Editorial

Journal of Applied Biology & Biotechnology
Vol. 11 (02), pp. i-iv, 2023
Available online at https://www.jabonline.in/
DOI: 10.7324/JABB.2023.112ed

Minerals Solubilizing Microbes for Agricultural Sustainability

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Microbes, the wonder organism of the world are known to play several essential roles in the environment such as nutrient cycling through weathering of rocks, degradation of the decay matter, functioning biogeochemical cycles and plant growth promotion. The beneficial microbes from diverse habitats have diverse applications in various sectors including medical, agriculture, and industries. In agriculture, microbes associated with plants and soil have been known to improve the host growth directly via availing the nutrients and plant growth regulators; and indirectly by protecting the plants from invaders like insects, and microbial pathogens. The microbes undergo various mechanisms to promote the plant growth including minerals solubilization. Solubilization is the process through which plant avails the soluble form of minerals like phosphorus (P), potassium (K), zinc (Zn), and selenium (Se) through insoluble form conversion using diverse mechanisms. The conversions of inslublie form into soluble form have been done soil and rhizospheric microbes by secreting of special compounds such as organic acid, exopolysaccharides and different enzymes. The use of mineral solubilizing microbes in the agricultural farms as biofertilizers could be play pivotal role in the plant growth promotion for agricultural as well as environmental sustainability.

Minerals are naturally occurring elements in the Earth's crust. The nutrients are essential for plant growth promotion and protection in natural as well as in biotic/abiotic stress conditions. The macronutrients (N, P, and K) are required in large quantities, while micronutrients (Zn, Fe, Se, Mn, B, and Mo) are required in lesser amounts. Minerals are found in soil in different chemical forms organic and inorganic those are unavailable to plants. The minerals present in the soil, differ on the basis of time and extent of pedogenesis, origin of parent material, vegetation cover on soil and pH of soil [1]. The available minerals for plant growth are the less in amount. The un-available form of minerals could be converted into available forms using diverse minerals solubilizing microbes by diverse mechanism of solubilization (Figure 1). The present scenario the scientists have developed a new strategy to increase the minerals in the soil in which bio-inoculants of mineral solubilizing microbes are the best option to increase plant growth, crop yields and soil fertility [2, 3].

Worldwide nutrient deficiencies are likely to occur sooner than generally expected. Such reduction will have an impact on crop yields, livestock and human health. Deficiencies can also affect plants, when the growing environments are unfavorable and plants are unable to absorb the nutrients available in the soil. In highly acidic or alkaline environments, dryness and waterlogging, plants may have trouble absorbing soil nutrients. Depletion in the soil for minerals deficiency could result in reduced crop yields [4]. A deficiency or imbalance of essential nutrients will prevent plants from growing and producing. The plant's ability to defend itself could be also being negatively affected, resulting in decreased resistance to pests and diseases. The deficiency of minerals (N, P, K, Mn, K, Zn, Fe, Mg, and S) in plant can cause various problems like stunt the plant growth by inhibiting the root system and flowering, shortening of internodes, lowering the yield of the crops, photosynthesis reduction, blackening of some tubers like potato, and scorching of all small grains, chlorosis and spotted refers to a surface that has colored spots (anthocyanin develops). Therefore, as the severity of the deficiency develops, potassium deficiency symptoms usually begin on the lower leaves of the plant and move upward [5].

