Towards the Soil Sustainability and Potassium-Solubilizing Microorganisms

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Abstract

Potassium (K) is needed in adequate quantities for a crop to achieve its maximum yield. The function of potassium in plant growth has not been clearly defined but it is associated with movement of water, nutrients and carbohydrates in plant tissue. When potassium is not adequate, the plants will have poor root development and will grow slowly, and their seeds will become small and have lower yields. About 5 million tonnes of potassic fertilizer requirement would be fulfilled through imports because India does not have commercial-grade sources of potash reserve. India is totally dependent on the import of potassic fertilizers. On the other hand, India has the largest reserve for low potassium-containing minerals. The depletion of potassium in soil has been started, and in future this will aggravate. In most of the soils, about 90–98 % of total K exists in relatively unavailable minerals such as feldspar, orthoclase and the micas (muscovite, biotite, phlogopite, etc.). These minerals are very resistant to decomposition and probably supply relatively smaller quantity of potassium to growing crops. Potassium in soil is present in four forms: water-soluble (solution K), exchangeable, non-exchangeable and structural or mineral forms. The fixed form of K minerals is solubilized by K solubilizers, and then acquisition or accumulation of potassium by crop plants certainly will be enhanced. For evergreen agriculture, production can only be fulfilled when the environment, its caretakers and surrounding communities are healthy, for this application of KSMs holds a key

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approach for K availability in soils. KSB increased K availability in soils and increased mineral nutrient specially K uptake by plant.

Keywords
KSMs • Biodiversity • Genetic modification • Agriculture • Soil sustainability

18.1 Introduction

Ensuring food security for burgeoning population requires additional food grain production from the same land and this is obviously fulfilled by the green revolution. Food grain production potential of the soil increases. Which is very impressive but with insufficient concern for environment and soil sustainability. It is a great challenge in date to search for sustainable strategies to alleviate detrimental effects of intensive farming practices based on chemical input. Use of soil microorganisms for sustainable agriculture has increased in various parts of the world because of the negative environmental impact of chemical fertilizers and their increasing costs during the last couple of decades. Now the government of India has been trying to promote an improved practice involving the use of biofertilizers/bio-organics together with chemical fertilizers. Nowadays, in a developing country like India, where land-person ratio is rapidly narrowing, the only means of meeting the needs of agricultural produce is through increasing productivity without harming the environment and agricultural sustainability. Fertilizers, therefore, assume a great significance and constitute one of the key inputs for achieving high productivity (Meena et al. 2013; Singh et al. 2015). Nowadays, chemical fertilizer has started to show side effects on human, soil, as well as environment due to their imbalanced application in crops. Among the chemical fertilizers, potassium is an important primary element which is utilized for many cereals, vegetables and fruits and being added to the soil as potassium sulphate or potassium chloride (Grayston et al. 1996; Khan et al. 2009; Li et al. 2003; Lopes-Assad et al. 2010).

Soils are store house of microorganisms of multiple natures and have been benefiting the vegetation without any care by human being. Many of them such as N_2 fixers, P solubilizers and organic matter decomposers have been explored for beneficial use in agriculture for plant nutrient acquisition. There are so many potassium-solubilizing bacteria that are in soil which vary in their nature and activities (Gromov 1957; Norkina and Pumpyansakya 1956). Indian farmer's economic condition is not so good. Sustainable agriculture is the process in which economically viable, environment-friendly and socially acceptable technology is used for enhancing agricultural productivity and soil fertility. For sustainability, agriculture can do in long run when the farmers and surrounding communities are healthy without degrading environment.

A good soil means it feels soft and crumby, it has high nutrient-supplying capacity, it is rich in nutrient, it has good water storage and drainage capacity, it has resistance to erosion and nutrient loss, it has good amount of soil microorganisms, its productivity is good, and it produces healthy and quality crops (Doran 1994).

