Phosphate dissolving fungi: a sustainable alternate for soil P nutrition

Phosphorus (P) is an indispensable element for plants due to its role in photosynthesis, respiration, energy storage and transfer and cell division. Its low availability in soil may limit the agricultural production in the next millennium. The poor use efficiency of applied inorganic P fertilizer due to chemical fixation, adverse effect of excessive use of P fertilizer (to meet plant P nutrition) on soil health and microbial diversity, high cost of chemical P fertilizer, expected higher consumption and depleting rock phosphate reserves necessitate the need for alternate agricultural practices that maximize the crop yield by increasing the availability of P that otherwise is inaccessible to plants. Employment of microbial inoculants for biological extraction of soil P is one of the promising, environment-friendly strategies that can improve the P availability from the native organic and inorganic P sources. However, the selection of efficient phosphate dissolving microbial strain to develop bio-fertilizer for target nutrient delivery in soil niche is of prime importance.

Fig. 1. A-URP solubilization, B- TCP solubilization, C-Siderophore production by *A.niger*

The first part of study investigated the selection of fungal strains with “multi-functional” attributes such as P dissolution and plant growth promoting traits and biocontrol active strain with capacity to solubilize P bearing minerals. Thus, potential of *Aspegillus niger* (ITCC 6719) and *Trichoderma harzianum* (ITCC 6721) for release of inorganic P (Pi) from sodium phytate (organic P source), tri calcium phosphate (TCP), Udaipur rock phosphate (URP), iron phosphate (FP) and aluminium phosphate (AP) was explored. *A. niger* could mineralize sodium phytate with release of 5-21 EU as inorganic P (Pi) min^{-1} and solubilize 65 %, 18 %, and 20 % of the P added through TCP, AP and URP respectively. However, *T. harzianum* with biocontrol potential was most competent to solubilize 14 % of the P added through FP. Increasing carbon concentration in growth medium affected the fungal solubilization efficiency of TCP, URP, AP and FP. Study showed that *T.harzianum* preferred 7 % carbon concentrations for mediating URP solubilization, compared to 5 % by *A.niger*. Both test fungi produced auxin, siderophore and ammonia (plant growth promoting traits) and could solubilize zinc.

The second part of the study investigated the mechanism involved in mineralization of organic phosphate and solubiliztion of inorganic phosphate. The cell free culture filtrate of *A. niger* detected high phytase and low acid phosphatase activity titer for mineralization of organic P whereas the results were vice versa for *T. harzianum*. Succinic and formic acid were detected in culture filtrate of *A. niger* with TCP as P source compared to citric, malic, succinic and formic acid with URP. However, absence of acid in culture filtrate of *A, niger* with AP as P source indicated that its solubilization was mediated through proton release during ammonium assimilation. Contrarily, citric acid was the main acid produced by *T. harzianum* for mediating the solubilization of TCP, URP and FP whereas AP was solubilized by production of succinic acid. Phosphate solubilization studies by pure organic acids also confirmed that citric acid was most efficient to release P from URP and FP

The third part of the study investigated the role of phosphate solubilization and production of indole acetic acid (IAA) on wheat plant growth under salt stress. Inoculated pots received 50 ml spore suspension of *A.niger* (1×10^{6} CFU ml$^{?1}$) and salt concentration (4.0 g NaCl kg?1drysoil), added sequentially as water solution.. At 30 d crop growth, root length and root biomass of wheat seedlings in inoculated hydroponic system increased by 34.81% and 37.7% respectively compared with their un-inoculated counterparts (without NaCl). Developing bio-inocullant using *A.niger* with multifunctional traits could be a sustainable approach to improve soil P availability, promote plant growth and alleviate adverse effect of salt stress.

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