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Role of Indigenous Nitrogen-fixing Bacteria in Promoting Plant Growth on Post Tin Mining Soil

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Abstract

Post tin mining soil is generally marginal with low pH, has poor nutrient content, and is thus unfavorable for plant growth, particularly for *Sorghum bicolor*, which is a nutrient-demanding plant. Indigenous bacteria are usually used in bioaugmentation to ameliorate environmental degradation due to their ability to adapt well. This research aimed to isolate indigenous nitrogen-fixing bacteria and evaluate its potential for promoting the growth of *S. bicolor* on post tin mining soil. Nitrogen-fixing bacteria were isolated from post tin mining soil by using specific media and identified by Bergey's manual. Twenty five isolates were obtained, and eight of them (*Azospirillum* sp., *Azospirillum lipoferum*, *Azotobacter chroococcum*, *A. paspalii*, and *Rhizobium* sp.) were identified as nitrogen-fixing bacteria. A greenhouse experiment was conducted using factorial completely randomized design with three replications. The first factors were fertilizers, i.e., NPK; *A. lipoferum* CBT4 + NPK; *A. lipoferum* CBT4; and without fertilizer (control). The second factors were soil types, i.e., A (fertile soil from Cibinong), B (soil from Bangka Botanical Garden), C (soil from post tin mines two years after mining), and D (soil from active tin mining). Result showed that *Azospirillum lipoferum* CBT4 isolated from C (soil from post tin mines two years after mining) exhibited the highest IAA, Ca-P solubilizing ability, and PME-ase activity. This species survived up to a population of 10^7 CFU/gram soil in the three types of post tin mining soils and could be a potential plant-growth promoting rhizobacteria (PGPR) species for effectively improving the growth of *S. bicolor* plant on post tin-mining soil.

Keywords: nitrogen fixing bacteria; PGPR, sorghum, tin mining soil, Bangka Island

Introduction

Nitrogen-fixing bacteria (NFB) are symbiotic and nonsymbiotic microorganisms. Symbiotic bacteria (*Rhizobium*) live freely and symbiotically infects legume roots, forming root nodules. Nonsymbiotic bacteria (*Azotobacter* and *Azospirillum*) live freely in various types of soil and rhizosphere. These bacteria can be associated with various types of plants that grow in different types of environments. The existence of these bacteria in soil is influenced by soil fertility, pH, contents of carbon (C), nitrogen (N), phosphorus (P), potassium (K), and micro nutrients [1], and soil aeration [2]. Several types of NFB can adapt to different habitats with varied temperature, acidity, and extreme oxygen pressure [3]. Some bacteria can live in any environment, such as in marginal ex-tin mining soil contaminated with heavy metals.

Tin mining activity damages the environment and leads to a decline in soil quality because of the high content of heavy metals, loss of macro and micro nutrients from top soil, disruption of humidity, temperature, pH, and exudates produced by plant roots, and reduced microbial activity in the rhizosphere [4]. Microbes play an important role in the mineralization of macro and micro elements for plant growth [5] as well as in metabolism and development of plants [6]; microbes also act as indigenous component in bioaugmentation. Microbes have great potential to speed up the rate of degradation of contaminated soil. Some bacteria, such as *Rhizobium*, *Azotobacter*, and *Azospirillum* cannot only to tie up nitrogen but also dissolve phosphates bonded to Al, Fe, and Ca [7] and in inorganic form [8]. N and P are essential elements in the soil to improve biogeochemical cycles and microbial activity in the rhizosphere of plants that grow in post-mining soil [9]. Bacteria can be a catalyst in nitrogenase cycle to improve the fertility of post mining soil due to its ability to reduce N_2 gas into ammonium in the atmosphere [4] and produce plant growth hormones, such as indole acetic acid (IAA), gibberellins, and cytokinins [10]. Therefore, that nitrogen fixing bacteria (*Rhizobium*, *Azotobacter*, and *Azospirillum*) are considered an important component of biological organic