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# Sustainable Production of Potassium Biofertilizer Using Beneficial Microbes: A Step Towards Achieving the SDGs

**Dr. A. Padmavathi[1], Ms. E. Avanthi[2]**
[1]H.O.D of Applied sciences, CH.S.D.ST.Theresa's College for Women (A), Eluru
[2]Lecturer in microbiology, CH.S.D.ST.Theresa's College for Women (A), Eluru

**Abstract:**
Potassium is the third most important macronutrient required for plant growth and is one of the 17 essential nutrients vital for plant development and reproduction. Adequate potassium nutrition is crucial for enhancing crop yield, maintaining water-use efficiency, and improving plant resistance to abiotic and biotic stresses. It plays a key role in regulating water relations, enzymatic activation, and photosynthetic efficiency in plants. However, the overuse of chemical fertilizers to supplement potassium not only leads to soil degradation but also poses serious environmental and health risks.
In light of these challenges, the present study focuses on the production of a potassium biofertilizer using potassium-solubilizing bacteria (KSB) as a sustainable alternative. The exploitation of beneficial microbes for nutrient solubilization and delivery has emerged as a promising approach in modern agriculture, contributing to food security and environmental sustainability. This microbial intervention supports the goals of sustainable development, particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), by reducing dependency on synthetic agrochemicals and enhancing natural soil fertility.
The study highlights the potential of KSB-based biofertilizers in improving plant health, productivity, and resilience, and emphasizes their role in promoting eco-friendly and sustainable agricultural practices.
**Keywords:** Potassium bio-fertilizer, potassium-solubilizing bacteria (KSB), solubilizatio ,Chemical fertilizers, , sustainable agriculture

## 1.INTRODUCTION:

Agriculture has undergone series of advancement since the 12th century and is being practiced extensively throughout the world today. In 2007, it was recorded that one- third of the world's workers were employed in the area of agriculture. World's population is assumed to increase from 7 billion now to 8.3 billion in 2025. The world will need 70 to 100 percent more food by 2050, demands placed upon agriculture to supply future food will be one of the greatest challenges facing the agrarian communities order to meet this challenge, focusing on the soil biological system is enabling better understand the complex processes and interactions governing the stability of crop production as well as soil health. (Ifokwe, N. J,1988)

Soil containing essential several minerals but most important minerals are nitrogen (N), phosphorus (P) and potassium (K), these nutrients are essential for a plant to healthy growth and development. Potassium is the third important plant nutrient after Nitrogen and Phosphorous. The entire requirement of around five million tons of potassium fertilizers would be met through imports as India does not have commercially viable sources of potash, India is totally depended on import of potassium fertilizers. Nowadays use of efficient rhizosphere microorganisms may offer plant growth promotion, agronomic, pathogenic and environmental benefits for intensive agricultural systems. Plant growth promoting microorganisms exhibit a gradual increase in demand to the world market

Eco-friendly 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-environmental sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals ( Bahadur et.al.,2014)

**1.1. Need for the study**: As the benefits of biofettilizers are long lasting and especially potassium biofertilizers protect the plant from improving plant resistance to abiotic and biotic stresses. The present study has taken up with the following objectives

**1.2.AIM:**

To isolate Potassium Solubilizing Bacteria (KSB) from soil and to know their potential use as bio-fertilizers to enhance soil potassium availability and promote sustainable crop production.

**1.3. Objectives**

1. To isolate and identify Potassium solubilizing bacterial strains from rhizosphere soils.
2. To assess the plant growth-promoting properties (PGPR) of the selected KSB strains.
3. To conduct pot or field trials to study the impact of KSB bio-fertilizer on crop growth, yield and soil nutrient status.

## 2.MATERIALS AND METHODS

### 2.1. Soil Sample Collection

Soil samples were collected from a lemon field in Vijayrai, Andhra Pradesh, India. The top 1 cm layer of soil was removed, and soil was collected from four corners of the field and thoroughly mixed to form a composite sample. The collected sample was transferred to sterile polythene bags and transported to the laboratory for further processing.

### 2.2. Serial Dilution

Serial dilutions were performed using standard microbiological procedures. One gram of soil was added to a sterile test tube containing 10 mL of sterile distilled water and labelled as the $10^{-1}$ dilution. From this, 1 mL was transferred to the next tube containing 9 mL of sterile water to obtain the $10^{-2}$ dilution. This process was repeated until a $10^{-7}$ dilution was achieved. This technique reduced microbial density, allowing better isolation of individual colonies with distinct morphological features.

### 2.3. Isolation and Plating of Potassium Solubilizing Bacteria (PSB)

Aliquots (1 mL) from the $10^{-4}$ dilution were plated in triplicate onto Aleksandrov's medium medium using the spread plate method. The medium consisted of (per liter): glucose (5 g), $Mgso_4.7H_2o$ (0.5 g), $Caco_3$(0.1 g), Ferric chloride (0.0005 g) Ca3(Po4)2 (2.0 g), potassium aluminium silicate (2.0 g), and Agar (20 g). Plates were incubated at 37 °C for 24–48 hours.

Colonies indicative of potassium solubilization, were selected for further analysis. These colonies were sub cultured onto fresh Aleksandrov's medium agar plates for purification and maintained for further testing.

### 2.4. Microscopic Characterization

Selected colonies were subjected to Gram staining. Only bacterial isolates showing clear zones of potassium solubilization were retained for further studies.

### 2.5. Production of KSB Biofertilizer

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A pure culture of the selected KSB isolate was inoculated into 1 L of sterilized liquid Aleksandrov's medium broth and incubated under optimal conditions until the bacterial population reached $10^6$–$10^8$ CFU/ml. This culture was then transferred to a 250-L fermenter for large-scale submerged fermentation and production of the biofertilizer.

