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Isolating and Characterising Phosphate-solubilising Bacteria from Oil Palm and Forest Soils for Improved Agricultural Practices

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ABSTRACT

Phosphate-solubilising bacteria (PSB) are important players in plant growth promotion. This study aimed to screen functionally active phosphate-solubilising bacteria (PSB) from oil palm and forests near oil palm plantations. The microbial composition of the two soil types was compared, revealing distinct differences. In forest soil, *Streptomyces* (31%) and *Bacillus* (23%) were the dominant genera, whereas in oil palm soil, *Burkholderia* (27%) was the most abundant, followed by *Streptomyces* (21%). Phosphate Solubilisation screening on Pikovskaya's agar identified 30 isolates producing halo zones indicative of tri-calcium phosphate Solubilisation. Dual-culture assays against *Ganoderma boninense* (PER71) shows six isolates with dual activity, exhibiting phosphate solubilising indices (2.30–4.22 cm) and radial growth inhibition of 50–70%. Further test on plant growth-promoting trait evaluation demonstrated (PSM 1, PSM 4, PSM 5, PSM 6, PSM 8 and PSM 9) produced Indole-3-Acetic Acid (IAA) in the range of 8.7-22.46 µg/mL. The findings highlight efficient PSB strains with dual functions in nutrient Solubilisation and pathogen suppression, offering a sustainable and eco-friendly approach for enhancing oil palm growth, disease management, and yield improvement.

Keywords: Phosphate Solubilising Bacteria (PSB), oil palm, *Ganoderma boninense,* plant growth promotion, soil microbial diversity

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INTRODUCTION

Phosphorus is an important macronutrient that essential for plant growth, together with nitrogen and potassium (Glaser & Lehr, 2019). Phosphate-solubilising bacteria (PSB) play a crucial role in converting soil-insoluble phosphates into bioavailable forms through various

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mechanisms, including the secretion of organic acids, enzyme production, and siderophore excretion (Puri et al., 2020).

Pathogens pose a significant threat to plant health by reducing plant yield and negatively impact food quality. Usage of chemical fertilisers for controlling phytopathogens has shown several side effects due to which different biocontrol agents have emerged as an efficient tool to protect the plant from pathogens (Fallahzadeh-Mamaghani et al., 2009; Yaqub & Shahzad, 2011). The term biocontrol means controlling the disease or reducing the number or effect of the pathogen infestation in the host (Choudhary & Johri, 2009).

Problem Statement

Oil palm cultivation relies heavily on chemical fertilizers, but excessive usage of degrades soil health and disrupts microbial diversity. High nitrogen inputs are further linked to increased basal stem rot (BSR) caused by *Ganoderma boninense*, which the most destructive oil palm pathogen. Identifying native microbes with nutrient-solubilising and biocontrol capacities offers a sustainable integrated nutrient and disease management strategy.

Research Questions

Do isolated microbial strains possess nutrient-solubilising abilities (such as phosphorus and potassium) and antagonistic activity against *Ganoderma boninense*, the pathogen responsible for basal stem rot in oil palm?

MATERIALS AND METHODS

Site Description and Sampling Design

A series of sampling was carried out in two types of soils (oil palm: Alluvial soil; forest adjacent oil palm) in the area of Segamat (2°10’29.5”N 103°00’03.7”E)and Keratong, Johor (2°46’34.2”N 102°55’13.2”E). Five samples were collected at each location. Each sample was taken at the depth of 15 cm, 30 cm and 45 cm with a hand auger and placed in plastic bags with appropriate labelling and brought to the laboratory for further analysis.

Isolations of Phosphate Solubilising Bacteria (PSB)

Soil samples from three depths were pooled, serially diluted up to 10^{-5}, and spread on Pikovskaya’s (PVK) agar. After 5 days of incubation at 28°C, colonies producing clear halo zones were purified on Nutrient Agar and re-inoculated onto PVK agar in triplicate. Pure phosphate-solubilising bacteria (PSB) isolates were then preserved at −80°C for further analysis.

Assessment of the Solubilising Activities of PSB Strains on Solid Media

The phosphate-solubilising ability of bacterial isolates was evaluated on PVK agar containing tricalcium phosphate (TCP). After 7 days of incubation at 28°C, the Solubilisation index (PSI) was calculated.

