SUMMARY AND CONCLUSION
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The effects of microbial activities on the biogeochemical cycling of plant nutrients are essential for sustainable ecosystems. The results of this study of the interaction between a biotechnological practice (microbial inoculation) and low input technology (RP application) have demonstrated the effectiveness of such combined practices in improving sustainable nutrient supply to plants. This effectiveness relies on the improvement of soil microbiota performance. The salient features of the findings obtained from the present study are given below.

Eighty one potential phosphate solubilizing bacteria were isolated from rhizosphere soils of different crop plants. All the isolates were tested for their ability to solubilize insoluble inorganic phosphates in liquid medium. Seventeen isolates showed promising results and they were re-evaluated for their P solubilization potential using Pikovskaya’s and NBRIP-BPB media. Two isolates were selected on the basis of their highest P solubilization in liquid media.

The most efficient isolates were identified as *Gluconacetobacter* sp (MTCC 8368) and *Burkholderia* sp. (MTCC 8369). Fatty acid methyl ester (FAME) analysis confirmed the morphological, physiological and biochemical identity of the isolates. These two bacteria along with a standard phosphate solubilizing bacteria (*P. striata*) were used for the further study.

16S rDNA typing of the selected isolates showed that these organism exhibit close similarity with *Gluconacetobacter* and *Burkholderia*
genera. RAPD fingerprints of the isolates were produced by the PCR amplification of the bacterial DNA using a 20 mer RAPD primer. The RAPD profile was unique due to the high annealing temperature used for the PCR reaction and 20 mer RAPD primer that binds more specifically to the template DNA. This RAPD fingerprint could be used as a rapid identification of these bacteria.

Studies were undertaken to determine the effect of various physiological factors (pH, temperature, carbon sources, nitrogen sources, salt concentrations and sugar concentrations) on phosphate solubilization by the isolates. The results revealed that the isolates preferred pH around 7 and temperature around 30°C for efficient phosphate solubilization. Glucose was the preferred carbon source for *Burkholderia* sp. However, *Gluconacetobacter* sp. showed maximum phosphate solubilization in presence of either glucose or lactose. Ammonium sulphate was noted as the best nitrogen source for *Burkholderia* sp. and *P. striata*. On the other hand *Gluconacetobacter* sp. preferred potassium nitrate for best TCP solubilization. When the glucose concentration in the media was increased from 1% to 3% a substantial increase in P solubilization was detected in all the three isolates. Similarly, isolates showed high P solubilization in presence of 0.1-0.5% of sodium chloride.

Solubilization of tricalcium phosphate and rock phosphate by the selected isolates were studied for a period of 30 days. *Gluconacetobacter* sp. solubilized maximum P after 15 days of incubation. On the other hand, 18 and 14 days were found to be optimum incubation time for *Burkholderia* sp. and *P. striata* respectively. RP solubilization pattern also showed similar trend though there was light variation in incubation time compared to TCP solubilization. pH profiles of the isolates revealed that
there was no direct relation between the phosphate solubilization and pH though an inverse correlation between these factors was detected during the early hours of P solubilization.

Phosphate solubilization potential of the selected isolates was checked in medium containing buffer and pesticides. The results indicated that buffering action of the media and pesticides had direct influence on the P solubilization potential of the isolates.

The most widely accepted mechanism of P solubilization is the production of organic acids by the phosphate solubilizing bacteria. This forced us to screen the culture filtrates of the bacteria for the presence of organic acids. HPLC analysis of the culture medium revealed the production of organic acids by the isolates. Gluconic acid was the principal organic acid detected in the culture filtrate.

In addition to P solubilization, the selected bacteria showed many traits associated with plant growth promotion. Both the isolates showed strong antagonistic activity against phytopathogenic fungi (*Phytophthora* sp. and *Fusarium oxysporum*). All the isolates were positive for siderophores and EPS production. *Gluconacetobacter* sp. was detected as a nitrogen fixing organism. On the other hand, *Burkholderia* sp. was unique with respect to its ability to produce plant growth hormone IAA.

A pot culture experiment was also conducted with rice as the test crop to assess the effect of bacterial isolates on growth, yield and nutrient uptake of crop plants. Inoculation of soil with phosphate solubilizing bacteria with or without RP substantially improved the phosphatase activity of the soil. The highest phosphatase activity was detected in treatments receiving *Gluconacetobacter* sp. Similarly, dehydrogenase
activity of soil was checked at every 30 days interval of crop growth. *Burkholderia* sp. + *Gluconacetobacter* sp. + RP<sub>60</sub> treatment showed the highest activity followed by *Burkholderia* sp+ RP<sub>60</sub> and *Gluconacetobacter* sp. + RP<sub>60</sub> treatments. The treatment receiving SP<sub>40</sub> and *Gluconacetobacter* sp.+ *Burkholderia* sp.+ RP<sub>60</sub> registered maximum soil P and they were at par during growth period. This clearly demonstrates the ability of inoculated microorganism to establish and proliferate in the natural soil habitats.

The nitrogen content and nitrogen uptake of plant was also appreciably increased due to PSB inoculation. *Burkholderia* sp. + *Gluconacetobacter* sp. with RP showed best results. The P content and uptake was also substantially higher in RP amended inoculated series compared to their respective controls without RP.

In presence of added RP, use of all the cultures significantly enhanced the straw and grain yield of rice. The increase in yield was prominent in treatment receiving *Burkholderia* sp. + *Gluconacetobacter* sp. + RP<sub>60</sub> followed by *Burkholderia* sp+ RP<sub>60</sub> and *Gluconacetobacter* sp + RP<sub>60</sub> treatments. The selected isolates also produced significant influence on all the yield parameters of rice viz; average grain weight/panicle, number of panicles, number of seeds/panicle, panicle length, and number of tillers/plant. All the RP<sub>60</sub> inoculated series showed statistically significant higher nutrient uptake compared to their respective controls.
5.1 **Future perspective**

1. An elaborate study seems to be worth full to expand the plant growth promoting traits of selected isolates.

2. Nitrogenase activity of *Gluconacetobacter* sp. can be studied under suboptimal nitrogen content in soil and this might provide more information to utilize dual characters of this organism.

3. *Burkholderia* sp. can be exploited for various biotechnological applications especially for the bioremediation of recalcitrant xenobiotics and as biocontrol agents.