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Influence of Plant Growth-Promoting Bacteria on the Growth Performance of Common Bean (*Phaseolus vulgaris* L.)

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Summary: Rapid population growth, expanding urbanization and industrialization are placing colossal pressure on agricultural systems by reducing cultivable land, degrading soil quality and increasing dependence on synthetic chemicals to meet global food demands. Plant growth-promoting bacteria have emerged as promising eco-friendly alternatives capable of enhancing plant growth and supporting sustainable agricultural production. The present study was undertaken to isolate multifunctional PGPB from soil and evaluate their growth-promoting potential in *Phaseolus vulgaris* L. Bacteria obtained using serial dilution techniques were purified and screened for important plant growth-promoting traits. A total of 19 bacterial isolates were obtained, among which three isolates, namely AB1051, AB1054 and AB1056, exhibited all the tested plant growth promoting traits. Seed germination assays showed that isolates AB1051 and AB1054 achieved 100% germination, whereas AB1056 and the control recorded 38.89% and 55.56% germination, respectively. Isolate AB1054 showed the best performance with the highest shoot length (20.77 ± 0.46 cm), root length (9.20 ± 0.30 cm) and number of leaves (11.67±0.58). The same isolate also recorded the highest shoot fresh weight (16.56±0.25 g), root fresh weight (2.30 ± 0.23 g), shoot dry weight (0.78±0.01 g) and root dry weight (0.19±0.00 g). Molecular characterization based on 16S rRNA gene sequencing showed highest sequence similarity of isolate AB1054 with *Acinetobacter* sp. The strong multifunctional plant growth-promoting traits and greater effects of isolate AB1054 indicate its promising potential as a bioinoculant for sustainable bean cultivation and reduced dependence on synthetic fertilizers.

Key words: bacteria, biofertilizers, indole-3-acetic acid, *Phaseolus vulgaris* L., phosphate solubilization, plant growth promotion, seed germination, bean

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Introduction

Phaseolus vulgaris (*P. vulgaris*), popularly known as common bean is an annual herb under the leguminosae family. It is one of the most widely cultivated and extensively distributed legume species worldwide, occupying approximately 36.8 million hectares with an annual production of about 28.4 million tons (Flores-Castañón et al., 2025). At present, grain legumes account for nearly 30% of the global grain supply and provide more than one-third of the dietary protein consumed by humans, while their herbal tissues also serve as a major source of animal feed, either as forage and pasture crops or as raw biomass processed into hay or silage (Myrtsi et al., 2024). The extensive consumption of *P. vulgaris* in countries such as Myanmar, India, Brazil, Mexico, China and Tanzania

has encouraged researchers to conduct numerous studies, as the species is considered to possess multiple benefits (Xuan et al., 2024). It provides multiple benefits through its different plant parts, as its leaves are consumed in salads, while the straw after bean harvest can be utilized as fodder (Ganesan & Xu, 2017). The seeds can be utilized in various forms, including as whole unprocessed seeds, in food mixtures, as canned products, or as a gluten-free alternative to wheat flour (Rodriguez et al., 2022). Legume seeds serve as a rich source of proteins, carbohydrates, dietary fiber, vitamins particularly, B-group vitamins and minerals (Neupane et al., 2024). Bean consumption is widely associated with numerous health benefits, including the prevention and management of obesity, diabetes mellitus, cardiovascular diseases and cancer, while also supporting gut health by promoting beneficial alterations in the gut microbiota and its activity (Bernardi et al., 2024). Enhancing the production and consumption of beans can support the achievement of the sustainable development goals (SDG 2030), particularly those focused on zero hunger (SDG 2), good health and well-being (SDG 3) and climate action (SDG 13) (Kumar et al., 2024).