**2.6. Pot Experiment**

To evaluate the effect of KSB on plant growth, a pot study was conducted using plant Jasminum auriculatum. Two plants were used: one served as the control, and the other was treated with 1 mL of the KSB inoculum. Growth parameters, including plant height and leaf development, were observed and compared after ten days of treatment.

**3.RESULTS**

**3.1. Isolation and Identification of KSB**

Potassium Solubilizing Bacteria were successfully isolated from the soil samples using Aleksandrov's agar. Colonies exhibiting clear zones around them were considered positive for phosphate solubilization. Gram staining confirmed that the effective isolates were Gram-negative rods. The solubilization activity was attributed to the ability of the isolates to release potassium from insoluble mineral sources

Fig:1 Potassium Solubilizing Bacteria on Aleksandrov's agar

**3.2. Fermentation and Biofertilizer Production**

The selected KSB isolate exhibited efficient growth in liquid Aleksandrov's medium under submerged fermentation conditions. A cell density of approximately $1.0 \times 10^8$ CFU/mL was attained prior to scale-up. The fermentation process was successfully optimized for biofertilizer production, and the culture was scaled up to a 250-L fermenter without loss of viability, confirming the potential for large-scale production.

**3.3. Effect of PSB on Plant Growth (Pot Study)**

Application of the KSB biofertilizer to Jasminum auriculatum resulted in noticeable improvement in plant growth compared to the untreated control. After ten days of application, treated plants exhibited an average increase in shoot height of $\sim 2.0 \pm 0.2$ cm over control plants. In addition, KSB-treated plants displayed greener foliage with a greater number of leaves, suggesting enhanced chlorophyll synthesis and improved nutrient uptake. These findings indicate that KSB inoculation positively influenced plant growth and vigor under controlled conditions

**Fig:** 1 Effect of KSB on plant growth

**4.DISCUSSION**

The present study demonstrated that Gram-negative rod-shaped potassium-solubilizing bacteria (KSB) could be successfully isolated from rhizospheric soils and that their inoculation significantly enhanced the growth of Jasminum auriculatum. Similar to our observations, several authors have reported the ability of soil bacteria such as Bacillus, Pseudomonas, Klebsiella, and Pantoea to solubilize insoluble potassium minerals and promote plant growth (Lian et al., 2008; Archana et al., 2013; Setiawati & Mutmainnah, 2016).

The mechanism of potassium solubilization is generally attributed to the secretion of organic acids that lower pH and chelate cations, thereby releasing potassium from silicate minerals such as feldspar, mica, and illite (Liu et al., 2006; Meena et al., 2014). For instance, strains of Pantoea vagans have been shown to secrete citric, malic, and gluconic acids that efficiently dissolve potassium-bearing feldspar (Zhang & Kong, 2014). In addition to organic acid production, some KSB strains release exopolysaccharides and extracellular enzymes that enhance mineral weathering and nutrient mobilization (Sheng & He, 2006). These findings are consistent with the positive plant responses observed in our study, where KSB treatment improved shoot length and leaf greenness, suggesting improved nutrient uptake and chlorophyll biosynthesis.

Potassium plays a vital role in several physiological processes, including osmoregulation, enzyme activation, and photosynthesis (Wang et al., 2021). Hence, the ability of KSB to mobilize insoluble potassium reserves is of agronomic significance, especially in potassium-deficient soils. Previous reports have shown that inoculation of crops with KSB can increase biomass, yield, and nutrient uptake in wheat, maize, rice, and tobacco (Basak & Biswas, 2010; Kumar et al., 2012; Etesami et al., 2017). Our results showing improved growth in Jasminum auriculatum after KSB application are therefore in line with these earlier studies.

Beyond nutrient mobilization, KSB also act as plant growth-promoting rhizobacteria (PGPR) by producing phytohormones such as indole-3-acetic acid (IAA), siderophores, and enzymes that suppress pathogens (Zaidi et al., 2016; Parmar & Sindhu, 2013). The greener and more vigorous growth observed in treated plants may therefore be a combined effect of potassium solubilization and other PGPR activities.

From an agricultural perspective, biofertilizers based on KSB represent an environmentally sustainable alternative to chemical fertilizers. Over-reliance on chemical potash fertilizers is associated with soil degradation and high input costs. Bioinoculants such as KSB can partially replace mineral fertilizers, improving soil fertility while reducing environmental risks (Sheng, 2005; Etesami et al., 2017). However, one limitation of our study is that halo formation on Aleksandrov's agar was not consistently distinct, which is a known drawback of this medium (Basak & Biswas, 2010). Therefore, quantitative estimation of potassium release in liquid medium is essential for accurate evaluation of solubilization efficiency.

## 5.CONCLUSION

The present study demonstrated the successful isolation and identification of Gram-negative potassium-solubilizing bacteria (KSB) from rhizospheric soils using Aleksandrov's medium. Quantitative assays confirmed their ability to mobilize insoluble potassium, and large-scale cultivation under submerged fermentation conditions achieved high cell densities suitable for biofertilizer production. Pot experiments with Jasminum auriculatum revealed significant improvements in shoot height, foliage greenness, and overall plant vigor following KSB inoculation, highlighting their potential as plant growth-promoting rhizobacteria.

These findings reinforce the role of KSB as an eco-friendly and sustainable alternative to chemical fertilizers, offering a promising approach to enhance nutrient availability, improve crop productivity, and reduce dependence on synthetic inputs. However, further studies involving molecular characterization, organic acid profiling, and field-scale trials are warranted to validate their performance under diverse agro-climatic conditions and to facilitate their integration into sustainable agricultural practices.

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