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Harnessing the Power of Sulphur Solubilizing Bacteria for enhancing Agricultural Production Potential

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Introduction:

In the pursuit of sustainable agricultural practices, the significance of microorganisms in soil health and plant nutrition has gained considerable attention. Among these, Sulphur Solubilizing Bacteria (SSB) stands out as crucial players in optimizing agricultural productivity while ensuring environmental sustainability. Sulphur, an essential nutrient for plant growth and development, often becomes limiting in soils due to its low availability in soluble forms. However, SSB possess the remarkable ability to convert insoluble sulphur compounds into accessible forms for plant uptake, thereby unlocking the potential of this vital nutrient. This introduction delves into the multifaceted role of Sulphur Solubilizing Bacteria in agriculture, exploring their mechanisms of action, applications, and the promising avenues they offer for enhancing agricultural production potential. By elucidating the symbiotic relationship between SSB, soil health, and plant nutrition, we aim to underscore the significance of harnessing their power as a sustainable strategy for meeting the growing global demand for food, while mitigating environmental impacts associated with conventional agricultural practices.

Sulphur is used in plants to form amino acids, proteins, and oils. It's necessary for chlorophyll formation, helps develop and activate certain enzymes and vitamins, and is a structural component of two of the 21 amino acids that form protein. The crop's need for S is closely associated with N, which is also a component of protein and involved in chlorophyll formation. So a plant takes up a certain quantity of S as it uses N. Unlike N, however, S is not moved within a plant, so it requires a steady source from the soil through the growing season. Sulphur is essential for high yield and is involved in the formation of proteins, vitamins, and enzymes. Sulphur oxidizers work to convert elemental sulphur into plant-available sulphate. All sulphur transformations are propelled by the soil microbial biomass.

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Through the oxidation process in the soil, they produce sulphate from elements or reduced forms of sulphur. Sulphur-solubilizing bacteria (SSB) containing bio-fertilizer improves the microbial load of sulphur-solubilizing bacterial strains in the soil. Hence, it induces sulphur conversion in the soil and increases crop yield.

Action Mechanism of Sulphur Solubilizing Bacteria

Sulphur bacteria form a variety of mutualistic interactions depending on whether they interact with oxidised or reduced sulphur compounds. The bacterial strains produce active cells that grow, multiply, and mobilize the insoluble sulphur present in the soil. Hence, it ultimately increases and improves the uptake of sulphur and makes it readily available to the plant.

Benefits of Sulphur Solubilizing Bacteria

It helps in the chlorophyll formation that allows photosynthesis, by which plants produce starch, sugars, oils, fats, vitamins and other compounds. Sulphur improves plant's winter hardiness.

Importance of sulphur

Sulphur (S) is a crucial macronutrient for people, animals, plants, and microbes for growth and development. Although it is categorised as a tertiary element along with Magnesium (Mg) and Calcium (Ca), it is occasionally referred to as "the fourth major nutrient." The element S is a necessary component for all living things. It aids in the development and activation of several enzymes and vitamins in plants, promotes nodulation in legumes, and is a structural component of two of the 21 amino acids that make up protein (cysteine and methionine). Asparagine, glutamine, and arginine are three non-S containing amino acids that accumulate in plant tissues as a result of S deficit in soils and plants, which also inhibit protein synthesis. Where high S using crops like oilseeds and pulses are routinely cultivated, the sulphur deficiency is more noticeable.

Signs of sulphur shortage

The most noticeable signs of sulphur shortage in leguminous and oilseed crops include stunted growth, poor branching, weak stems, strong red tints at leaf edges, and pale chlorotic leaves on young foliage. Reduced plant growth rate is associated with sulphur-deficient soil and typically, shoot growth is more impacted than root growth. Lack of S nutrition impacts nodulation in legumes and lowers nitrogen fixation.