The world population is increasing at an unprecedented rate, leading to a growing demand for food, shelter and other essential resources, while the land available for agricultural production continues to decline. Industrialization and urbanization have further reduced cultivable areas by converting fertile farmland into residential, commercial and industrial zones. At the same time, climate change has intensified environmental stresses through rising temperatures, erratic rainfall, frequent droughts, floods and soil degradation, all of which negatively affect crop productivity and stability. Agricultural production currently relies heavily on the large-scale application of chemical fertilizers and pesticides, which may enhance yield and productivity, but their uses bring many harmful effects. The intensive use of synthetic chemical fertilizers and pesticides in modern agriculture has led to serious environmental problems such as groundwater contamination, soil degradation and biodiversity loss (Das et al., 2025). Given the limitations of synthetic fertilizers, there is a pressing need to develop alternative fertilization strategies that support sustainable food production systems. The use of beneficial microbes, particularly plant growth-promoting bacteria (PGPB), has gained considerable attention due to their wide range of positive effects on plant growth and overall productivity. PGPB enhance plant growth and development through a wide range of direct and indirect mechanisms that influence plant physiology, nutrient availability and protection against environmental stress. Direct mechanisms encompass all activities performed or metabolites produced by PGPB that directly enhance plant growth, including facilitation the solubilization and uptake of minerals such as iron(Fe), potassium (K) and phosphorus (P), biological nitrogen (N) fixation, biosynthesis of phytohormones and regulation of plant ethylene and 1-aminocyclopropane-1-carboxylate levels, whereas indirect mechanisms involve the mitigation of plant damage or growth inhibition caused by phytopathogens through the production of antibiotics and hydrogen cyanide (HCN), solubilization and sequestration of Fe to limit pathogen availability, synthesis of fungal cell-wall-degrading enzymes, competitive exclusion of pathogens, emission of volatile organic compounds, modulation of plant ethylene levels, induction of systemic resistance and disruption of pathogen communication (Reed & Glick, 2023). PGPB also enhance plant resilience and strengthens bioremediation potential under multiple stresses, including heavy metal toxicity and changing climatic conditions (Singh et al., 2026).

This study aimed to promote sustainable bean cultivation by reducing dependence on synthetic fertilizers through the application of PGPB. Accordingly, 19 bacterial isolates were screened for key PGP traits in order to identify the most promising candidates with potential use as PGPR in sustainable agriculture.

Material and Methods

Collection of soil sample: Soil samples were collected on 28/10/2025 from a kitchen garden located at Diphubar B, Chumukedima, Nagaland, India (25.855659°N, 93.754969°E). Sampling was carried out from a depth of approximately 15 cm. The soil samples were then transferred into

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sterilized plastic bags, labelled and transported to the Life Science Laboratory, St. Joseph University, Nagaland, for microbiological analyses.

Plant material: Seeds of *P. vulgaris* L. (france beans sel-12, a hybrid bean cultivar) were purchased from local seed vendor in Chumukedima, Nagaland, India. A single lot was used throughout the experiment to maintain uniformity of the experimental material. The cultivar was selected based on its local availability and popularity among local growers.

Bacterial Isolation: One gram of soil was suspended in 10 mL of saline buffer and serially diluted up to 10^{-6}. Aliquots of 0.1 mL from the 10^{-4}, 10^{-5} and 10^{-6} dilution were aseptically transferred onto petri plates containing nutrient agar (HiMedia, India). All plates were prepared in triplicate and incubated at 37°C for 48 hours. Following incubation, morphologically distinct bacterial colonies were selected and streak onto fresh nutrient agar plates to obtain pure isolates.

Screening of multi-trait bacteria: Qualitative estimation of IAA production was performed following the method of Meneguzzi et al. (2024). The essay was conducted both in the presence and absence of L-tryptophan as an IAA precursor. A total of 100 mL of luriabertani broth (HiMedia, India) was inoculatedwith 100 µL of bacterial culture adjusted to an optical density of 0.5 (10^{7}-10^{8} CFUmL^{-1}) at 600 nm. The cultures were incubated at 28 ± 2°C for 96 hours with continuous shaking at 150 rpm. After incubation the cultures were centrifuged at 10,000 rpm for 10 min to obtain the cell-free supernatant. For IAA detection 100 ul of Salkowski reagent was added to 100 µL of the supernatant and incubated at room temperature for 30 min. The appearance of a pink coloration indicated positive IAA production. The N-fixing ability of isolates was evaluated using Jensen's following Adeleke and Fakoya (2025). The medium was sterilized at 121°C for 15 min, cooled and poured into petriplates. Bacterial isolates was inoculated and incubated at 30°C for 5 days. Visible bacterial growth on the medium indicated a positive result for N fixation while uninoculated plate served as control. Siderophore production by bacterial isolate was assessed using chrome azurol sulphonate (CAS) agar Plates. The bacterial inoculum was spot-inoculated onto the plates and incubated at 28 ± 2°C for 5 days (Waday et al., 2022). The appearance of yellowish, pinkish, or whitish halo surrounding the colonies against the dark blue background of the medium indicated positive siderophore production. The bacteria isolates were spot-inoculated on Aleksandrow agar plates following Sood et al. (2023). The plates were then incubated at 28°C for 3-7 days to observe the formation of clear zones around the colonies.P solubilisation was assessed using Pikovskaya's medium as described by Alkahtani et al. (2020). The medium was inoculated with the bacterial isolates and incubated at 30 ± 2°C for 48 hours, while uninoculated plate served as control. The appearance of clear zones surrounding bacterial colonies indicated phosphate-solubilizing activity. Zinc (Zn) solubilization was evaluated using Zn solubilizing agar containing (g/L) dextrose 10, $(NH_4)_2SO_4$ 1, KCl 0.02, K_2HPO_4 0.1, $MgSO_4$ $2H_2O$ 0.2 and ZnO 1 (Chhetri et al., 2025). The isolates were spot-inoculated onto the medium and incubated at 30 ± 2°C for 24 - 48 hours. The appearance of clear halo zone surrounding the colonies indicated positive Zn solubilization activity.