Extensive use of chemical fertilizers caused ecological imbalance, environmental pollution and hazards to soil health. Microbial inoculants are now becoming more popular in India and abroad as they are inexpensive and simple to use and have no side effects. Therefore, the use of efficient strains of biofertilizer microorganisms plays a vital role in agriculture and ecosystems. Enhancement in productivity of cereals, pulses and vegetables has been reported by Maurya et al. (2014), Meena et al. (2014a) and Verma et al. (2013).

In India, the total potassium fertilizer requirement is nearly about 5 million tonnes and totally made through imports, because India does not have commercial-grade rock for K fertilizer making (Goteti et al. 2013). Nowadays, the use of efficient rhizospheric microorganisms may offer plant growth promotion and agronomic, pathogenic and environmental benefits for intensive agricultural systems. The plant growth-promoting microorganisms (PGPMs) exhibit a gradual increase in demand in the world market. One possible mechanism for the effectiveness of biofertilizers, such as mobilization of sparingly available potassium (Meena et al. 2013; 2015a; Maurya et al. 2014), is its capacity to produce plant growth-promoting substances, which enhanced/induced resistance to environmental stress. In some cases, it reduces the direct or indirect infection of plant pathogenic microorganisms. Ecofriendly agricultural system has emerged as an important priority area globally in view of the growing demand for safe and healthy food and long-term soil as well as environmental sustainability and concerns on environmental pollution associated with the indiscriminate use of agrochemicals (Milic et al. 2004). These efficient microorganisms play a very important role as the component of the biological soil phase and also as indicator of soil fertility and soil degradation (Kim et al. 1998).

India is promising to have the world's enormous accumulation of mica distributed in Bihar, Jharkhand, Rajasthan and Andhra Pradesh. During the dressing of raw mica mined from mica mines located in these districts, a huge amount of waste mica are produced (about 75 % of total mined mica), and it contains 8–12 % K_2O that may be used in agriculture as a source of potassium which increases the crop production significantly (Nishanth and Biswas 2008; Meena et al. 2015b).

18.2 Need of Potassium-Solubilizing Microorganisms (KSMs) in K Nutrition

Plants can take up potassium only from the soil solution. Its availability is totally dependent upon the K dynamics as well as on total K content. Most of the Indian soils are rich in potassium. However, as a result of increase in crop yield due to rapid development and the use of modern intensive agriculture in the world and India, in particular, soil nutrient levels have dropped due to mining through crop removal without replenishing soil through fertilizer. Soil potassium and fertilizer deficiency is the major problem in the future for the development of Indian agriculture (Sheng and Huang 2002). Overuses of chemical fertilizers in crop production are costly as well as different unpropitious consequences like soil degradation and inconsistency in plant nutrition. Now is the time to develop reasonable, effective and ecofriendly nutrient sources which work without disturbing the environment (Aleksandrov 1958; Barre et al. 2008).

Bio-intervention of waste mica with potassium-solubilizing microorganism could be the alternative and viable technology to solubilize insoluble K in mica into plant-available pool and used efficiently as a source of K fertilizer for sustaining crop production and maintaining soil K (Basak and Biswas 2009). Research carried out earlier reported that some microorganisms in the soil are able to solubilize unavailable forms of K-bearing minerals such as micas, illite and orthoclases by excreting organic acids (Friedrich et al. 1991; Ullaman et al. 1996; Bennett et al. 1998).

Right now satisfied species of microorganism are extensively used which have unique properties to provide natural products and can be used as chemical fertilizer substitutes. Injudicious use of chemical fertilizer increases the cost and decreases the efficiency of K fertilizer, ruining the environment (Zhang et al. 2013). The alternative of the chemical/mineral potassium fertilizer is necessary for the evergreen agriculture/sustainable agriculture. In India, it is estimated that by 2020, for fulfilling the targeted production of about 325 million tonnes of food grain, the requirement of nutrient will be about 29 million tonnes, while their availability will be only about 21.6 million tonnes, having a deficit of about 7.4 million tonnes (Uroz et al. 2009). Therefore, the application of potassium-solubilizing microorganisms may be a promising approach for increasing K availability in soils.

Their use in agriculture can reduce the use of chemical fertilizer and support ecofriendly crop production (Meena et al. 2014a; Berthelin and Leyval 1982; Bennet et al. 2001; Deshwal and Kumar 2013).