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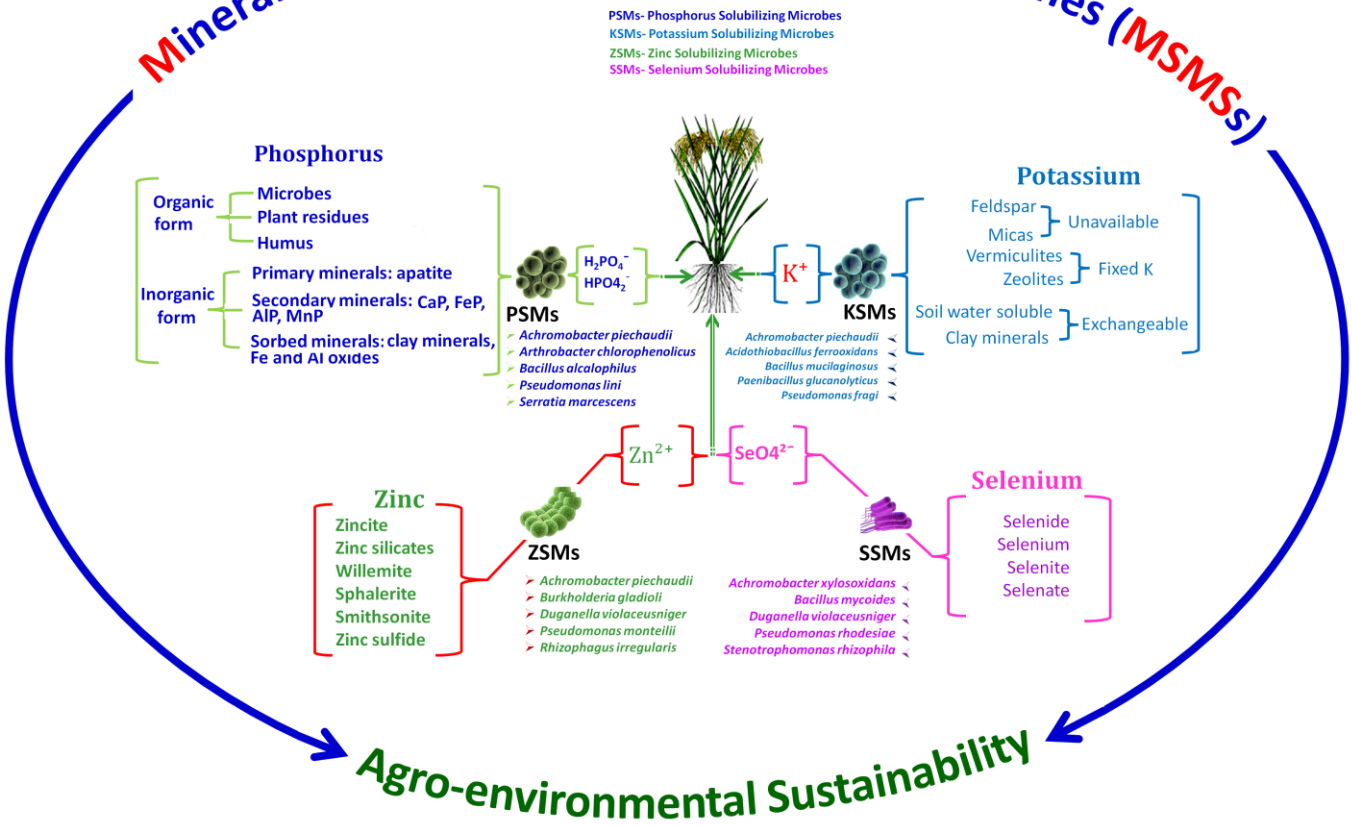

Figure 1 Mineral solubilizing and mobilizing microbes for agro-environmental sustainability. Adapted with permission from Devi et al. [11].

The most common symptom of mineral deficiency is chlorosis (yellow scorching or firing along the edge of the leaf). In this situation mineral deficiency affects older leaves and lower leaves first before spreading to newer leaves. Minerals play significant role in root and shoot development, so plants that are deficient in minerals stunt new growth and reduce food yields due to which the plant becomes very weak and the yield decreases [6, 7].