Bacterial inoculums and preparation of seed: After screening for in vitro plants plant growth promoting (PGP) traits, three promising bacterial isolates including AB1051, AB1054 and AB1056 were selected for treating common bean seeds. An uninoculated treatment was maintained as the control. These four treatments were used consistently in the subsequent assays. Each isolate was cultured in a 100 mL conical flask containing 50 mL of nutrient broth and incubated in a rotary shaker at 150 rpm and 30°C for 48 hours, after which the cells were harvested and resuspended in sterile distilled water. The bacterial cell concentration was adjusted with sterile distilled water and the final inoculum density was standardized to 2×10^{9} cells mL^{-1} for seeds inoculation (Sherpa et al., 2021).

Beans seed were surface sterilized with 1% sodium hypochlorite for three to five min and rinsed three times with sterile distilled water.

Seed germination assay: The effect of bacterial strain on seed germination was tested following the method described by Hyder et al. (2020). The sterilized seeds were soaked in 250 mL of

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bacterial suspension and gently shaken for 2 h. Control seeds were soaked only in autoclaved distilled water. Both treated and control seeds were placed on moist blotting paper (Whatman filter paper No. 41) in petri plates, with six seeds per plate and incubated at 26 ± 2°C. Seeds germination was recorded after five days of incubation. Each treatment was conducted in triplicate and mean germination values were calculated. Seed germination percentage was determined using the following formula:

$$\text{Seed germination (\%)} = \frac{\text{No of germinated seeds}}{\text{Total number of seeds}} \text{ x } 100$$

Bioassay-based evaluation of plant growth promotion: The PGP bioassay was performed following a modified protocol of Sherpa et al. (2021). The pot experiment was conducted under poly-house conditions at the Department of Botany, St Joseph University, Nagaland, India (25.852089ºN 93.748379ºE). Bean seeds were soaked separately in each bacterial suspension and sterile distilled water at room temperature for 5 hours. The treated seeds were then sown in a poly bags (20cm diameter × 20cm depth) containing 3.5 kg of autoclaved, sterilised soil (pH 6.0). The experiment was laid out in a randomized block design. For each treatment, one pot containing 5 seeds was considered as a single replicate and three replicates were maintained per treatment. Pots were irrigated with 200 mL sterile distilled water at three-day intervals. For growth assessment, plants were carefully harvested from each pot after 35 days of sowing, gently washed to remove adhering soil particles, blotted dry and parameters including shoot and root height, number of leaves per plant and fresh and dry weight of shoot and root were recorded. Dry weight was determined after oven drying the samples at 80°C for 72 hours.