Besides the above facts, the long-term use of biofertilizers is cheap, ecofriendly, effective, productive and approachable to farmers over chemical fertilizers (Subba 2001). Potassium constitutes about 2.5 % of the lithosphere, and concentration in soil of these nutrients varies widely ranging from 0.04 % to 3.0 %: only 1–2 % of this is available to plants and the rest were bound with minerals present in soil and that is why they are unavailable to plants. Potassium availability depends on the K dynamics and its total K content. Plant can uptake only from soil solution (Girgis 2006; Goteti et al. 2013; Kawalekar 2013).

The role of efficient rhizospheric microorganisms in silicate mineral mineralization was known in the nineteenth century. After that considerable studies were done on mineral potassium mineralization by naturally abundant rhizospheric microbes. K solubilization is carried out by a large number of bacteria like *B. mucilaginosus*, *B. edaphicus*, *B. circulans*, *Acidithiobacillus ferrooxidans*, *Paenibacillus* spp. and *Aspergillus* spp. Major amounts of K-containing minerals (muscovite, orthoclase, biotite, feldspar, illite, mica) are present in the soil as a fixed form which is not directly utilize by the crop plant (Meena et al. 2014b; Kumar et al. 2015).

Nowadays, most of the farmers use injudicious application of chemical fertilizers for achieving maximum productivity (Sparks and Huang 1987). The KSMs are globally distributed but numbers vary from one soil to another. KSMs are present in rhizospheric soils in large number as compared with nonrhizospheric soils, and they are also metabolically active than non-rhizosphere-isolated microbes (Maurya et al. 2014). KSMs obtained from rhizosphere are more tolerant to salt, pH and temperature. When KSMs are inoculated in a solid medium containing insoluble/mineral K, they are detected by the formation of clear halo zone around the colony, and methods for the isolation of KSMs were developed by many researchers (Maurya et al. 2014; Bahadur et al. 2015; Meena et al. 2015a).

Microbes can enhance mineral dissolution rate by producing and excreting metabolic by-products that interact with the mineral surface. Complete microbial respiration and degradation of particulate and dissolved organic carbon can elevate carbonic acid concentration at mineral surfaces in soils and in ground water (Barker et al. 1998) which can lead to an increase in the rates of mineral weathering by a proton-promoted dissolution mechanism. Therefore, dissolution of soil K minerals by silicate-dissolving bacteria was purified by repeated inoculation and maintained for further genetical and morphological study. And efficient KSMs were selected on the basis of ability of K release and plant growth promotion activities. Finally, efficient isolates were selected and are used for making the inoculants and tested in field and pot experiments in various crop, and the strains were established as potassic biofertilizers (Purushothaman and Natarajan 1974; Rajawat et al. 2012; Prajapati et al. 2013).

18.3 Biodiversity of KSMs

Research issue of the use of microorganisms for plant growth and control of plant pests is very quickly expanding. Various amalgamations of amino acids (lysine, arginine, leucine, isoleucine, valine, glycine, proline, cysteine, etc.), organic acids (citric acid, oxalic acid, malic acid, acetic acid, pyruvic acid, formic acid, butyric acid, glycolic acid, succinic acid, etc.), sugars (glucose, fructose, galactose, ribose, xylose, niacin, raffinose, oligosaccharides, etc.), vitamins (biotin, thiamine, pantothenate, niacin, riboflavin, etc.), purines, adenine, guanine, cytidine, uridine, enzymes (phosphatase, invertase, amylase, protease, urease, etc.) and some gaseous molecules (OH^-, HCO_3^-, $CO_2^-H_2$, etc.) in root exudates of different plant species (Dakora and Phillips 2002) help microbes survive in various condition. Microbes produce many root exudates which are very helpful in plant nutrition and growth.

