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# Role of microbial solubilisers on major nutrient uptake - A review

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## Abstract
The poor productivity of crops has always been primarily attributed to imbalance application of nutrients and use of traditional varieties. Significant increase in seed P of different legumes due to co-inoculation of *Rhizobium* and PSB over control have been observed. Production of growth-promoting substances and high colonization ability of rhizobacteria such as *Pseudomonas* because they enhance the nitrogen fixation of soybean when co-inoculated with *Bradyrhizobium japonicum.* phosphorus (P) is a major growth-limiting nutrient, and unlike the case for nitrogen, there is no large atmospheric source that can be made biologically available. Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases are the attributes associated with phosphorus nutrition. In light of several literature this paper has briefly reviewed the role of microbial solubilisers on major nutrient uptake.

**Keywords:** major nutrient, productivity, stem strength

## Introduction
The poor productivity of soybean is mainly due to imbalance application of nutrients and use of traditional varieties. Under such situations, use of *Rhizobium* and phosphate solubilizing bacteria (PSB) had shown advantage in enhancing soybean productivity. Microbial inoculants are cost effective, eco-friendly, and renewable sources of plant nutrients. Rhizobium and PSB assume a great importance on account of their vital role in $N_2$-fixation and P-solubilisation. The introduction of efficient strains of P-solubilizing species of *Bacillus megaterium Biovarphosphaticum, Bacillus polymyxa, Pseudomonas striata, Aspergillus awamori, and Penicillium digitatum*in the rhizosphere of crops and soils has been reported to help in increasing phosphorus availability in the soil. Macro-nutrients such as nitrogen, phosphorus and potassium play a crucial role in plant growth and yield. This paper reviews some of the role of microbial solubilisers on major nutrients uptake.

### Effect of nutrient mobilizing microorganisms on nutrient uptake crop [1]
Significant increase in seed P of different legumes due to co-inoculation of *Rhizobium* and PSB over control and observed that the proportion of plant N derived from atmospheric nitrogen increased with time as soil N was further depleted and reached >80% between 98 and 114 days with the highest rate of inoculation [2]. Root nodulation as well as N and P, uptake was improved in green gram plant with the application of favourably interacting rhizospheric microorganisms as the inoculants and hence, yield was also increased in the phosphorous deficient soils and also the nitrogen uptake was increased from 12.12 to 17.82% and P increased from 12.10 to 13.71% under application of bio-fertilizers (*Bradyrhizobial* inoculants and PSB fertilizer) as compared to farmer's fertilizer level (uninoculant) [3]. An experiment on response of green gram (*Vigna radiata*) with biofertilizers under different fertility levels and recorded that the combined application of *Rhizobium* + PSB significantly improved the N and P uptake in green gram, respectively over the control.

### Efficiency of microbial inoculants on mobilization of essential nutrients
### Effect on various microbial inoculants on mobilization of nitrogen [4]
Total N accumulation in some non-nodulating soybean cultivars was to the extent of 70-95 kg N/ha without supply of any fertilizer nitrogen. Therefore, 100 kg N/ha was considered to be accumulated in soybean plants from sources other than atmospheric N fixation [5]. Production of growth-promoting substances and high colonization ability of rhizobacteria such as *Pseudomonas* because they enhance the nitrogen fixation of soybean when co-inoculated with *Bradyrhizobium japonicum* [6]. Conducted research work on effect of *Rhizobium japonicum* inoculum doses (liquid culture) on the growth and seed yield of soybean crop and observed

that the proportion of plant N derived from atmospheric nitrogen increased with time as soil N was further depleted and reached >80% between 98 and 114 days with the highest rate of inoculation [7].

Reported that macro-nutrients such as nitrogen, phosphorus and potassium play a crucial role in plant growth and yield. Soybean nitrogen requirements are met in a complex manner, as this crop is capable of utilizing both soil N (mostly in the form of nitrate) and atmospheric N (through symbiotic nitrogen fixation) [8]. Found that the inoculation with *Aspergillus awamori* treatment has maximum N uptake at flowering and harvesting and it was superior to all the treatments [9]. Application of a small amount of N at planting called as ‘‘starter N’’ is to be beneficial to improve early growth and yield of soybean [10]. The dual inoculation of *Rhizobium* and *PSB* resulted more availability of N and P because of their association in solubilization from non-exchangeable to labile form, which leads to significant increase in growth and yield attributes as compared to single or uninoculated plot [3].