16S rRNA gene-based molecular identification of isolate: Genomic DNA was extracted from overnight bacterial cultures following the CTAB method described by Wilson, (2001). An aliquot of 1.5 mL of overnight culture was centrifuged to obtain a compact cell pellet, which was resuspended in 567 µL TE buffer. 30 µl of 10% SDS and 3 µl of proteinase K (20 mg/mL) were added and the mixture was gently mixed and incubated at 37°C for 1 h. 100 µl of 5 M NaCl was added and mixed thoroughly, followed by the addition of 80 µL CTAB/NaCl solution. The suspension was incubated at 65°C for 10 min. An equal volume of chloroform: isoamyl alcohol (24:1) was then added, mixed thoroughly and centrifuged. The aqueous upper phase was pipette out, followed by extraction with an equal volume of phenol:chloroform:isoamyl alcohol (25:24:1) and centrifugation for 5 min. The clear supernatant was transferred to a new tube. DNA was precipitated by adding 0.6 volume of isopropanol and gently inverting the tube until visible DNA strands appeared. The precipitated DNA was pelleted by centrifugation, washed with 70% ethanol and centrifuged again for 5 min. The ethanol was carefully discarded and the pellet was air-dried to remove residual solvent. The DNA pellet was dissolved in 100 µl TE buffer and stored at 4 °C for further molecular analyses. The extracted genomic DNA was sent to the Biotech Park (Guwahati, India), for molecular identification. Raw sequence data were edited and assembled using Bio Edit version 7.0.4. The Basic Local Alignment Search Tool (BLASTn) was used to compare gene sequences with others in the National Center for Biotechnology Information (NCBI) GenBank database.

Statistical analysis: All data are presented as mean ± standard deviation (SD). A one-way analysis of variance (ANOVA) was performed to evaluate differences among growth parameters and germination rates using SPSS version 21.0. When significant differences were detected, Tukey's post hoc test was used for comparison among treatment means. Differences were considered statistically significant at $p < 0.05$.

Results and discussion

A total of 19 bacterial isolates were obtained and screened for various plant growth-promoting (PGP) traits (Table 1). Ten isolates demonstrated the ability to produce IAA, a key phytohormone involved in regulating plant growth and development. The production of IAA by PGPB has been widely documented in earlier studies. For instance, Goswami et al. (2013) reported

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that an olive-green *Pseudomonas* sp. isolate produced 29 µg mL^{-1} of IAA and attributed the enhanced root growth and development in chickpea and green gram to the IAA producing ability of the isolate. Similarly, Wagi and Ahmed (2019) demonstrated IAA production by *Bacillus* species and suggested that optimizing IAA production could enhance bacterial efficacy as biofertilizers. IAA influences several plant activities from germination to maturity and is actively involved in cell division and enlargement, initiation and expansion of leaf, root initiation, as well as the development of lateral roots and root hairs, delay of abscission, phototropism geotropism, development of fruit and enhances plant tolerance to various abiotic stresses (Bessai et al., 2022). Siderophore production was observed in seven isolates, representing another important indirect PGP mechanism. Siderophores are low molecular weight compounds that chelate Fe^{3+} and other metals present in the rhizospheric region, making them unavailable to the phytopathogens and helps in maintaining plant health (Meza et al., 2022). N fixation ability was recorded in ten isolates, highlighting one of the most valuable agronomic traits. N is a major macronutrient required for plant growth, yet N_2 is not directly available to plants. N-fixing bacteria convert N_2into plant usable from through biological N fixation, thereby increasing N availability in the soil. In terms of mineral solubilization, five isolates exhibited K-solubilizing activity. K is an essential nutrient involved in various plant physiological processes. PGPB facilitate K release through the secretion of organic acids such as citric, oxalic and tartaric acids, (Fanai et al., 2024). Phosphate solubilization emerged as the most prevalent trait, observed in 11 isolates. The presence of phosphate-solubilizing microbial populations in soil can serve as a positive indicator of their potential use as biofertilizers in sustainable agriculture (Majeed et al., 2015). Zn solubilization was observed in eight isolates, showing their importance in micronutrient management. Zn is an essential trace element required in small amounts, yet it exerts significant growth-promoting effects in plants by playing a vital role in enzymatic activities, protein synthesis, and metabolic processes (Sethi et al., 2025). ZSB play a crucial role in overcoming Zn deficiency through the production of organic acid metabolites that lower soil pH, along with the secretion of Fe-chelating enzymes (Fanai et al., 2024).

Table 1. Screening of plant growth promoting traits

Sl. No.	Isolates	NF	PS	KM	ZS	SP	IAA
1	A1041		+			+	+
2	A1042				+		+
3	A1043	+		+			
4	A1044						+
5	A1049		+		+		
6	A10410	+	+			+	
7	A1061			+			+
8	A1062	+					+
9	A1063	+	+		+	+	
10	A1064	+	+				
11	A1065						+
12	A1067	+	+		+		
13	AB1051	+	+	+	+	+	+
14	AB1052	+	+		+		
15	AB1054	+	+	+	+	+	+
16	AB1056	+	+	+	+	+	+
17	AB1061		+				
18	AB1064					+	
19	AB1065						+

NF: nitrogen fixation, PS: phosphate solubilisation, KM: potassium mobilisation, ZS: Zinc solubilisation, SP: siderophore production, IAA: indole -3-acetic acid production.

