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Stress Adaptive Phosphorus Solubilizing Microbiomes for Agricultural Sustainability

Divjot Kour[1], Ajar Nath Yadav[2]

Phosphorus (P) is one of the essential macronutrients making up about 0.2% of plant dry weight. At the same time, it is the most limiting macronutrient after nitrogen for plant growth. On occurrence of the abiotic stress, the availability and uptake of the phosphorus for the plants further decreases. There are diverse groups of the plant and soil associated microbes which possess the ability to release phosphates from sparingly soluble mineral phosphates. Thus, they play major roles in providing the plants with the phosphorus. P-solubilizing microbes have been isolated and reported from stressed environments which included diverse genera of *Acinetobacter*, *Aspergillus*, *Bacillus*, *Penicillium*, *Pseudomonas, Streptomyces* and *Trichoderma*. The use of the P-solubilizers as bioinoculant in agricultural systems is an important approach to circumvent the application of the harmful chemical fertilizers. The implementation of novel technologies is important for the development P-biofertilizers.

Phosphorus is a vital macronutrient for life on the earth as well as for the plants. It plays diverse roles in the plants. It is chief element with a major role in the processes including respiration and photosynthesis. It is well known for its involvement in the biosynthesis of the nucleic acids and membranes. Phosphorus is the chief regulator of the several enzymes. Phosphorus is taken up by the plants as orthophosphate, and this has been a thoroughly studied aspect of plant nutrition. Phosphorus is the most limiting macro element thus affecting productivity in both natural and agricultural systems. Limitation of plant productivity due to phosphorus is well known and expected to increase in future. Thus, to sustain crop growth and productivity, large amounts of phosphatic fertilizers have to apply for higher crop yield to feed the increasing population. On contrary, with increasing the application of phosphatic fertilizers, plant P efficiency in general declines, which results in P losses to the environment with negative outcomes for ecosystems [1].

The occurrence of the abiotic stress such as alkalinity, sodicity, drought, temperature, and heavy metals are a great threat to agriculture sustainability. The increasing intensification of agriculture and other anthropogenic activities, area of agricultural lands having salinity, alkalinity and water stress problems is constantly increasing. The abiotic stress is further known to decrease the availability and uptake of the nutrients in addition to making the soil deficient in Ca, Fe, N, Zn, and available P [2]. The stress adaptive P-solubilizing microbes play major roles in enhancing the efficiency of soil and promoting the plant growth by different mechanisms under abiotic stress conditions. Thus, increasing the bioavailability of phosphorus for plants in a sustainable way is the major goal of the agriculture. P-solubilizing microbes (PSMs) are gaining attention due to low cost, high efficiency and eco-friendliness.

P-solubilizing microbial communities have been reported from rhizosphere, phyllosphere and internal tissue of the plants as well as the bulk soil [3, 4]. P-solubilizing microbes belong to diverse phyla such as Proteobacteria, Mucoromycota, Firmicutes, Euryarchaeota, Basidiomycota, Bacteriodetes, Ascomycota, and Actinobacteria [5]. P-solubilizing archaea have been reported first time by Yadav et al. [6]. P-solubilizing microbes have been reported from salinity stress [7, 8]; cold stress [9];

[1]Department of Microbiology, Akal College of Basic Sciences, Eternal University, Baru Sahib, Sirmour-173101, India.

[2]Microbial Biotechnology Laboratory, Department of Biotechnology, Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Sirmour, Himachal Pradesh, India.
Email: ajarbiotech@gmail.com

high temperature stress [10]; drought stress [11, 12] and heavy metal stress [13, 14]. Some studies reported the efficiency of P-solubilizers on quantitative basis under normal and stressful environment.

