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Potassium Solubilizing Bacteria (KSB) A Viable Option For Sustainable Agriculture

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Abstract

After nitrogen and phosphorus, potassium is the third most important nutrient for plants, plays a vital function in plant metabolism. In soil, potassium is found in the forms of available, fixed, interlayer and mineral, despite the fact that K is a plentiful element in soil, only 1–2% of its total amount is available to plants. Potassium-solubilizing bacteria are bacteria that are engaged in the solubilization of potassium from K-bearing materials (KSB). The most important mechanisms known in K mineral solubilization by KSB are (i) by lowering the pH, (ii) by enhancing chelation of the cations bound to K and (iii) acidolysis of the surrounding area of microorganism. The present article highlights the importance of KSB for enhancing crop production. The mechanisms used by KSB for K solubilization have been discussed.

Keywords Insoluble K, Microorganisms, K solubilization, Chelation

Introduction

The global population is growing at an alarming rate, necessitating a massive increase in food production to feed this growing population. Intensification of agriculture have made the farmers to use increasing amounts of chemical fertilizers particularly NPK to overcome deficiencies and improve the yields. World average fertilizer consumption of NPK is 136.82 kg/ha, whereas in India is 175 kg/ha. When these chemical fertilizers were first introduced to agriculture in the last century, they solved the majority of the challenges associated with increasing yields. However, in this century, its widespread usage has had negative consequences for soil, water, and the environment, ultimately affecting human health. New technology is being developed these days to boost crop output while reducing the need of chemical fertilizers. In this scenario soil-plant-microbes interactions play an important role in improving crop productivity on sustainable basis.

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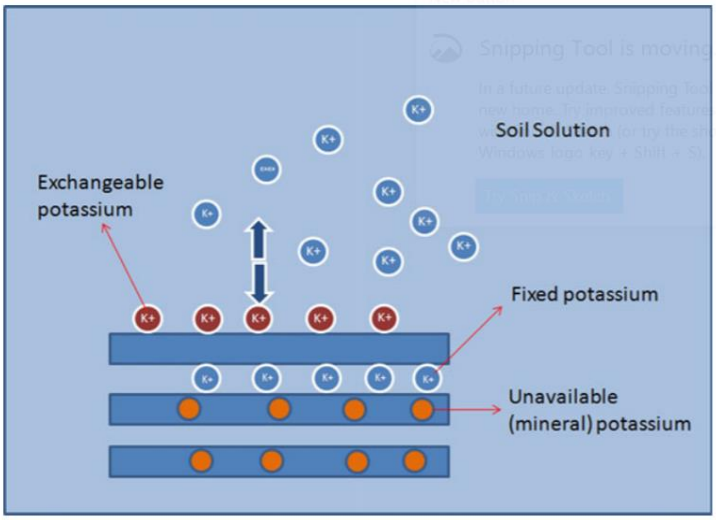
Need for potassium solubilizing bacteria (KSB)

After nitrogen and phosphorus, potassium is the third most important nutrient for plants. It plays a vital function in plant metabolism by triggering the majority of the enzymes involved in plant physiology. Potassium deficiency, impairs plant physiology, resulting in poor growth and development as well as lower yields. Plants' immune system are also disrupted, making them more susceptible to disease and pest attack.

K is the seventh most abundant element in Earth's outside layer. In soil, potassium is found in the forms of available, fixed, interlayer and mineral K. Total K concentration in soils varies between 0.04 and 3% (0.4 to 30 g K kg1 soil). Despite the fact that K is a plentiful element in soil, only 1–2% of its total amount is available to plants. Feldspar, mica, muscovite, biotite, orthoclase, illite, vermiculite, and smectite are the most common K-bearing minerals. These minerals supply slowly available K to plants.