Seed germination and early seedling establishment are important determinants of crop growth and production. The PGP efficacy of selected bacterial isolates was evaluated using

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AB1051, AB1054 and AB1056, which were chosen based on their multiple PGP traits. Seeds treated with individual isolates were compared with control (without bacterial inoculation) to assess their influence on germination (Figure 1). A clear variation in germination response was observed among treatments after five days. Isolates AB1051 and AB1054 exhibited a remarkable 100% germination rate, whereas AB1056 and the control recorded comparatively lower germination rates of 38.89% and 55.56%, respectively (Figure 2). The germination response observed in the present study was comparable to, but more variable than, that reported by Arslan and Bulut (2023), who recorded the highest germination rate of 97.5% in *P. vulgaris* inoculated with *Bacillus* sp. SZF135 and the lowest rate of 65.7% in seeds inoculated with *Bacillus thuringiensis*. These findings indicate that not all isolates exert a positive effect and the efficiency of PGPB on seed germination is strain-dependent. The enhanced germination observed with AB1051 and AB1054 may be attributed to their multiple PGP traits which might have improve nutrient availability and stimulate physiological processes involved in seed germination and early growth. Similar explanations have been provided by (Rahman et al., 2017) who attributed improvement in germination and plant growth to N-fixing and phosphate-solubilizing abilities of the bacteria, along with their capacity to produce growth-promoting substances.