The effect of combined application of *Rhizobium* + PSM and found more N and P uptake. The magnitude of increase in N uptake was 72.8, 33.7 and 39.6% in seed and 66.3, 25.1 and 33.2% in straw, where-as P uptake was 83.1, 36.8 and 29.1% in seed and 59.1, 22.2 and 17.9% in straw by greengram respectively over the *Rhizobium* and PSB alone. The uptake of N and P might have increased due to increased content and biological yield with the use of biofertilizers

**Effect of microbial inoculants on mobilization of phosphorus** [11]

Studied the relation between nutrient P and Zn levels and the phytic acid, P and Zn concentrations in soybean (*Glycine max*) seed. The effects of nutrient P treatments on the concentrations of phytic acid, seed P and leaf P were also studied in the p-sensitive cultivars. The cultivars and isolines more closely paralleled leaf P concentration observed during seed development, than those observed at the onset of seed development [12]. Reported that phosphate solubilizing bacteria inoculants simultaneously increases P uptake by the plant and crop yield. Strains from genera *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most power full phosphate solubilizers. The principal mechanism for mineral phosphate solubilization is the production of organic acids and acid phosphatases play a major role in the mineralization of organic phosphorous in soil [13].

Stated that phosphorus (P) is a major growth-limiting nutrient, and unlike the case for nitrogen, there is no large atmospheric source that can be made biologically available. Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases are the attributes associated with phosphorus nutrition [14]. Revealed that inorganic forms of P are solubilized by a group of heterotrophic microorganisms excreting organic acids that dissolve phosphatic minerals and/or chelate cationic partners of the P ions i.e. $PO_4^{-3}$. Directly, releasing P into solution and soil microorganisms play a key role in soil P dynamics and subsequent availability of phosphate to plants [15]. Reported maximum root weight highest number of nodules in the *Bradyrhizobium* and $P_2O_5$ treatment. It was interesting to note that plants inoculated with *Pseudomonas* alone also produced nodules. The possibility of contamination cannot be overruled. However, increased nodulation was seen due to phosphate solubilizers (*Sordariafimicola*).

[16] Showed that in comparison to fertility status of unfertilized plots and soil under no inoculation plots fertilized with N 20 + P 40 + K 20 + S 40 kg ha$^{-1}$ and *Bradyrhizobium japonicum* + *PSB* treated plots had highest available N and P content in soils after harvest of the crop [17]. Found that In green gram the *Rhizobium* alone did not increase seed P content. However, PSB alone increase P content as compared to control. Many researchers reported increased seed P content by phosphate solubilizing microorganisms. But dual inoculation without fertilizer could not improve seed P concentration. This may be due to competition of the microbes for P [18]. Observed that co-inoculation of synergistic microbes is benefited by phosphatic fertilizer application. It is evident from the colony-forming unit (CFU) values of the applied microbes in the rhizosphere as well. Number of pods was highly correlated with grain yield, seed N and seed P. [19] Conducted a pot culture experiment and their results revealed that inoculation of soybean seeds with *A. awamori* showed significant improvement in available P in soil treated with P sources followed by the bacterium *P. striata.*

**Effect of microbial inoculants on mobilization of potassium** [20]

Studied the Organic carbon and available K in the soil after the harvest of soybean increased over the control significantly when FYM was applied alone or along with bio-inoculants. The highest organic carbon (1.08%) and available K (222.3 kg/ha) were recorded with combined inoculation of *Rhizobium* + *Azotobacter* + PSB + FYM (T6), followed by *Rhizobium* + PSM + FYM (T15). The available soil K status after soybean harvest was depleted from initial level under all the biofertilizer treatments [21]. Noted that availability of N, P and K recorded in a treatment with 100% RDF + *Rhizobium* + PSB over control in soybean [22]. Studied the potash mobilizing biofertilizers applied in combination with *Rhizobium, Azospirillium, Azotobacter, Acetobacter,* PSM etc. Potash mobilizing bacterial based product containing *Frateuria aurentia* producing plant growth promoting substances which offers plant a multifaceted benefits in terms of growth, by mobilizing potash and making it available to crops. It also enhances the efficiency of chemical fertilizer.