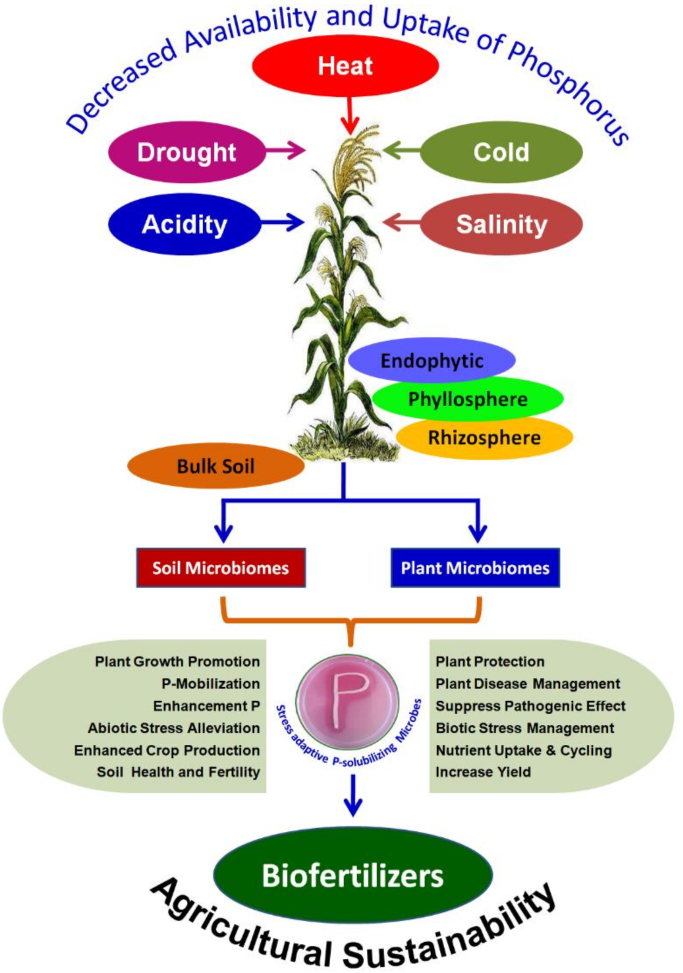

Fig. 1: Role of stress adaptive P-solubilizing microbes in agricultural sustainability.

The key mechanism for mineral phosphate solubilization in Gram-negative bacteria is known to involve direct oxidation of glucose to gluconic acid [15]. The biosynthesis of gluconic acid is carried out by the glucose dehydrogenase (GDH), a quinoprotein enzyme and requires pyrroloquinoline quinone (PQQ) as redox co-factor. The production of gluconic acid along with other organic acids for solubilization of phosphorus has been reported in haloarchaea [6]. Stress adaptive and P-solubilizers promote plant growth under diverse environmental conditions by producing auxins, 1-aminocyclopropane-1-carboxylate (ACC) deaminase, hydrolytic enzymes, ammonia, HCN, and siderophores; solubilizing other micro and macro nutrients, fixing the atmospheric nitrogen [16]. These mechanisms protect the plants from abiotic stress and as a result enhance crop sustainability.

The use of P-solubilizing microbes as biofertilizers is a promising approach to improve food production and crop yields. Inoculations with P-solubilizers have been reported to improve the plant growth. The lessening of the harmful effects of drought stress with treatment of drought adaptive and P-solubilizing microbes has been reported in foxtail millet, great millet and wheat [11, 12, 17]. Thus, P-solubilizing microbes are efficient bioresources to reduce the dependence on chemical P fertilizers. They can be used as inoculants in agricultural systems to boost up the fertility of the soil. Novel P-solubilizers can be explored and screened for multifarious PGP characteristics under normal and diverse stress conditions. Stress adaptive P-solubilizers possessing multiple PGP traits can be utilized as bioinoculants under different climatic conditions by conducting extensive pot and field trials. Based on the scientific literature and ongoing research in this field, safe and healthy products of P-solubilizing microbes are expected in future.

CONFLICTS OF INTEREST

Author declares that there are no conflicts of interest.

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