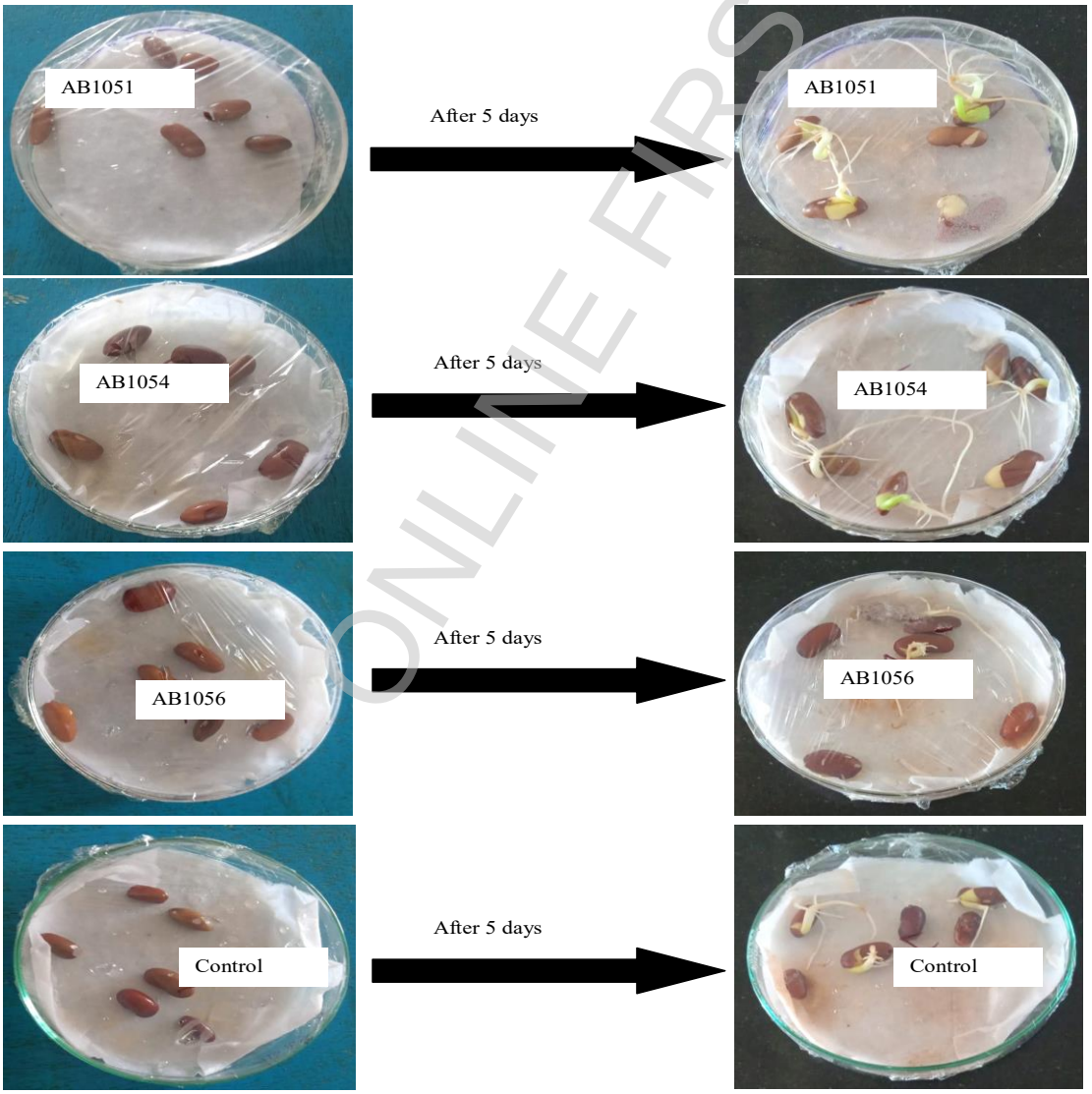


Figure 1. Bean plant growth under different bacterial treatments after five days

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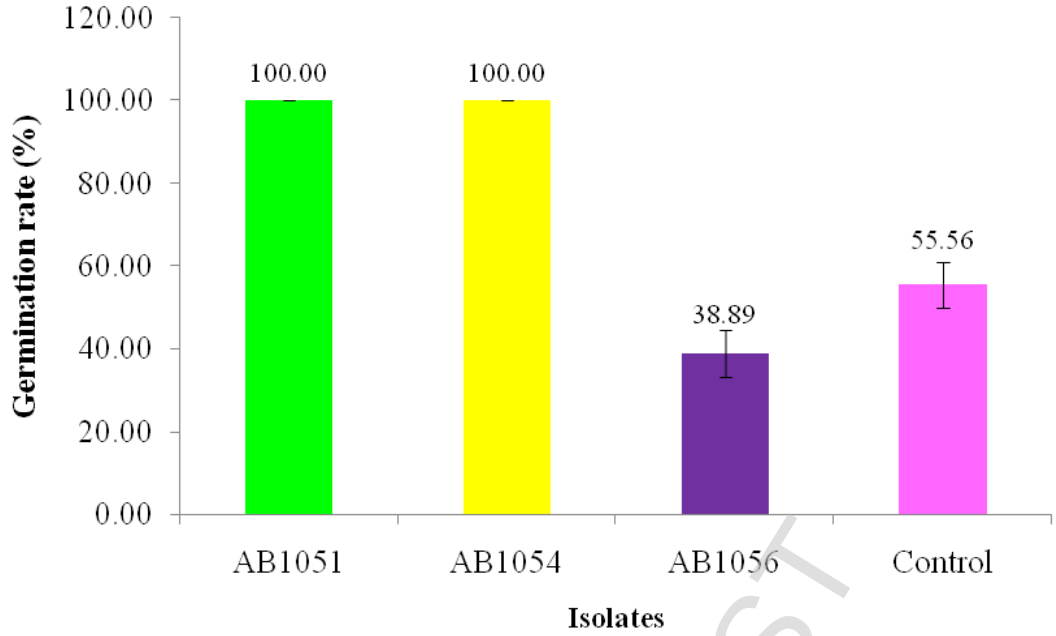


Figure 2. Seed germination rate of isolates and control after five days of treatment