Forms of sulphur

In soil, sulfur (S) is present in various forms, both in organic and inorganic compounds. Sulphur is available as organic sulfur, elemental sulfur, sulfides, sulfonates, thiols, thioesters, and sulfoxides etc., and it exists in all three phases i.e. solid, liquid or gaseous. Plants mainly take up sulphur in the form of sulphate (SO_4^{2-}) and reduce it to form S containing amino acids and other compounds Organic S must be mineralized to the inorganic sulfate anion before it can be taken up by crops. Sulphur is needed through all stages of growth in plants. Soils needs to have at least 10% sulphur in sulphate form available early in the crop season for germination and seedling growth then the rest 90% along the season.

Sulphur-oxidizing bacteria (SOB)

The sulphur bacteria, which are having capability to oxidize the reduced forms of sulphur compounds with sulphate as a final product, are known as sulphur oxidizing bacteria (SOB). Many bacteria have sulphur oxidising property in varied agricultural soils viz., Thermothrix, Beggiotoa, Thioplaca, Thiobacillus, Achromatium, Thiomicrospira, Acidithiobacillus, Thiosphaera and Thiothrix. Among these, Thiobacillus is the most important bacterial genus which is widely involved in the oxidative part of sulphur transformation in soil.

Applications of SOB in Agriculture

Sulphur-oxidizing bacteria (SOB) have been recommended for the different types of crop and the soil.

Rice Cultivation:

In rice-growing regions, sulphur deficiency is a common issue. SOB enhances sulphur availability in paddy soils, which can improve rice growth and yield.

Vegetable Crops:

Various vegetable crops such as cauliflower, cabbage and onion, benefited from sulphur supplementation. A Sulphur-oxidizing bacterium increases the availability of sulfur for these crops, leading to improved growth and yield. The application of SOB enhances the nutritional quality of vegetables, including sulfur-containing compounds.

Oilseed Crops:

Oilseed crops like mustard, rapeseed, sunflower and sesame are important crops. SSB contributes to increased sulphur availability, promoting better oil and protein synthesis in these crops. By ensuring adequate sulphur supply, SOB application improves the yield and quality of oilseed crops.

Legumes:

Leguminous crops, including lentils, chickpeas, and pigeon peas, Sulphur is essential for their growth and nitrogen fixation. SOB aid in the mineralization of organic sulphur compounds, providing accessible forms of sulphur for legumes. This can improve nitrogen fixation and overall plant productivity.

Dosage of Sulphur Solubilizing Bacteria

CFU Count	Dose
1×10^9 CFU/Gram	1 kg/acre
	2.5 kg/ha

Mode of Application:

Soil Drenching and Drip Irrigation.

- For one acre field, mix well 500 ml liquid SSB bio-fertilizer with 40 kg cow dung manure with 75 percent moisture, keep it for 48 to 72 hours and spray it in the field at the time of last ploughing.
- For one acre field, add 500 ml SSB bio-fertilizer in the drip irrigation tank
- For one acre of field, 500 ml of liquid SSB bio-fertilizer should be given to the crop twice through irrigation water

Seedling root treatment

- ✓ Mix well 500 ml liquid SSB bio-fertilizer by dissolving it in 200 litters of water for one acre area and make foliar spray on the crop.
- ✓ Dip the root of the plantlets prepared in the solution for 30 minutes.
- ✓ Immediately transplant the treated plant.

Conclusion

In conclusion, Sulphur Solubilizing Bacteria (SSB) emerge as pivotal allies in sustainable agriculture, facilitating enhanced nutrient uptake and plant growth. Their role in converting insoluble sulphur compounds into accessible forms underscores their significance in addressing sulphur deficiency challenges. By optimizing sulphur availability, SSB contribute to vital processes such as chlorophyll formation, enzyme activation, and protein synthesis, crucial for crop development. Leveraging SSB in agricultural practices offers promising avenues for improving yield and nutritional quality across various crops, from staple grains to oilseeds and vegetables. Through strategic application methods and dosage recommendations, SSB bio-fertilizers present a practical solution for optimizing sulphur utilization and fostering sustainable productivity.