These amalgamations were decisive for the applicability of microbes as bio-inoculants/ biofertilizers for acquisition of nutrient for plant growth. A wide range of bacteria is able to solubilize potassium from mineral K-containing soil that enhanced the availability of potassium in soil solution which is easily utilized by crop plant, resulting in healthy growth of plant and improved yield. Plant replenishes the automated platform, facilitating uptake of nutrient and water, and plant roots also secrete a wide range of compounds (Walker et al. 2003). These exudates released by roots of plant attract the wide range of microbes which is heterogeneous, diverse and metabolically active soil microbial communities. These root exudates act as binding material/cementing agent of soil and, thus, improve soil structure and regulate and maintain the microbial population near the root surface. That is why rhizosphere reaches in microbial communities and its population.

Microbial activity near the root surface plays an important role in the development and rooting pattern of the plant. A fraction of these plant-derived small organic molecules are further metabolized by microorganisms in the vicinity as carbon and nitrogen sources, and some microbe-oriented molecules are subsequently retaken up by plants for growth and development (He and Sheng 2006). Several bacterial species known as KSB assist plant growth by mobilizing insoluble K. Population of KSB vary from soil to soil. A variety of bacteria discovered by many scientists as K solubilizers includes *Bacillus mucilaginosus*, *B. edaphicus*, *B. circulans*, *Arthrobacter* spp., etc.

18.4 The Nature of K Biofertilizers

Rhizospheric topsoils are rich in microbes and contain about 400 kg per acre of earthworms, 1088.622 kg per acre of fungi, 680 kg per acre of bacteria, 60 kg per acre of protozoa and 403 kg per acre of arthropods and algae, and even in small mammals in some cases (Verma et al. 2009). That is why soil can be viewed as a living community rather than an inert body. A decomposed part of organic matter called as humus contains dead organisms and plant organic materials in different decomposition stages. Humus and organic matters are reservoir of plant nutrient element; they also help in soil structure formation and provide some other benefits (Welch and Ullman 1993).

In fact, topsoil is the most biologically diverse part of the earth. Soil-dwelling organisms release bound-up minerals, converting them into plant-available forms that are then taken up by the plants growing on the site (Deshwal and Kumar 2013; Kawalekar 2013).

K-solubilizing microorganisms are morphologically diverse in characteristics such as colony form, margin, elevation, colour, slime production and gram's reaction. In many experiments, KSMs have been found in circular form, entire margin and cream-coloured colony. They are both in gram-negative and gram-positive rods that varied in length from short to long rods, cocci, etc. KSMs were observed for production of slime in different amount, i.e. high, medium and low. Extracellular production of slime is the main feature of potassium solubilizers. They survive in various climatic conditions as well as different types of soil that have been tested in different temperature as well as pH ranges (US Department of Agriculture 1998; Vandevivere et al. 1994; Xie 1998; Sheng 2002; Zhao et al. 2008).

18.4.1 Potassium-Solubilizing Microorganisms (KSMs)

The potassium-solubilizing microorganisms (KSMs) are rhizospheric microorganisms which solubilize the insoluble potassium (K) to soluble forms of K for plant growth and yield. K solubilization is carried out by a wide range of microorganisms (*B. mucilaginosus*, *B. edaphicus*, *B. circulans*, *B. subtilis*, *B. pumilus*, *Agrobacterium tumefaciens*, *Flavobacterium* spp., *Rhizobium* spp., etc.) and fungal strains (*Aspergillus* spp.) (Li et al. 2003; Meena et al. 2014a, b; Maurya et al. 2015; Zarjani et al. 2013; Gundala et al. 2013). Major amounts of potassium-containing minerals (muscovite, orthoclase, biotite, feldspar, illite, mica) are present in the soil as a fixed form which is not directly taken up by the plant. These insoluble sources are solubilized by many specific types of microorganisms called KSMs (Meena et al. 2014a, b; 2015b). This available K can be easily taken up by the plant for growth and development. These areas of the research are less focused or unidentified, but nowadays the growth of the research in these areas is enhanced. The KSB/KSR is isolated from different crop rhizospheres and from minerals, and these microbes are able to dissolve potassium from mineral soils that enhanced the crop growth, yield and soil sustainability (Maurya et al. 2014; Meena et al. 2015b). The evidence of solubilization of mineral potassium is studied by many scientists starting from the nineteenth century; Berthelin and Leyval (1982) suggested the regulation of silicon and its cycling in sea water, and they also reported the production of different organic and inorganic acids by these organisms. Groudev (1987) stated that silicate mineral dissolution was enhanced by exopolysaccharides, extrapolysaccharides and mucilaginous compound.