Mineral solubilizing microbes exhibit various numbers of mechanisms, which enhances the growth of plant directly and indirectly. Solubilization is the main mechanism that mineral solubilizing microbe's exhibits in which several nutrients such as P, K, Zn, Se and silicon are converted from insoluble to soluble form [8, 9]. The solubilization further achieved through the production of pH lowering compounds including organic acid such as α-ketogluconic acid, acetic, oxalic, fumaric acid, formic acid, carboxylic acid, glyoxalic acid, gluconic acid, lactic acid, malic acid, pyruvic acid, propionic acid, succinic acid and tartaric acid [8]. Mineral solubilizing microbes also produced exopolysaccharides which is a complex blend of biopolymers consisting of polysaccharides, along with lipids, nucleic acids, humic substances and proteins. Another mechanisms of solubilization is enzymolysis, in which various types of enzymes are produced by microbes, which helps in forwarding the solubilization reactions [10]. Other than solubilization mineral solubilizing microbes also helps in the mineralization (conversion of organic form of nutrients to inorganic form) and mobilization (helps plant to uptake the solubilized nutrients) of the nutrients [11]. Mineral solubilizing microbes exhibits other plant growth promoting mechanisms other than solubilization i.e. nitrogen fixation, chelation of iron (siderophores), and production of plant growth promoting regulators (PGPRs) i.e. phytohormones such as auxin, cytokinin and gibberellic acid, that enhances the growth of plant directly via supplying the required nutrients [12]. Indirectly mineral solubilizing microbes enhances the plant growth through the mechanism such as production of hydrogen cyanide, ammonia, hydrolytic enzymes such as amylase,

chitinase, xylanase, cellulase, protease, and pectinase that helps in protecting the plants from invaders and pathogens which cause various diseases to the plants. The mineral solubilizing microbes have been also known for exhibiting the 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase attributes, which helps plant to survive in the harsh abiotic stress such as drought, salinity, extreme temperatures, alkalinity and acidity [13, 14].

The plants are sensitive to environmental changes. Many biotic and abiotic factors have a significant impact on their growth and development. Diverse microbial communities found in soil help plants flourish even in unfavourable environmental conditions [15]. This beneficial and climate-resilient plant-microbe interaction maintains that plant growth is unhindered by biotic and abiotic stress conditions [16]. The soil microbiome aids in reducing a variety of abiotic and biotic stresses, improving phytoremediation effectiveness, boosting plant development, easing metal stress, and lowering metal phytotoxicity. As a result, the natural microbial communities that thrive inside the soil ecosystem help to enhance the sustainability of the agriculture sector. Bioformulations are any biologically active chemicals created from microbial biomass or products containing microbial metabolites that could be utilized to promote plant growth, acquire nutrients, and treat disease in an environmentally friendly manner. Biofertilizers could be used for the encouragement of plant development, the eradication of phytopathogens, the maintenance of soil fertility, and the eradication of disease. Bioformulated solutions offer environmentally friendly alternatives to traditionally used chemical fertilizers and pesticides [17].

Sustainability of environment is one of the core agenda of the worldwide scientists due to the deteriorated environmental health, which is the result of industrialization, anthropogenic activities of humans and chemical utilization in agricultural farms. Many alternatives have proposed in past few decades to solve the problems environment and utilization of microbes have known as appropriate alternative so far. Microbes have been known to be used in the various sectors including agriculture. In agriculture microbes could be used as substitute of the chemical based fertilizers and pesticides as they are known to promote the growth of plant directly and indirectly through various mechanisms including solubilization of minerals. Mineral solubilizing microbes are solubilizes the convert the minerals from its insoluble to soluble form which could be used by the plants for its growth. The utilization of mineral solubilizing microbes is a sustainable method for the production of food to feed the ever growing population. In future, more studies could be conducted to on the different mineral solubilizing microbes from various part of globe and could be applied in the agricultural farms.

CONFLICTS OF INTEREST

Author declares that there are no conflicts of interest.

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How to cite this article:

Yadav AN. Minerals Solubilizing Microbes for Agricultural Sustainability. J Appl Biol Biotech. 2023; 11 (02), i-iv.