Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.8539

Soil Geochemical Dynamics of Arsenic and Nutrients Affects Microbial Diversity, Elemental Release and Plant-Microbe Interactions: A Long-term Study from Field to Genomics

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Alluvial soil is enriched in nutrients that helps to maintain a healthy plant-microbial symbiosis. This six-yearlong field-based study focuses on the As dynamics in agricultural soil affecting the rice productivity, plant physiology, and altered soil microbial communities under differential cultivation approaches. Soil macro-micronutrients were also found to modulate the microbial communities while expressing differential As-resistance and metabolizing genes in the soil systems. Metagenomics and gene-specific High Throughput sequencing (HTS) of predominant soil microbes with Gene Ontology (GO) profiling, KEGG metabolism pathways assessment, Panther-pathways analysis, microbial network distributions were performed [1,2] in every season of each year to understand how As and soil nutrient dynamics conjugatively influence the dominant soil microbiome. Such altered microbial profile also induce plant As responsive genes and biochemical enzyme productions under changed soil conditions. This first-of-its-kind study indicated that the drying-wetting (DW) irrigation, compared to the continuously flooding (CF), can retain a redox status of soil optimal for the soil microbes [3] to thrive while releasing the greatest pulses of bioavailable nutrient pool. Such burst of nutrients triggers the plant's growth and reduces the generation of stress markers even under high As contaminated soil. Metagenomics and HTS of microbes showed that *ars* operon and *aio-arr* gene clusters were mostly up-regulated in the CF fields to tackle the high As availability. DW field analyzed microbes expressed these genes in a lower degree with greater expressions of central carbohydrate metabolism, multivitamin-cofactor synthesis, nitrogen-sulfur metabolism and amino acid synthesis, as analyzed via GO and KEGG modules. Microbial network analysis from DW samples indicated greater species enrichment, α/β indices with higher relative abundance and rarefaction analysis. Rice harvesting index from FL and DW fields suggested a prominent role of microbes in reduction of As stress and enhanced nutrient uptake. This whole study provides an important understanding of soil elemental influence on microbes to confer changes in crops.

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