Bacterial inoculation influenced the growth of bean plants at 35 days after sowing, with clear differences among the isolates (Table 2). All inoculated treatments exhibited a significantly higher number of leaves and greater shoot length compared to the control. The increase in shoot length may be attributed to molecules produced by certain bacterial strains, along with the mineralization of nutrients that enhances their availability to plants (Kouki et al., 2023). Root growth responses varied among the treatments, with plants treated with AB1054 (9.20 cm) and AB1056 (7.80 cm) showing significantly greater root lengths than the control (5.87 cm), corresponding to increases of 56.55% and 32.88%, respectively. In contrast, inoculation with AB1051 did not result in a significant change in root length compared with the uninoculated control. Among the treatments, AB1054 consistently performed better, showing improvement leaf number and shoot and root length. The better performance of AB1054 could be due to production of higher phytohormone especially IAA as compared to other isolates. IAA promotes root elongation and stimulates the formation of lateral roots, chancing the plant's ability to absorb water and essential nutrients which ultimately contributes to the development of a well-established, vigorous and healthy plant (Naqqash et al., 2016). The role of multi-trait PGPB in enhancing plant growth is also supported by previous study where Abd-Alla et al. (2024) reported that certain bacteria, such as symbiotic rhizobia and free-living N-fixing species, are capable of synthesizing IAA, which improves root architecture in legumes and enhances root colonization and nutrient acquisition. In the present study, the enhanced root growth observed in inoculated treatments likely facilitated greater nutrient uptake, which in turn supported improved shoot growth and overall plant development. Fresh and dry shoot weights were the highest in plants treated with AB1054, followed by AB1051. On the contrary, the lowest values were recorded in AB1056 treated plants, which were even lower than those of the control. A similar trend was observed for root biomass where fresh and dry root weight was the highest in AB1054, followed by AB1051 and the control, while AB1056 recorded the lowest value. The higher dry weight of plants treated with AB1054 may be attributed to the enhanced leaf area in the plant (Naqqash et al., 2016). Another study also demonstrated that inoculation with certain isolates enhanced bean shoot and root length, as well as shoot and root dry weight relative to the control, whereas treatment with other isolates resulted in lower values than the control (Arslan & Bulut, 2023).

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Table 2. Growth rate of bean plant under greenhouse condition

Isolate	Shoot length (cm)	Root length (cm)	No. of leaves	FWS (g)	FWR (g)	DWS (g)	DWR (g)
AB1051	12.47± 0.67^{c}	6.90± 0.53^{bc}	8.67± 0.58^{c}	9.63± 0.36^{b}	1.07± 0.07^{b}	0.51± 0.01^{b}	0.09± 0.00^{b}
AB1054	20.77± 0.46^{a}	9.20± 0.30^{a}	11.67± 0.58^{a}	16.56± 0.25^{a}	2.30± 0.23^{a}	0.78± 0.01^{a}	0.19± 0.00^{a}
AB1056	15.20 ± 0.44^{b}	7.80 ± 0.70^{b}	10.33± 0.58^{ab}	4.24 ± 0.24^{d}	0.75 ± 0.04^{c}	0.27 ± 0.01^{c}	0.04 ± 0.00^{c}
Control	11.27± 0.42^{c}	5.87± 0.06^{c}	5.67± 0.58^{d}	6.01± 0.04^{c}	0.96 ± 0.02^{bc}	0.34 ± 0.01^{c}	0.09 ± 0.00^{b}

Mean±Standard deviation (n=3), Different letters in each column indicate significant differences, FWS: fresh weight of shoot, FWR: fresh weight of root, DWS: dry weight of shoot, DWR: dry weight of root.

As the experiment was conducted in autoclaved soil, the role of native microbial communities can be excluded and the plant responses can be directly linked to the inoculated isolates. Comparable observations have been reported in other plant, where enhanced growth under sterile conditions was linked to the PGP activities of the inoculated strains (Saadaoui et al., 2022). Under controlled conditions, differences in growth response are likely due to variation in the efficiency, expression and balance of traits such as IAA production, siderophore activity and nutrient solubilization among others. The success of inoculation is also influenced by factors such as the inoculation method, growth medium, moisture level, temperature and compatibility between the bacterial strain and the host plant (Bizjak Johansson et al., 2025). Therefore, factors related the selected polyhouse conditions and the isolates ability to adapt there might also be contributing factors. Additionally, the ability of the isolates to colonize the rhizosphere and maintain activity over time may have played an important role. AB1054 appears to have established more effectively, resulting in improved growth parameters, whereas AB1056 may have shown limited colonization or lower metabolic activity, leading to reduced plant response.

Molecular characterization of isolate AB1054 based on 16S rRNA gene sequence analysis revealed its highest sequence similarity to previously reported *Acinetobacter* spp. However, this level of similarity is insufficient to support reliable genus-level assignment. Therefore, the isolate is referred to as isolate AB1054 rather than *Acinetobacter* sp. In the present investigation, AB1054 exhibited positive responses for all the PGP traits evaluated, indicating strong multifunctional potential as PGP bacterium. Previous reports have demonstrated the ability of *Acinetobacter* species to produce phytohormones and solubilize phosphate (Moreno-Ramirez et al., 2014). The PGP efficiency of isolate AB1054 was further supported by seed germination and plant growth assays, in which its inoculation resulted in the highest seed germination percentage and superior growth parameters among the tested treatments. These findings demonstrate the multifarious PGP potential of isolate AB1054 and emphasize the need for further molecular characterization and taxonomic identification to establish its identity and assess its potential for biofertilizer development and sustainable agricultural applications.