**Effect of microbial inoculants on mobilization of sulphur** [23]

conducted a field experiment at University of Agricultural Science, Bangalore (Karnataka) on red sandy clay loam soil with soybean crop and reported that the available nitrogen and potassium was the lowest (140 and 231 kg ha$^{-1}$, respectively) with the application of 100% NPKS + Zn, B, Mo + Rhizobium + PSB. Available phosphorus and sulphur were low (36.4 and 13.5 kg ha$^{-1}$, respectively) with control which might be due to uptake of residual sulphur and phosphorus present in the soil by the crop.

**Effect of microbial inoculants on mobilization of micronutrients** [24]

Studied about zinc interfered with translocation of iron from roots to above ground parts of *Glycine max.* (L). during periods in which zinc impeded iron translocation, it also suppressed the production of reductant by roots. They concluded that in the root epidermis, potassium ferric cyanide formed a precipitate (Prussian blue) with ferrous iron derived from the previous supplied iron ethylene diaminedihydroxy phenyl-acetic acid. The reduction of ferric iron was suppressed by zinc [25]. Conducted a field experiment in *rabi*

1999-2000 on use of fertilizers, organics and biofertilizers in mustard and results revealed that effective use of FYM biofertilizers along with chemical fertilizers improved organic carbon and available Fe and Zn [26]. Worked on the three *B. aryabhattai* strains and foundwere enhancement of root and shoot dry weight, and zinc uptake in both soybean and wheat crops. Further, they also stated that inoculation of *B. aryabhattai* strains significantly increased shoot and seed weight, Zn uptake/assimilation as com-pared to un-inoculated control in soybean and wheat crops [27]. Conducted a study to evaluate the effect of micronutrient supplemented *Bradyrhizobium* biofertilizers on nodulation and dry matter production of soybean. The result indicated significant increase in the nodule number, nodule dry weight and nodule N content due to seed treatment of *B.japonicum* strains along with the combination of zinc and molybdenum [28]. Studied the liquid microbial Consortium- A potential tool for sustainable soil health and reported that liquid PSM significantly increased micro nutrient content in soil like Mn, Mg, Fe, Mo, B, Zn, Cu etc., and make them available to the plant parts stimulates formation of fats, convertible starches and healthy seeds [29]. Found increased seed yield achieved upon inoculation of different *B. aryabhattail* strains as compared to un-inoculated control this may be mainly due to higher enzyme activities, microbial biomass-C, significant drop in rhizo-sphere pH, and redistribution among native zinc pools resulting in increased zinc availability for crop acquisition [30]. Studied the effect of zinc solubilizing bio inoculants on zinc nutrition of wheat (*Triticum aestivum* L.) The bacteria isolated from a Zn deficient soil namely *Burkholderia sp.* SG1, *Acinetobacter sp.* SG2 and *Acinetobacter s*p. SG3 showed Zn solublizing activity. These bacteria when used either individually or in combination augmented Zn nutrition of wheat crop and increased the concentration and uptake of Zn both in grains and straw.

**Conclusion**

A potential tool for sustainable soil health and reported that liquid PSM significantly increased micro nutrient content in soil like Mn, Mg, Fe, Mo, B, Zn, Cu etc., and make them available to the plant parts stimulates formation of fats, convertible starches and healthy seeds. Increased seed yield achieved upon inoculation of different *B. aryabhattail* strains as compared to un-inoculated control this may be mainly due to higher enzyme activities, microbial biomass-C, significant drop in rhizo-sphere pH, and redistribution among native zinc pools resulting in increased zinc availability for crop acquisition.

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