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## Lentils Thrive well with Nature's Helpers: Exploring *Rhizobium* and PSB for Better Harvests

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### Abstract: -

Lentil (*Lens culinaris* L.) is valued for both its nutritional benefits and its role in sustainable agriculture through nitrogen fixation. However, the pressures of intensive farming have led to declining soil health and an overdependence on chemical fertilizers, raising both environmental and economic concerns. In this context, biofertilizers such as *Rhizobium* and phosphate-solubilizing bacteria (PSB) are emerging as powerful, eco-friendly solutions. These beneficial microbes enhance the availability of essential nutrients viz. nitrogen and phosphorus naturally, reducing the need for synthetic inputs. When applied through seed treatment or soil incorporation, *Rhizobium* and PSB significantly improve root nodulation, nutrient absorption, and overall plant vigor. Research indicates that co-inoculation of these microbes can lead to impressive gains, increasing seed yield by up to 29% and stover yield by 17%. Remarkably, lentil crops can fulfill up to 85% of their nitrogen requirements through biological fixation alone. The integration of *Rhizobium* and PSB into lentil cultivation is not only cost-effective but also a forward-thinking approach to restoring soil fertility, boosting crop productivity, and advancing environmentally responsible farming practices.

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**Introduction:**

Lentil (*Lens culinaris* L.), or ‘masoor dal’, has been cherished throughout the world for its good nutritional qualities including a rich source of protein, complex carbohydrates, vital minerals and vitamins, phytochemicals, and dietary fiber (Dhull *et al.*, 2022). Beyond their nutritional appeal, lentils play a crucial role in sustainable agriculture, particularly through their ability to fix atmospheric nitrogen in association with symbiotic bacteria. However, modern intensive farming has led to declining soil health and excessive reliance on chemical fertilizers (Kumar and Singh., 2025). To counter these issues, nature-based solutions like beneficial soil microbes like *Rhizobium* and phosphate-solubilizing bacteria (PSB) are gaining importance in the cropping system (Kumar and Maurya, 2006, Kumar, *et al.*, 2013). These microbes enhance the availability of key nutrients like nitrogen and phosphorus, promote plant growth, and improve long-term soil health (Meena *et al.*, 2024), offering a sustainable alternative to synthetic inputs (Kumar *et al.*, 2014; Kumar and Paswan., 2014).

**The Power of Lentils:**

Lentils play a vital role in sustainable agriculture due to their natural ability to fix atmospheric nitrogen through a symbiotic relationship with *Rhizobium leguminosarum*. These bacteria form nodules on lentil roots,

where they convert atmospheric nitrogen into a plant-usable form, reducing the need for synthetic fertilizers (Kumar *et al.*, 2025). This not only lowers production costs and environmental impact but also improves soil fertility for subsequent crops. By enhancing soil organic matter and structure, lentils support a more resilient and eco-friendly farming system (Rekha *et al.*, 2019).

**Meet the Microbial Allies: *Rhizobium* and PSB:**

***Rhizobium*:** *Rhizobium* is a bacterium that lives in the root nodules of legume plants like lentils. It captures nitrogen from the air, converts it into ammonium (NH<sub>4</sub><sup>+</sup>) form and make available nitrogen for plants as a nature’s source, saving the need for nitrogen fertilizers. These bacteria that associate with plant roots not only improve nutrient absorption but also offer protection against soil-borne pathogens (De *et al.*, 2006).

***Phosphate Solubilizing Bacteria*:** PSB (Phosphate Solubilizing Bacteria), on the other hand, helps in unlocking the unavailable form of phosphorus present in the soil. Together, they form a dynamic duo for the supplement of two primary macro nutrients: *Rhizobium* strengthens nitrogen supply, while PSB ensures phosphorus availability. Both microbes help plants grow faster, healthier, and stronger. PSB can also enhance plants' ability to withstand stress (Kumar *et al.*, 2024).