Determination of the Production of Indole Acetic Acid

Phosphate-solubilising Bacteria (PSB) were assayed for their capacity to produce indole acetic acid (IAA) (Kumar et al., 2015). Absorbance was measured at 530 nm using UV-Vis Spectrophotometer (Shimadzu, UV-1800, Japan) and the quantity of IAA was determined from a standard curve and expressed as µg/mL. These experiments were carried out in triplicate for each isolate.

DNA Extraction, PCR Amplification, and Sequencing

The screened PSB were then subjected for the bacterial genomic DNA extraction by using Plant DNeasy Mini Kit (Qiagen, Germany). The PCR was done by using bacterial 16SrRNA primer with GoTaq® Green Master mix (Promega, USA) (Amri et al., 2023). The amplified products were purified and sequenced by Apical Scientific Sdn. Bhd. (Malaysia).

RESULTS AND DISCUSSION

Composition of Phosphate Solubilising Bacteria (PSB) Community and Molecular Identification

The comparative relative abundance of phosphate-solubilising microbes (PSMs) in forest soil and oil palm soil is presented in Figure 1.

Phosphate Solubilisation Index

The ability of PSB to solubilize phosphate is visually confirmed by the formation of clear halos around bacterial colonies on PVK agar plates. A higher SI suggests a more effective

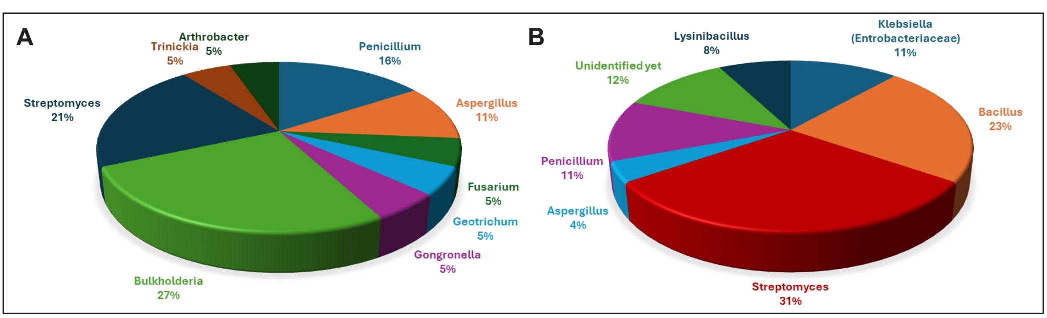

Figure 1. Relative abundance of the different species of phosphate-solubilising Microbes (PSB) in the studied oil palm (A) and forest soil (B)

Table 1
Phosphate solubilising index

No	Isolates ID	Colony Diameter (mm)	Solubilisation diameter (mm)	Solubilisation index (SI)
		Forest Soil		
	PSM5	0.48 ± 0.04	0.68 ± 0.01	2.42[a]
	PSM4	1.03 ± 0.11	1.63 ± 0.04	2.59[a]
		Oil Palm		
	PSM6	5.99 ± 0.04	19.25 ± 5.52	4.22[b]
	PSM1	7.10 ± 0.14	21.88 ± 5.69	4.08[b]
	PSM8	11.0 ± 1.91	24.73 ± 1.17	3.25[b]
	PSM9	8.10 ± 0.67	10.53 ± 0.67	2.30[ab]

Note. Means with same letter are not significantly different at $P>0.05$ using Turkey test

phosphate Solubilisation potential. The average solubilising index (SI) of the selected isolates is presented in Table 1.

Determination of the Production of Indole Acetic Acid

Indole-3-Acetic Acid (IAA) production varied significantly among the phosphate-solubilising bacterial isolates. PSM 6, PSM 8, and PSM 9 showed the highest absorbance, indicating greater IAA biosynthesis compared to other strains. These isolates demonstrate strong potential as plant growth-promoting rhizobacteria (PGPR) by enhancing root development and elongation.

CONCLUSION

In conclusion, this study indicates that certain microbial isolates, particularly PSM 1, PSM 6 and PSM8 have high potential for phosphate Solubilisation.

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