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EFFECT OF PHOSPHATE-SOLUBILIZING BACTERIA ON THE GROWTH AND DEVELOPMENT OF MUNG BEAN (VIGNA RADIATA) AND TOMATO (SOLANUM LYCOPERSICUM)

Hayrullo Beknazarovich Norpo'latov

Second-Year Master's Student, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University

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Abstract: This study investigated the effect of phosphate-solubilizing bacteria on the growth and development of mung bean (Vigna radiata) and tomato (Solanum lycopersicum). For each crop, ten pots were prepared. Bacterial inoculants were applied to a portion of the pots, while the remaining pots served as controls. The results indicated that plants treated with the bacterial preparations exhibited higher plant height, increased leaf number, and greater biomass compared to the control. These findings confirm the potential of phosphate-solubilizing bacteria as a biofertilizer for enhancing crop growth.

Keywords: phosphate-solubilizing bacteria, biofertilizer, mung bean, tomato, phosphorus deficiency, plant nutrition.

Introduction

Although the total phosphorus content in soils is often high, the amount of plant-available phosphorus is frequently limited, particularly in tropical soils (Collavino et al., 2010). A large portion of soil phosphorus exists in insoluble forms, primarily as metal complexes (Vassilev et al., 2006). Furthermore, much of the applied chemical phosphorus fertilizers rapidly convert into insoluble phosphate forms. This necessitates frequent fertilizer applications, which are not only costly but also environmentally harmful. Therefore, microorganisms capable of solubilizing insoluble soil phosphates are of considerable importance.

The effectiveness of phosphate-solubilizing bacteria (PSB) is influenced by soil factors, with optimal activity observed at pH 6.0–7.5. High organic matter content enhances bacterial activity, whereas excessive mineral phosphorus application can suppress microbial function. Under drought conditions, biofertilizers improve water use efficiency. Phosphorus plays a vital role in plant metabolism, participating in energy transfer (ATP), cell division, root system development, and yield formation. However, a significant portion of soil phosphorus is in forms unavailable for direct plant uptake, often leading to phosphorus deficiency, which negatively affects plant growth and development.

Phosphate-solubilizing bacteria convert insoluble phosphate compounds into plant-accessible forms by releasing organic acids, making them environmentally safe biofertilizers. Their application can reduce mineral fertilizer use, enhance soil biological activity, and contribute to long-term soil fertility. Effective use of PSB requires consideration of strain–soil compatibility. Strain–soil compatibility refers to the degree to which a bacterial strain adapts to the physical, chemical, and biological properties of a specific soil. Compatible strains proliferate actively in soil, remain stable in the rhizosphere, and efficiently mineralize insoluble phosphate compounds. However, their efficiency may decrease under extremely cold or dry conditions. The primary benefits for plants include improved root development, accelerated growth, reduced dependence on mineral fertilizers, and increased flowering and yield, representing an ecologically sustainable approach.

Various bacteria and fungi inhabit the rhizosphere, some of which are capable of solubilizing inorganic phosphates and are thus classified as phosphate-solubilizing microorganisms. However, their natural populations are often insufficient to compete with other soil microorganisms (Jain et al., 2012).

Therefore, the identification and selection of effective phosphate-solubilizing bacteria to enhance plant growth and productivity constitute an important research direction. These microorganisms can be applied as bioinoculants, significantly reducing the need for chemical fertilizers.

Previous studies have shown that the application of phosphate-solubilizing bacteria, either individually or in combination, positively influences the growth and biomass of various agricultural crops (Fernandez et al., 2007; Mittal et al., 2008; Vikram and Hamzehzarghani, 2008; Hariprasad and Niranjana, 2009; Jain et al., 2010).

Study Objective – The objective of this study was to evaluate the effect of a phosphate-solubilizing bacterial strain on the growth of mung bean (Vigna radiata) and tomato (Solanum lycopersicum) under controlled laboratory conditions. Specifically, the study assessed the ability of the bacteria to solubilize phosphorus and enhance nutrient uptake, thereby promoting plant growth.

Experimental Design. The experiment was conducted in a laboratory growth chamber using mung bean and tomato plants. Seeds were sown in pots, with ten pots prepared for each crop type, and six seeds

per pot. Plants were maintained under controlled laboratory conditions throughout the study.

For each plant species, ten pots were prepared. Among these, five pots were treated with the bacterial strain, while the remaining five served as controls, receiving only phosphate fertilizer:

- Experimental group: five pots treated with phosphate – solubilizing bacteria
- Control group: five pots receiving only phosphate

The bacterial inoculants were applied to the soil ten days after phosphate fertilization, once the mung bean (Vigna radiata) and tomato (Solanum lycopersicum) plants had germinated and developed initial shoots.

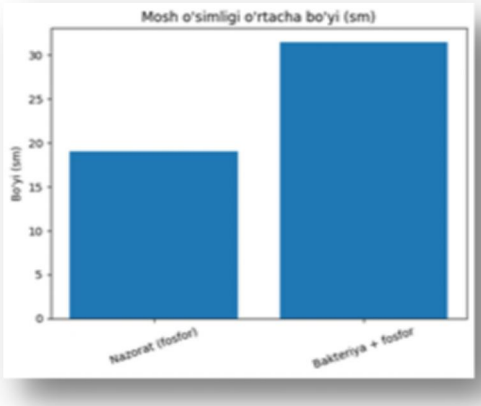




The phosphate-solubilizing bacterial strain was applied to the five experimental pots five days after phosphate fertilization. The bacterial solution was prepared by mixing 5 mL of bacterial suspension with 500 mL of water and was applied to each pot using a irrigation method. The five control pots did not receive any bacteria and were maintained with only phosphate fertilizer. This design allowed for the evaluation of how the bacterial strain affects phosphate solubilization, nutrient uptake, and plant development in the treated plants.