18.4.2 Search for Potassium-Solubilizing Microorganisms (KSMs)

The KSMs will be isolated on Aleksandrov medium using serial dilution followed by pour plate or streaking (Aleksandrov et al. 1967) from rhizospheric soil, nonrhizospheric soil and overburden samples near the mica deposit area (Basak and Biswas 2010; Maurya et al. 2014) (Fig. 18.1).

Once the efficient KSMs are screened, then it is tested for solubilization of potassium in Aleksandrov broth medium containing insoluble source of potassium mineral. For screening the KSMs, considering the high K solubilization capacity, efficient potassium-solubilizing isolates were selected for in vivo study of K solubilization capacity in soil mixed with K mineral at different time intervals. Ultimately efficient potassium solubilizers are used for pot culture and field authentication using various crops (Archana et al. 2013). The KSMs are isolated/obtained from different rhizospheric soils of various plants such as wheat (Parmar and Sindhu 2013; Zhang et al. 2013), feldspar (Sheng et al. 2002), potato-soybean cropping sequence (Biswas 2011), Iranian soils (Zarjani et al. 2013), ceramic industry soil (Prajapati and Modi 2012), mica core of Andhra Pradesh (Gundala et al. 2013), common bean (Kumar et al. 2012), biofertilizers (Zakaria 2009), sorghum and maize (Archana et al. 2013).

18.5 KSM: A Promising Approach in Sustainable Agriculture

The currently increasing human population, industrialization and urbanization cause the shrinkage of agricultural land and food crisis. It is a misconception that Indian soils are rich in potassium. In the future, deficiency of potassium in soil certainly would be a serious problem. These K solubilizers play a significant role in the solubilization of the part of mineral K of soil (90 %) to partially cater the plants' need of K (Fig. 18.2).

It is estimated that ~50–60 % of potash chemical fertilizers usage can be reduced by using *Frateuria aurantia*, a new bacterial species (species conformation by IMTECH Chandigarh) as a bio-inoculants. These new bacteria belonging to the family *Pseudomonadaceae* have the extra ability to mobilize K in almost all types of soils especially low K content soils and soils of pH 5–11, and they survive in a temperature of up to 42 °C. This potash-mobilizing biofertilizers can be applied in combination with *Rhizobium*, *Azospirillum*, *Azotobacter*, *Acetobacter*, PSM, etc. Potash-mobilizing bacterial-based product containing *Frateuria aurantia* produces plant growth-promoting substances which offer plant a multifaceted benefit in terms of growth, by mobilizing potash and making it available to crops. It also enhances the efficiency of chemical fertilizer (Patel 2011). Soil microorganisms enhance the potassium availability and production of PGPS (plant growth-promoting substances) (Barre et al. 2008).