### Application Methods in Simple Terms:

#### Seed Treatment:

For seed treatment, start by mixing the *Rhizobium* and PSB cultures with a sticky agent, such as a jaggery (molasses) solution. Let it to become cool and add the biofertilizers. This helps the biofertilizers adhere effectively to the seed surface. Once mixed, coat the seeds evenly with the solution and allow them to dry in the shade before sowing. This method ensures that the beneficial microbes come into immediate contact with the seedling roots, promoting early colonization and better plant establishment.

#### Soil Application:

##### 1. Direct soil application:

For soil application, combine the *Rhizobium* and PSB biofertilizers with well-decomposed compost or farmyard manure. This mixture serves as a carrier and nutrient source for the microbes, enhancing their survival and activity in the soil. Evenly broadcast the prepared mixture in the field just before the final ploughing. This practice helps distribute the beneficial microbes throughout the root zone, ensuring better nutrient availability and plant-microbe interaction during crop growth (Meena *et al.*, 2022).

##### 2. Soil application through incubation:

An effective way to apply biofertilizers like *Rhizobium* and PSB is through incubation

with compost or FYM (farmyard manure). The required amount is mixed with the taken media, thoroughly mixed with it and keep by spraying water (Kumar and Singh, 2022).

#### Combined Application: A Winning Strategy

The combined use of *Rhizobium* and phosphate-solubilizing bacteria (PSB) in lentil cultivation forms a synergistic relationship that significantly boosts plant growth, nutrient availability, and soil health. *Rhizobium* fixes atmospheric nitrogen, while PSB mobilizes bound phosphorus—both essential for optimal plant development. This interaction enhances nodulation and nitrogen fixation efficiency, as phosphorus supports vital metabolic processes like ammonium assimilation and ureide synthesis (Mitran *et al.*, 2018). By ensuring a steady phosphorus supply, PSB strengthens the *Rhizobium*-lentil symbiosis (Kumar *et al.*, 2024). Beyond improving yields, this biofertilizer approach offers a sustainable, eco-friendly alternative to chemical fertilizers, reducing input costs, enhancing microbial diversity, and minimizing environmental pollution and ensures a good ecosystem services.

#### Field Success Stories:

Multiple studies have highlighted the positive impact of microbial inoculants on lentil growth and yield. Waroda *et al.* (2024); Kumar *et al.*, 2025, found that *Rhizobium* inoculation significantly improved branches,

Pods, seeds per pod, test weight, and ultimately seed and stover yields. Rasool *et al.* (2016) reported that dual inoculation with *Rhizobium* and phosphate-solubilizing bacteria (PSB) resulted in the highest yields, increasing seed and straw yields by 29% and 17%, respectively, over the control. Individually, *Rhizobium* improved seed yield by 11%, while PSB led to 7% and 9% higher yields compared to *Rhizobium* alone and the control. Kabir *et al.* (2019) further noted that lentils could fulfill up to 85% of their nitrogen needs through atmospheric nitrogen fixation. These findings underscore the vital role of *Rhizobium* and PSB in boosting nitrogen fixation and yield in lentil cultivation (Meena *et al.*, 2024).

### Conclusion:

The integration of *Rhizobium* and phosphate-solubilizing bacteria (PSB) into lentil cultivation presents a powerful, sustainable solution to modern agricultural challenges. These microbial allies significantly improve nitrogen fixation, phosphorus availability, and overall plant health, leading to increased yields and reduced reliance on chemical fertilizers. Seed treatment and soil application methods ensure efficient colonization and activity of these biofertilizers. Field studies consistently affirm their effectiveness, with co-inoculation delivering substantial gains in both seed and stover yields. Furthermore, the natural nitrogen-

fixing ability of lentils, supported by these microbes, enhances soil fertility for subsequent crops, contributing to long-term ecological balance. Embracing such biofertilizer-based practices offers a resilient and environmentally sound strategy for sustainable lentil production.

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