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The role of arsenic resistant *Bacillus aryabhattai* MCC3374 in promotion of rice seedlings growth and alleviation of arsenic phytotoxicity

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HIGHLIGHTS

- As resistant *Bacillus aryabhattai* AS6 strain isolated from contaminated rhizosphere.
- AS6 strain could tolerate As (v) and As (III) upto 100 mM and 20 mM respectively.
- It exhibited IAA and siderophore production, P-solubilization and ACCD activity.
- High As removal and bioaccumulation of AS6 confirmed from various *in vitro* studies.
- It improved rice seedling growth under As(V)-spiked soil by reducing phytotoxicity.

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ABSTRACT

The biological agents have been utilized as an affordable alternative to conventional costly metal remediation technologies for last few years. The present investigation introduces arsenic (As) resistant plant growth promoting rhizobacteria (PGPR) isolated from the As-contaminated agricultural field of West Bengal, India that alleviates arsenic-induced toxicity and exhibited many plant growth promoting traits (PGP). The isolated strain designated as AS6 has identified as *Bacillus aryabhattai* based on phenotypic characteristics, physio-biochemical tests, MALDI-TOFMS bio-typing, FAME analysis and 16S rDNA sequence homology. The strain found to exhibit five times more resistance to arsenate than arsenite with minimum inhibitory concentrations (MIC) being 100 mM and 20 mM respectively. The result showed that accumulation of As was evidenced by SEM- EDAX, TEM-EDAX studies. The intracellular accumulation of arsenic was also confirmed as in bacterial biomass by AAS, FTIR, XRD and XRF analyses. The increased rate of As (V) reduction by this strain found to be exploited for the remediation of arsenic in the contaminated agricultural field. The strain also found to exhibit important PGP traits viz., ACC deaminase activity (2022 nmol α-ketobutyrate/mg protein/h), IAA production (166 μg/ml), N_2 fixation (0.32 μgN fixed/h/mg proteins) and siderophore production (72%) etc. Positive influenced of AS6 strain on rice seedlings growth promotion under As stress was observed considering the several morphological, biochemical parameters including antioxidants activities as compared with an uninoculated set. Thus this strain might be exploited for stress amelioration and plant growth enhancement of rice cultivar under arsenic spiked agricultural soil.

1. Introduction

Arsenic is a toxic metalloid caused serious health problems were described as "the greatest mass poisoning in human history" by World Health Organization (WHO, 2001) and recognized as "Class-1 human carcinogen" by the USEPA (United States Environmental Protection Agency) as a global concern (Ng et al., 2003). In the periodic table, Arsenic (As) belongs to a group 15, period 4, P block

Abbreviations: MALDI-TOFMS, Matrix assisted laser desorption ionization-time of flight mass spectrometry; FAME, Fatty acid methyl ester; SEM, Scanning electron microscopy; TEM, Transmission electron microscopy; EDAX, Energy dispersive X-ray spectroscopy; FTIR, Fourier transform infrared spectroscopy; XRF, X-ray fluorescence.

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Chapter 3
Role of ACC Deaminase as a Stress Ameliorating Enzyme of Plant Growth-Promoting Rhizobacteria Useful in Stress Agriculture: A Review

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Abstract The crop production is inhibited by a large number of both biotic and abiotic stresses. These stresses include presence of toxic heavy metals, high salt, flood, drought, temperature, wounding, various pathogens, etc. The agricultural production was intensified by management of these stresses with increased use of chemicals, and it needs more attention for incoming population explosion. These chemical inputs caused several harmful effects on the environment and sustainable agriculture. It is ne3cessary to decrease dependence of chemical input for sustainable agriculture with a holistic approach and also essential for environmental protection. One such possible approach is the use of 1-aminocyclopropane-1-carboxylate (ACC) deaminase-producing plant growth-promoting rhizobacteria (PGPR) to protect the crop plants from the harmful effects of both biotic and abiotic stresses. The enzyme ACC deaminase (EC 4.1.99.4) regulates stress ethylene production by catalysing ACC into α-ketobutyrate and ammonia. Various research works have documented the application of ACC deaminase-producing PGPR under both normal and stressed conditions responsible for the increased growth, health and productivity of crop plant. These beneficial rhizobacteria may decrease the dependence on agrochemicals (fertilizer and pesticides) to stabilize the agroecosystems and maintained sustainable agriculture. Different biochemical and biophysical properties of this enzyme and its regulation have been briefly described. This review also describes the role of ACC deaminase enzyme in plant growth and production by ameliorating different stress conditions including heavy metal, salinity, drought, flood, temperature, etc. Finally, the latest paradigms for useful application of ACC deaminase-containing plant growth-promoting rhizobacteria in different agroecosystems have been discussed comprehensively under stress conditions to highlight the recent scenario with the aim to develop future insights.

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