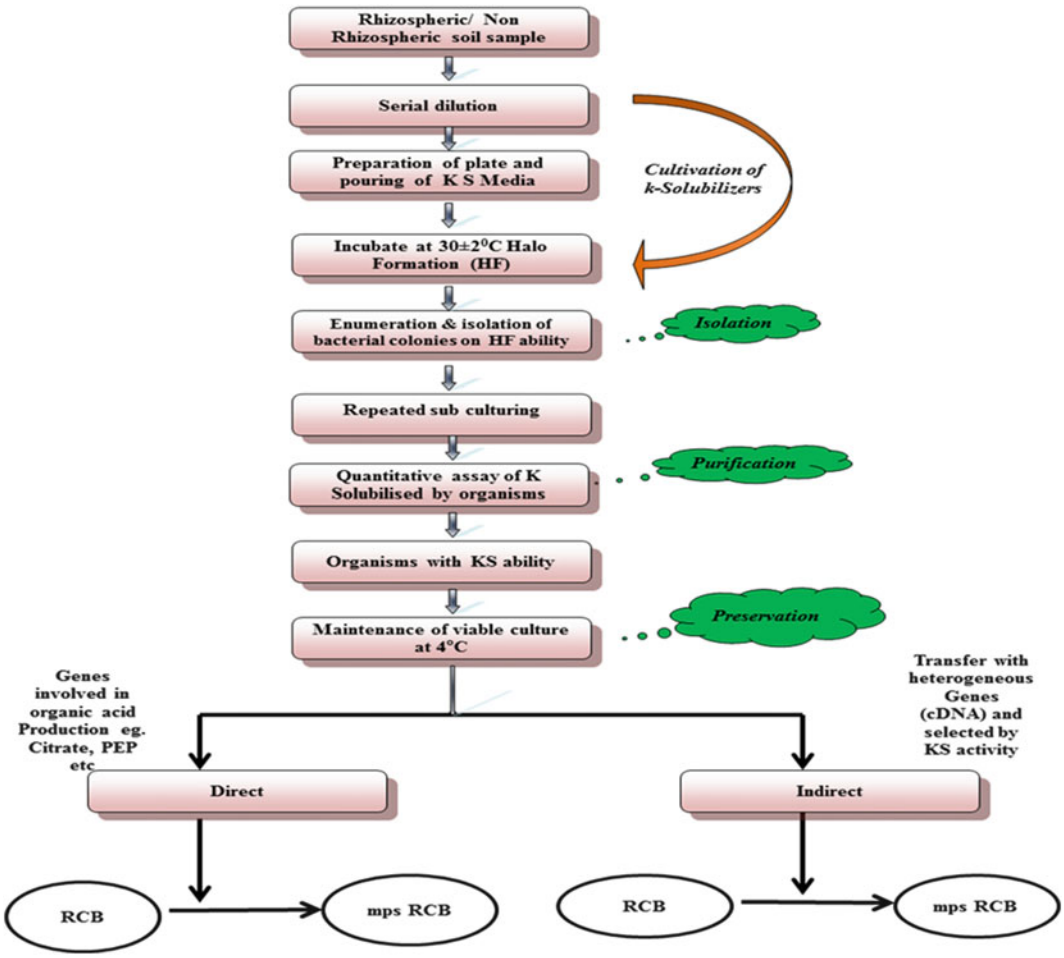

Fig. 18.1 Figure showing potassium-solubilizing microorganism (KSM) isolation, characterization and genetic modification

18.6 Methods of KSM Applications

KSB inoculants used as a seed treatment are cheap and common and the easiest means of inoculation. When properly applied, this method ensures that each seed receives the introduced KSB micophos. It is also used as a seedling treatment. One packet of inoculants (200 g) is mixed with 500 ml of water to make slurry (Bahadur et al. 2014). The seeds required are mixed in the slurry to have a uniform coating of the inoculants over the seeds and then shade dried for 30 min. The shade-dried seeds should be sown within 24 h. One packet of inoculants (200 g) is sufficient to treat 10 kg of seeds (Subba 2001). However, the use of a sticker solution of *gum acacia* improves the adherence of the inoculant KSMs on the seed. Thus, in accordance with these considerations, two approaches can be applied for KSM inoculation: firstly, the single-culture approach (SCA), where K solubilizers can be used alone, and, secondly, the multiple or mixed culture approach (MCA), often called co-inoculation, where KSMs are used along with other beneficial rhizosphere microorganisms.