Potassium fractions in the soil (Sharma *et al*., 2016)

Use of potassium fertilizers to supplement available K in agricultural systems is a common practice these days. Potash fertilizers on the global market are expensive, which raises input costs and reduces agricultural profitability. By solubilizing these minerals, the amount of K available from them can be increased. In this context, the role of KSB in modern agriculture is becoming increasingly important for long-term crop productivity. Potassium-solubilizing bacteria are bacteria that are engaged in the solubilization of potassium from K-bearing materials (KSB). In soil, they have the ability to transform insoluble/mineral K into available K. A large number of these bacteria live in the rhizosphere and improved plant growth by a number of mechanisms. Some examples of K solubilizers include *Bacillus*

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mucilaginosus, Burkholderia, Enterobacter hormaechei, Arthrobacter spp. *Paenibacillus mucilaginosus* and *Paenibacillus glucanolyticus.* They are also able to decompose organic matter so play an important role in nutrient recycling.

Mechanisms of KSB

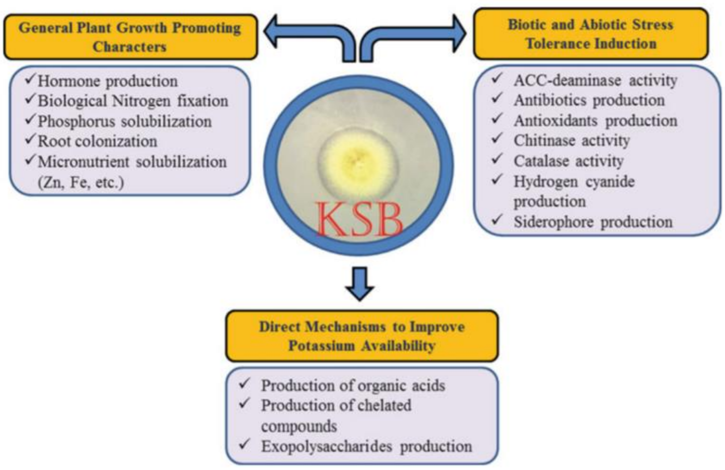
The major mechanism of K mineral solubilization, similar to that of P mineral solubilization, is the of by production organic and inorganic acids and production of protons (acidolysis mechanism) which are able to convert the insoluble K (mica, muscovite, and biotite feldspar) to soluble forms of K, easily taken up by the plant. The types of various organic acids such as oxalic acid, tartaric acids, gluconic acid, 2-ketogluconic acid, citric acid, malic acid, succinic acid, lactic acid, propionic acid, glycolic acid, malonic acid, fumaric acid, etc. have been reported to be released by KSB, which are effective in releasing K from K-bearing minerals. Among the different organic acids involved in the solubilization of insoluble K, tartaric acid, citric acid, succinic acid, α-ketogluconic acid, and oxalic acid are the most prominent acids released by KSB.

In addition to decreasing soil pH organic acids produced by KSB can release K ions by chelating (complex formation) Si^{4+}, Al^{3+}, Fe^{2+}, and Ca^{2+} ions associated with K minerals. It also produces various extracellular polymers (primarily proteins and polysaccharides) can also help in releasing of K from K bearing minerals. The most important mechanisms known in K mineral solubilization by KSB are (i) by lowering the pH, (ii) by enhancing chelation of the cations bound to K and (iii) acidolysis of the surrounding area of microorganism.

Role of KSB in plant growth

Because of the availability of high-yielding crop types and increased agricultural intensification, soil K stocks are depleting at a faster rate. Microbial inoculants ready to release K from silicate have the impact on plant development parameters, yield, and K take-up through plants. The microbial inoculant boosted biomass yield both directly and indirectly by solubilizing soil K reserves and inducing greater plant development. These bacteria are also important for plant growth promotion since they protect plants from infections and stress. KSB greatly improved plant growth and soil nutrient levels. Furthermore, they are known to release amino acids, vitamins, and growth-promoting chemicals like as indole-3-acetic acid (IAA) and gibberellic acid (GA3), which aid in plant growth.

Direct and indirect mechanisms used by KSB (Ahmad *et al*., 2016)



Conclusion

KSBs play the most important role in the environmental sustainability by providing essential nutrients from primary minerals that are required for plants and to maintain soil health and quality.

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