Microbiome dynamics in rice's rhizosphere when stressed by climate or soil arsenic

E. MARIE MUEHE[1,2], DANIEL STRAUB[1], SARA KLEINDIENST[1], ANDREAS KAPPLER[1], SCOTT FENDORF[2]

[1]University of Tuebingen, 72076 Tuebingen, Germany
[2]Stanford University, Stanford, CA-94305, USA

As rice sustains more than half of the global population, we need to assess the constraints to rice production today and for the future. An increase in global temperatures and atmospheric CO_2 concentration is expected to affect the production of rice adversely, which directly translates to impeding food security. Previous greenhouse studies in our lab showed that soil arsenic (As) in combination with a shift in climate decreased rice productivity dramatically. The partitioning of As from soil solids to soil solution in the rhizosphere increased with climatic change, enhancing the toxic effects of As on rice. Here, we elucidate the combined impact of climatic and soil As conditions on the rhizosphere microbiome of rice to evaluate observed differences in rice productivity.

Mechanistic studies in rhizoboxes showed that the tiller width of rice decreased with increased temperature. Lower total and spatial radial oxygen loss may result from roots into the surrounding soil, creating a steeper redox gradient away from roots. As a result, less iron (Fe) plaque with lower As retention capacity was formed around the roots. Sequencing of bacterial and archaeal 16S rRNA genes as well as fungal ITS in combination with qPCR revealed the abundance and diversity of microbial communities involved in the rhizosphere of rice under the imposed climatic and soil As conditions. We spatially resolved microbial communities from the bulk soil to the rhizosphere soil, root surface, iron plaque, and root endophytes. To this end, we specifically map the dynamics of microbial functional groups involved in As redox cycling and detoxification, Fe plaque formation through Fe redox cycling, plant growth promotion, plant-microbe interaction, and plant or microbe pathogenicity.

In sum, our data indicates that climatic change will affect the microbiome of rice's rhizosphere differently compared to elevated soil As. Consequently, we show that Fe plaque formation as well as its ability to retain As in the rhizosphere is not just determined by plant activity but also by rhizosphere microbiome dynamics.