The application of potassic biofertilizer is also used as a seedling root dip; this method is used for transplanted crops, and it is also used with

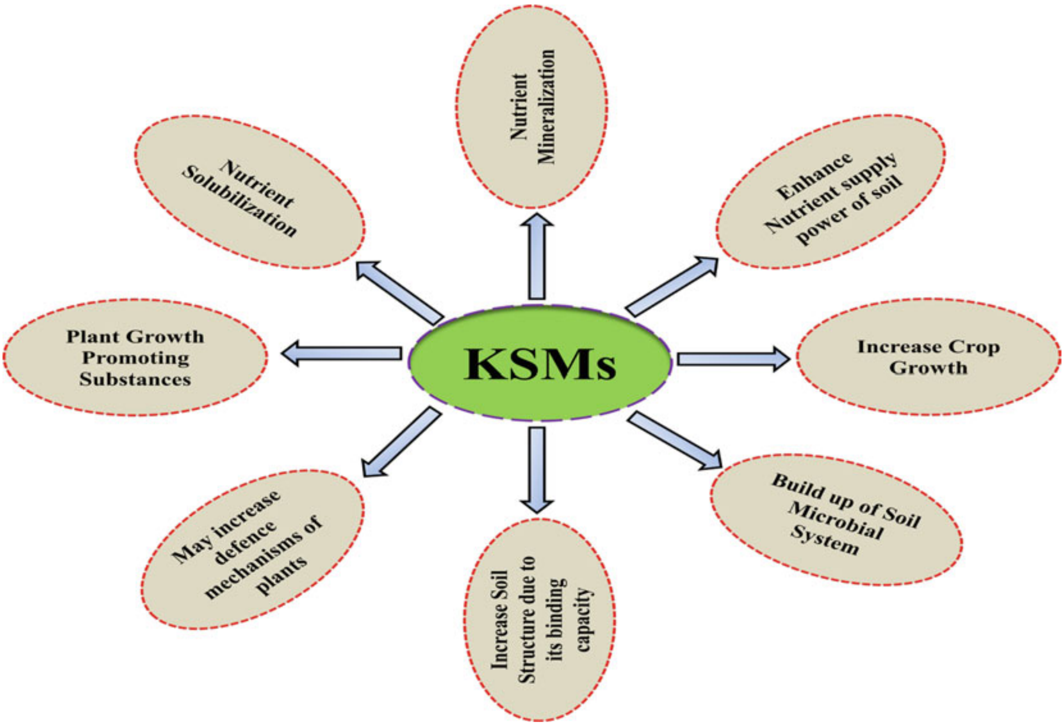

Fig. 18.2 How potassium-solubilizing microorganisms (KSMs) help in soil sustainability for a system development

farmyard manure by broadcasting in the main field just before transplanting/sowing of seeds. There are, however, certain situations where seed applications may be an ineffective means of application, e.g. with seeds dressed with pesticides incompatible with PSMs. Under such circumstances, soil application may be followed. Inoculants applied to the soil have the following advantages: greater population of KSM per unit area, minimized direct contact with chemically treated seeds, elimination of seed mixing and apparent ability to withstand low moisture conditions better than the powder form.

18.7 Factors Affecting KSM Inoculants

Indigenous microbes residing in soil contest for nutrition and moisture with applied microbial inoculants and frequently do not confess their productive establishment in the soil with the inoculated population. Sometimes poor or inefficient organic matter and moisture status in the inoculated field might limit the growth and multiplication of KSMs. The population declines during the off season but may increase after planting of crop. Using proper inoculation technique, survival of potassium-solubilizing microorganisms is enhanced. KSMs live in a microbial culture so they require careful handling, storage and transportation facility.

18.8 Effects of KSMs on Crop Response

Bio-tampering of K mineral (waste mica) with KSMs perhaps substitutes a feasible technology to solubilize mineral potassium present in mica into plant useable nutrient efficiently used as a source of K nutrition for sustaining crop production and maintaining soil potassium (Basak and Biswas 2009; Meena et al. 2015a, b; Maurya et al. 2015).

