGPR treatments with or without L-TRP, both had higher concentrations than the control. This indicates that the PGPR treatment can influence plant gibberellin production, with or without L-TRP supplementation. These findings align with previous research by Shahzad et al. [13], which shows that PGPR can increase gibberellin concentrations in plants and other hormones, such as auxin, consistent with other studies [13–15].

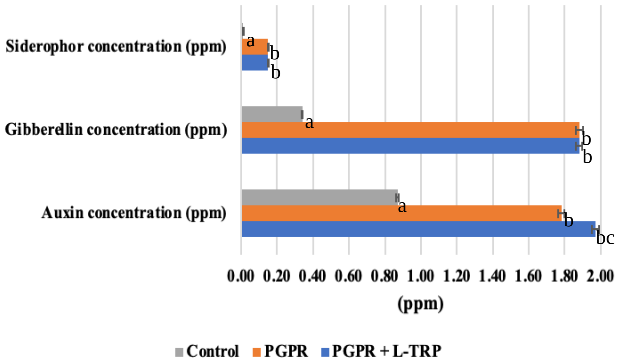

Figure 1. Concentrations of auxin, gibberellins and siderophores in the treatment group. The same notation on the bars shows an insignificant difference (P>0,05).

Furthermore, the higher siderophore concentration in the PGPR treatments with or without L-TRP indicates that PGPR treatments have the potential to enhance iron uptake by plants. This is important because siderophores are compounds that facilitate iron uptake in plants [16–22]. The study by Khalid et al. [23] supports these findings by demonstrating that PGPR can enhance plant nutrient uptake efficiency, including iron. Increasing iron availability gives plants better access to the nutrients needed for chlorophyll synthesis, energy metabolism, and other physiological functions, which positively impact plant growth and productivity [1,2,10,24].

The effect of PGPR treatment with and without the addition of L-TRP on plant growth parameters for Maize Growth Parameters, as shown in Table 1, indicates that the PGPR treatment with the addition of L-TRP resulted in the highest average plant height compared to the PGPR treatment without L-TRP and the control group. Similarly, the PGPR + L-TRP treatment had the highest average leaf number and plant weight, followed by the PGPR treatment without L-TRP and the control group. These findings suggest that adding L-TRP enhances the effectiveness of PGPR in improving plant growth and productivity.

Table 1. The average measurement results of the effect of PGPR *Burkholderia* sp. treatment of maize growth parameters

Treatment Group	Plant Height (cm)	Number of leaves	Plant Weight (gram)
PGPR + L-TRP	95.0 ± 0.11[a]	17.2 ± 0.50[a]	902.7 ± 5.81[a]
PGPR	91.3 ± 0.23[b]	15.4 ± 0.82[b]	785.4 ± 3.75[b]
Control	74.6 ± 0.14[c]	12.1 ± 0.71[c]	510.6 ± 5.27[c]

These findings indicate that maize plants treated with PGPR supplemented with L-tryptophan (L-TRP) exhibited superior growth parameters—higher plant height, increased leaf number, and greater plant weight—compared to those treated with PGPR alone or the control group, provide compelling evidence of the synergistic effect of L-TRP on PGPR's plant growth-promoting abilities. The notable increase in plant height, leaf number, and weight in the PGPR + L-TRP treatment group underscores the enhanced effectiveness of PGPR when combined with L-TRP, suggesting that L-TRP supplementation plays a critical role in optimizing plant growth conditions.

This augmentation of PGPR's performance through L-TRP addition could be attributed to L-TRP's known role as a precursor for the synthesis of auxin, an essential plant hormone involved in regulating plant growth and development. L-TRP might facilitate increased auxin production by the PGPR, thereby enhancing plant growth and productivity more significantly than PGPR treatment alone. This hypothesis is supported by Nassar et al. [7], who reported that L-TRP supplementation could improve plant nutrient efficiency, thereby optimizing growth. Furthermore, the enhanced colonization of plant roots by PGPR in the presence of L-TRP, as observed by Karnwal [23], indicates a more effective microbial-plant interaction, leading to improved nutrient exchange and signalling pathways essential for plant development [12].

The significant differences in growth parameters between the PGPR treatments with and without L-TRP supplementation highlight the importance of understanding the mechanisms underlying this enhanced effectiveness. These mechanisms may involve a complex interplay between microbial-produced hormones, nutrient solubilization, and improved stress resistance facilitated by L-TRP [13,25–27]. The findings suggest that incorporating L-TRP into PGPR treatments could be a viable strategy to enhance agricultural productivity, particularly for crops like maize that play a crucial role in global food security.

Future research should focus on elucidating the molecular and biochemical interactions between PGPR, L-TRP, and plant systems to build on these findings. Such studies could reveal the potential for genetic enhancements of PGPR or the development of specialized formulations combining PGPR with L-TRP or other beneficial compounds to increase their efficacy in agricultural settings further. Moreover, field trials assessing the long-term impacts of PGPR and L-TRP supplementation on crop yield and soil health will be critical in translating these laboratory findings into practical, sustainable agricultural practices. The exploration of optimized PGPR formulations supplemented with L-TRP presents an exciting frontier for enhancing crop productivity sustainably, reducing the reliance on chemical fertilizers, and promoting environmentally friendly farming techniques.

Furthermore, in-depth research on the interaction mechanisms between PGPR, L-TRP, and plants can provide deeper insights into how microorganisms can be genetically enhanced or aided by additional nutrients to enhance their benefits for plants. Further studies can also explore the practical applications of these findings, including developing optimized PGPR formulations supplemented with L-TRP to improve agricultural yields sustainably.

Overall, these findings significantly contribute to understanding the role of L-TRP in enhancing the effectiveness of PGPR in promoting plant growth and production. The practical implication is that combining PGPR with L-TRP supplementation can be an effective strategy for improving agricultural yields, especially in the context of increasing maize plant productivity.

Conclusion

This study reveals that L-TRP supplementation in PGPR Burkholderia sp. enhances plant auxin production, gibberellin concentration, and siderophore availability, significantly influencing the growth and productivity of maize plants. The results indicate that the PGPR treatment with L-TRP resulted in the tallest plants, highest leaf numbers, and most incredible plant weights. These findings confirm that combining PGPR with L-TRP can be an effective strategy for improving agricultural outcomes, particularly in the context of increasing maize plant productivity. The practical implication is the potential to develop optimized PGPR formulations supplemented with L-TRP to enhance agricultural yields sustainably.

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