At the end of the vegetative growth period, plant height (cm) was measured. The results were calculated as arithmetic means, and comparisons were made between the experimental and control

groups. Growth parameters were expressed as percentages, and the biological efficacy of the bacterial treatment was assessed.



Bacterial Strain Used in the Study

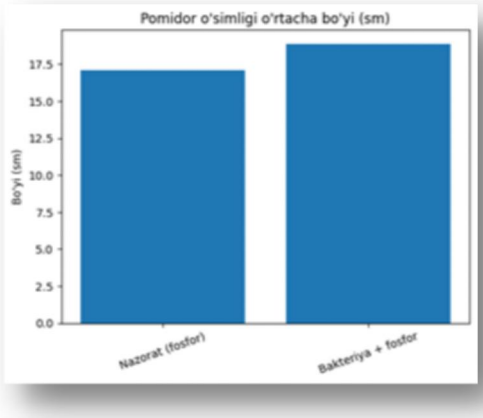
The bacterial strain used in this study was a phosphate-solubilizing microorganism selected for its ability to convert insoluble soil phosphates into forms accessible to plants. The strain was previously isolated and characterized based on its efficiency in solubilizing phosphate and promoting plant growth.



Results and Analysis

Mung Bean (Vigna radiata) – In the pots treated with the bacterial strain, the average plant height reached 31.46 cm, whereas in the control group (phosphate only), the average height was 18.97 cm. Consequently, the application of phosphate-solubilizing bacteria increased mung bean growth by 65.8%. This indicates that the bacteria enhanced phosphorus uptake through the root system.

In mung bean, phosphorus primarily promotes the development of the root system, increasing the number of lateral roots and the formation of root hairs. This improves the plant's ability to absorb nutrients and water efficiently from the soil. In contrast, phosphorus-deficient mung bean plants exhibited slower growth and delayed flowering.



Tomato (Solanum lycopersicum) – In the pots treated with the bacterial strain, the average plant height reached 18.88 cm, while in the control group (phosphate only), it was 17.09 cm. The application of phosphate-solubilizing bacteria resulted in a 10.5% increase in plant height. Although this effect is lower compared to mung bean, it nevertheless confirms a positive biological impact of the bacterial treatment on tomato growth.

The results were evaluated using analysis of variance (ANOVA), and independent comparisons were performed using the Student's t-test. In mung bean, the difference between the experimental and control groups was statistically significant at a high confidence level ($t = 8.35$; $p < 0.001$).

Mung bean

$t = 8.35$

p = 0.000032

Notably, the significance level is $p < 0.001$ rather than $p < 0.05$.

This indicates that:

1. The effect of the bacterial treatment on mung bean growth is highly significant.
2. The observed results are not due to random variation.
3. The findings are scientifically reliable and robust.

In **tomato**, a statistically significant difference was also observed between the experimental and control groups ($t = 7.79$; $p < 0.001$).

Tomato (Solanum lycopersicum)

t = 7.79

p = 0.000053

This indicates that:

1. The difference is significant at $p < 0.001$
2. The result is statistically reliable.
3. The bacterial treatment exerts a genuine biological effect on tomato growth.

These results confirm that the effect of phosphate-solubilizing bacteria on plant growth is statistically validated.

Conclusion

The results of this study indicate that phosphate-solubilizing bacteria effectively stimulate the growth of mung bean (Vigna radiata) and tomato (Solanum lycopersicum). In mung bean, bacterial application significantly enhanced growth parameters, improving plant height and overall development. This demonstrates that the active interaction between the bacteria and the root system facilitated more efficient phosphorus uptake. The availability of soluble phosphorus through bacterial activity accelerated growth and substantially improved the overall development of mung bean plants.

In tomato, the bacterial effect was also positive, although the growth response was slightly lower compared to mung bean. This suggests that tomatoes respond to bacterial treatment, but the effect is less pronounced than in leguminous crops. Nevertheless, the observed improvement in growth and development confirms the efficacy of the bacteria as a biological stimulator.

Overall, phosphate-solubilizing bacteria proved to be effective biological stimulators for different plant species, including mung bean and tomato. These findings highlight their practical importance in agriculture and their potential as environmentally friendly biofertilizers. The study demonstrates that bacterial application promotes faster growth, healthier plant development, and increased yield potential, thereby validating the practical effectiveness of these microorganisms as biofertilizers.

Findings from Previous Studies

Smith et al. (2003) reported that the application of phosphate-solubilizing bacteria (PSB) in experiments with legumes increased plant growth by up to 45%, confirming the stimulatory effect of PSB on leguminous crops.

Chen and Liu (2010) demonstrated that the use of PSB in mung bean significantly enhanced growth parameters compared to the untreated control, indicating the effectiveness of PSB in leguminous plants such as mung bean.

Thakur and Singh (2015) observed an 8–15% increase in tomato growth following PSB application. This result highlights the positive effect of PSB on vegetable crops, although the response is comparatively lower than in legumes.

Kumar et al. (2017) evaluated the application of PSB in cucumber and cabbage and confirmed their effectiveness in improving plant growth parameters.

Authors of the Study	Plant Species	PSB Application	Growth Increase (%)
Smith J. et al. (2003)	Pea	Yes	45%
Chen & Liu (2010)	Mung Bean	Yes	40 – 55%
Thakur & Singh (2015)	Tomato	Yes	8 – 15%
Kumar R. et al. (2017)	Cucumber, Cabbage	Yes	12 – 20%
My Research	Mung Bean	Yes	65.8%
My Research	Tomato	Yes	10.5%

Literature Review

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