Inoculation with KSMs have been described strive valuable resultance on growth of many crops were established by many worker cotton and mustard (Sheng 2005) pepper and cucumber (Han et al. 2006), banana (Hassan et al. 2010), sorghum (Badr 2006), wheat (Sheng and He 2006), tomato (Lian et al. 2008), chilli (Ramarethinam and Chandra 2005) and sudan grass (Basak and Biswas 2010). Similarly, Zahra et al. (1984) reported that soil inoculated with silicate-dissolving bacteria *B. circulans* for solubilization of potassium and silicate from various silicate minerals showed significant increase of organic matter and ~17 % yield of rice. Augmentation of wheat yield up to 1.04 t per hectare was reported. According to Badar (2006), the co-inoculation of KSMs in both phosphorus- and potassium-bearing minerals on sorghum was recorded to enhance dry matter yield and nutrient uptake (~48 %, 65 % and 58 %), P (~71 %, 110 % and 116 %) and K (~41 %, 93 %, and 79 %) from three uptakes in three distinct soils, respectively. Archana et al. (2008) reported that the KSMs were isolated from rock and rhizosphere soils of *Vigna radiata* and reported that these KSMs enhance the solubilization of K in acid-leached soil as well as increase seedling growth and yield.

Many investigators have recorded the existence of soil microbes capable of solubilizing insoluble mineral resources to plant-available forms by excreting several metabolic by-products that interact with mineral surfaces and release nutrients. Silicophilic and aluminophilic bacteria are potential agents to release K from potassic minerals, and consequently they bring K solution for plant use. In vitro condition It was observed that K-solubilizing bacterial colonies characteristically produce slime intensively that provides a tool for the isolation of K-solubilizing bacteria. Microbial inoculants exhibit their response by improvement in soil fertility and/or increase in grain yield.

18.9 Reasons Why KSM Inoculants Do Not Respond to the Crop Species

In India, biofertilizer industry increased strangely in the last two and a half decades, but they are still in shortage of biofertilizer and are far away from their potential. And a very few private industries are engaged with K biofertilizers. Limited nutrient mobilization potential compared to their chemical counterparts and slow impact on crop growth are the major constraints. Inconsistent responses in the field under varied agroecological niches and cropping systems have also contributed to their low acceptance by farmers. Besides these, there are some technological constraints, which restrict the fast growth of biofertilizer industry. Some of the major constraints and limitations of the industry are as follows:

(a) Susceptibility of strains to high chemical fertilizer use.
(b) Less interest in scientific community on the development of K biofertilizer technologies.
(c) Culture collection banks not yet developed for KSMs due to this loss of efficient strains developed by scientists.
(d) Deficiency in technology in respect to carrier suitability and product formulations.
(e) Lack of automation in product handling.
(f) Liquid inoculants are coming up as solution, but the technology is still immature and not available in public domain and more or less it is costly.
(g) Distribution channels through government agencies are not effective, which leads to cut throat competition among bidders, resulting in a low-cost and poor-quality inoculant production.

18.10 Conclusions

The development of sustainable agricultural system requires a new technique to use less amount of chemical fertilizer while maintaining proper crop yields. The application of biological resources to exploit nutrient present in soil may hold promises for the future. Now facts are established that microbes are useful in increasing plant growth in many ways, like nutrient acquisition, solubilization, mobilization and secretion of root exudates which help in plant growth promotion, disease prevention and suppuration and stress control. Chemical fertilizer gradually commenced their side effect on human being and environment; however, the use of KSMs as a biofertilizer can improve available plant nutrient and production of crop in a sustainable way. It is very important to make a successful research work done for the recognition of an elite microbial strain capable of solubilizing potassium minerals quickly in large quantity which can conserve our existing resources and avoid environmental pollution hazards caused by excessive/injudicious use of chemical fertilizers. This communication highlighted the contributions of rhizospheric microorganisms especially potassium-solubilizing bacteria which can enhance the productivity of agricultural crops without disturbing the environment. This type of microbial consortium is cost-effective and ecofriendly for enhancing the sustainable agriculture. Application of waste mica could be a substitute for chemical fertilizer, and it is an important technology for the solubilization of potassium from insoluble sources in an ecofriendly way for sustainable crop production and supply of K. In addition, to safeguard the quantity as well as quality of food in developing countries like India, China, Canada, etc. in the long run, there is an indispensable urgency for the sustainable intensification of agricultural production system for productivity and revenue origination. In this situation, a viable, innovative, unique, genetically modified, soil and location-specific KSM biotechnology is the ultimate tool for use in the farmers' field in a short time to mitigate the potassium loss.

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