Conclusion

PGPB have gained considerable attention as environmentally sustainable alternatives due to their ability to enhance nutrient availability, PGP substances and improve plant tolerance to adverse environmental conditions. In the present study, total of 19 bacterial isolates were obtained, among which isolates AB1051, AB1054 and AB1056 demonstrated all the tested PGP attributes, indicating their multifunctional nature and potential application as bioinoculants. The selected isolates positively influenced seed germination and plant growth under greenhouse conditions, although their effects varied depending on the strain. Seed treatment with AB1051 and AB1054 resulted in complete germination of all tested seeds, indicating their strong stimulatory effect

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during early seedling establishment. Among the evaluated isolates, AB1054 produced the most pronounced enhancement in plant growth, significantly increasing shoot and root length, fresh and dry biomass accumulation and leaf production compared to the uninoculated control. The study supports the growing evidence that PGPB can contribute to sustainable agriculture by reducing dependence on chemical fertilizers and promoting environmentally friendly crop production systems. However, future research should focus on detailed molecular, biochemical and genomic characterization of isolate AB1054 as it may represent a potentially novel bacterial strain with unique functional properties. Additional studies under field conditions across different soil types and environmental conditions are necessary to evaluate its long-term efficiency, rhizosphere competence and consistency in promoting crop productivity.

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Ethical issues statement: AI based tool (Grammarly) was used to assist in improving grammar the manuscript.

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Uticaj bakterija koje podstiču rast biljaka na parametre rasta pasulja (*Phaseolus vulgaris* L.)

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Sažetak: Brz porast stanovništva, širenje urbanizacije i industrijalizacija vrše ogroman pritisak na poljoprivredne sisteme smanjenjem površina obradivog zemljišta, degradacijom kvaliteta zemljišta i povećanjem zavisnosti od sintetičkih hemikalija radi zadovoljavanja globalnih potreba za hranom. Bakterije koje podstiču rast biljaka (PGPB) izdvojile su se kao obećavajuće, ekološki prihvatljive alternative sposobne da unaprede rast biljaka i podrže održivu poljoprivrednu proizvodnju. Ovo istraživanje je sprovedeno sa ciljem izolacije multifunkcionalnih PGPB iz zemljišta i procene njihovog potencijala za podsticanje rasta kod vrste *Phaseolus vulgaris* L. Bakterije dobijene primenom tehnike serijskog razblaživanja su prečišćene i ispitane u pogledu važnih svojstava koja podstiču rast biljaka. Dobijeno je ukupno 19 bakterijskih izolata, među kojima su tri izolata – AB1051, AB1054 i AB1056 – pokazala sva ispitivana svojstva podsticanja rasta biljaka. Testovi klijanja semena pokazali su da su izolati AB1051 i AB1054 ostvarili klijavost od 100%, dok su izolat AB1056 i kontrola zabeležili klijavost od 38,89%, odnosno 55,56%. Izolat AB1054 pokazao je najbolje rezultate, uz najveću dužinu izdanka (20,77 ± 0,46 cm), dužinu korena (9,20 ± 0,30 cm) i broj listova (11,67 ± 0,58). Taj isti izolat takođe je zabeležio najveću svežu masu izdanka (16,56 ± 0,25 g), svežu masu korena (2,30 ± 0,23 g), suvu masu izdanka (0,78 ± 0,01 g) i suvu masu korena (0,19 ± 0,00 g). Molekularna karakterizacija zasnovana na sekvenciranju gena za 16S rRNA pokazala je najveću sličnost sekvence izolata AB1054 sa *Acinetobacter* sp. Izražena multifunkcionalna svojstva izolata AB1054, koja podstiču rast biljaka, kao i njegovi značajniji efekti, ukazuju na njegov veliki potencijal kao bioinokulanta za održivu proizvodnju pasulja i smanjenje zavisnosti od sintetičkih đubriva.

Ključne reči: bakterije, biođubriva, indol-3-sirćetna kiselina, *Phaseolus vulgaris* L., solubilizacija fosfata, podsticanje rasta biljaka, klijanje semena, pasulj

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