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Case Report

Archaea Endowed with Plant Growth Promoting Attributes

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Abstract

The archaea are ubiquitous in extreme habitat and have been firstly reported from only in harsh environments, such as hot springs and salt lakes, but due to metagenomic, it revealed that archaea found in a broad range of habitats, including soils, oceans, and marshlands. Archaea are a major part of Earth's planets and may play roles in C-cycle and N-cycle. The archaea belonged to mainly two phyla Euryarchaeota and Crenarchaeota, other groups have been tentatively created such as Nanoarchaeota and Korarchaeota, which contains a small group of unusual thermophilic species that shares features of both of the main phyla of Euryarchaeota and Crenarchaeota. Microorganisms, particularly eubacteria and fungi are known to play an important role in biogeochemical cycling and making available important nutrients like N, P, K, Fe and Zn to the plants through fixation, solubilization or mobilization of nutrients. However, the role of archaea, that inhabits extreme environments, comprises more than 20% of the world' biomass has not been well studied. There are few reports on plant growth promoting archaea including phosphorus solubilization, nitrogen fixation, siderophore production and Indole acetic acids production. Plant growth promoting attributes found in different archaea including *Natrialba, Natrinema, Halolamina, Halosarcina, Halostagnicola, Haloarcula, Natronoarchaeum, Halobacterium, Halococcus, Haloferax* and *Haloterrigena*. Due to unique adaptation to drastically varying ecosystems, archaea have special interest of potential biotechnological application in agriculture, medicine and industry.

Keywords: *Archaea; Extreme Environments; Microbiome; Plant Growth Promotion*

Introduction

Extreme environments are one of the most suitable niches for extremophilic microbes, in which archaea have been reported worldwide from hypersaline, thermal springs and cold environments. On the basis of their physiological characters the archaea have been grouped in different phyla namely Euryarchaeota, Crenarchaeota, Nanoarchaeota and Korarchaeota. Archaea exist in a broad range of habitats, and as a major part of global ecosystems, may contribute up to 20% of Earth's biomass [1]. Hypersaline habitats are extreme environments which are dominated by haloarchaea that required a minimum of 9% (w/v) (1.5 M) NaCl for growth [2]. Most of species in Halobacteriaceae are true extreme halophiles according to Kushner [3], however, Halobacteriaceae contains some species which can grow in low salinity for instance, *Haloferax sulfurifontis* [4], *Haladaptatus paucihalophilus* [5] and *Halosarcina pallida* [6]. Archaea have been reported as ubiquitous and present in a wide range of environments from hypersaline regions. Many species of haloarchaea of halobacteriaceae family have been isolated from hypersaline environments including *Haloarcula, Halobacterium, Halococcus, Haloferax, Halolamina, Haloplanus, Halorubrum, Halostagnicola , Haloterrigena, Natrinema, Natronoarchaeum* and *Natronorubrum* [1-9].

Of the numerous species of Archaea, thermophilic and hyperthermophilic archaea, specifically crenarcheotes in the class Thermoprotei, are known to inhabit environments such as hot springs, ocean vents, and geysers which are uncongenial to many other forms of life. Now day biotechnological interest on thermophilic archaea is due to their unique adaptability to high temperatures. The thermophilic archaea have possible adaptations to high temperatures due to presences of ubiquitous topoisomerase reverse gyrase, ether-linked L-lipids membranes and the high number of modified nucleosides. The different species of thermophilic archaea including *Acidianus infernus, Archaeoglobus fulgidus, Methanobacterium thermoautotrophicum, Methanothermus fervidus, Pyrobaculum islandicum, Pyrodictium occultum, Sulfolobus solfataricus, Thermodiscus maritimus, Thermoplasma acidophilum*, and *Thermoproteas neutrophilus* have been reported from hyperthermal regions [10-14]. More than 80% of the earth's biosphere is permanently low temperature (< 5°C). From cold environments, psychrophilic Archaea, cold-loving organisms that inhabit areas at temperature near the freezing point of water have been reported. There were many reports on psychrophilic bacteria and fungi isolated from low temperature habitat worldwide [15-25], but there are very few reports on psychrophilic archaea [26,27].

The microbiome from diverse ecosystem including different extreme environments of temperatures, salinity, acidic, alkaline and drought as well as associated with different crops growing in normal and at diverse abiotic stress condition as epiphytic, endophytic and rhizospheric have been reported and characterized for sustainable as agricultures as well as for different biotechnological application in medicine and industrial processes. Microorganisms, particularly eubacteria and fungi are known to play an important role in biogeochemical cycling and making available important nutrients like N, P and K to the plants through fixation, solubilization or mobilization of nutrients. Plant growth promoting (PGP) microbes promote plant growth and development directly or indirectly, either by releasing plant growth regulators/phytohormones; solubilization of phosphorus, potassium and zinc; biological nitrogen fixation or by producing siderophore, ammonia, HCN and other secondary metabolites which are antagonistic against pathogenic microbes [17,28-32]. However, the role of archaea, that inhabits extreme environments, comprise more than 20% of the world' biomass and are among the most primitive and ancient life forms on earth, in biogeochemical cycling and in sustenance of vegetation in saline environments have not been studied. Few reports are available for archaea as plant growth promoting, which includes phosphorus solubilization by haloarchaea [8], nitrogen fixation by methanogens [33], siderophore production [34] and IAA production [35].

P-solubilizing halophilic archaea have been isolated from halophilic plants (*Abutilon, Cenchrus, Dicanthium, Sporobolous* and *Suaeda nudiflora*) from hypersaline regions of Rann of Kutch. The isolated halophilic archaea have been identified using 16S rRNA gene sequencing as *Natrialba, Natrinema, Halolamina, Halosarcina, Halostagnicola, Haloarcula, Natronoarchaeum, Halobacterium, Halococcus, Haloferax* and *Haloterrigena*. The identified haloarchaea have been characterized for P-solubilization using Haloarchaea P Solubilization (HPS) medium and found that *Natrinema* sp. and *Halococcus hamelinensis* solubilized phosphorus 134.61 mg/L and 112.56 mg/L respectively. Haloarchaea solubilized the mineral phosphate by the production of production of organic acids (gluconic, 2-ketogluconic, citric, oxalic, lactic, isovaleric, succinic, glycolic and acetic acids). Production of organic acids results in the lowering of pH in the surroundings and it suggests a positive correlation between lowering of pH and mineral phosphate solubilization. These P-solubilizing halophilic archaea may play a role in P nutrition to vegetation growing in hypersaline soils [8].

Conclusion and Future Prospect

The archaea are ubiquitous in extreme environment and have been reported from hypersaline, high temperature and low temperature environments. There are only few reports on plant growth promoting activity by halophilic and thermophilic archaea isolated from hypersaline soil and thermal springs respectively. The archaea isolated from diverse extreme environments were found to play role in adaptation in extreme habitat. Due to unique adaptation to drastically varying ecosystems have special interest of potential biotechnological application in agriculture, medicine and industry. Archaea from extreme environments could be applied as plant growth promoters for crops growing in varying extreme habitat.

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Competing Interests

The authors declare no conflict of interest.

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