Exploring the mechanisms by which rhizosphere bacteria promote plant growth

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Abstract

It is well established that specific rhizosphere bacteria have the ability to promote plant growth. However, the molecular mechanisms that underlie the ability of these bacteria to associate with plant roots (both as epiphytes and endophytes), as well as to promote plant growth, are still poorly understood. In our laboratory, we are exploring both the bacterial and plant functions necessary for the establishment and efficacy of these beneficial plant-microbe interactions. We employ plant model systems such as Arabidopsis thaliana, Brachypodium distachyon and Setaria viridis to explore the transcriptional, proteomic and metabolic response to bacterial inoculation. For example, the data demonstrate a clear difference between the plant response to inoculation with wild-type bacteria and mutant strains unable to fix atmospheric nitrogen, emphasizing the impact of nitrogen fixation in these associations. We are also utilizing genome wide association analysis to define those specific plant alleles important for the plant response to bacterial colonization. With regard to the bacteria, we are using well-characterized plant growth promoting bacteria (PGPB), including Azoarcus olearius, Azospirillum brasilense, Herbaspirillum seropedicae, and Bacillus pumilis. As one approach, we conducted Tn-seq experiments to define those bacterial genes important for bacterial colonization of the rhizosphere. For example, these experiments identified genes involved in polyhydroxybutyrate (PHB) biosynthesis and catabolism as playing a crucial role in the ability of the bacteria to promote plant growth. In general, we do not find evidence for a strong role for phytohormone synthesis or response in the experiments we have conducted. The data suggest that the plant response to bacterial colonization is likely a multigenic, quantitative trait, which may vary significantly between genotypes of the plant host or bacterial partner.

Assessment of Hydrogeomorphic Hazards in the Context of Sustainable Land Management

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Abstract

This presentation focuses on the importance of understanding, mitigating, and preventing of natural hazards that impact people and their environments around the world, including the hydrogeomorphic processes that affect these hazards, as well as the implications for sustainable land management. Complex hydrogeomorphic processes contribute to both chronic and episodic hazards, inducing gully erosion, debris flows, glacial/permafrost hazards, and landslides depending on the dominant earth surface dynamics and environmental setting. For example, the 2016 Kumamoto Earthquake caused numerous landslides associated with ground shaking, but also poses subsequent susceptibility for debris flows and landslides due to infilling of headwater channels with landslide sediment and development of fissures along ridgelines that promote preferential flow. Similarly, preferential flow in seismically-induced fissures may have induced large landslides in loess deposits in the Fergana Basin of Kyrgyzstan. These impacts in Japan and Kyrgyzstan pose major problems for sustainable agriculture and pasture management.

A benchmark finding in hydrology involved the discovery of zero-order basins, including their hydrogeomorphic function. Much of this initial work was conducted in Tokyo University of Agriculture and Technology and TUAT may play a future significant role in related hydrology and geomorphology topics. These features are now recognized as having unique hydrological and sediment generation functions and are recognized as unique landscape elements in land management, such as leave areas in forest harvest plans.

Hydrogeomorphic processes in drylands of Australia, Saudi Arabia, and Tajikistan control gully development and erosion, as well as episodic debris flow initiation (e.g., in wadis of southwest Saudi Arabia). In the Pamirs of Tajikistan, melting glaciers and changes in snow accumulation and snowmelt affect not only the occurrence of floods and landslides, but also summer droughts. These changes in water resources present major challenges for sustainable agriculture in the dry, high elevation Pamir environment that is disproportionally affected by climate change. However, climate change impacts are not uniform across this region in terms of snow and glacier melt and subsequent contributions to river and stream flow. Disintegration of permafrost in a warming climate appears to be an underestimated process in this high elevation region, with great potential to contribute to mass wasting.

Throughout Central Asia, adapting to environmental change, developing sustainable land management and supporting resilient mountain societies will become increasingly important in an uncertain future. Such adaptations will benefit from implementation of detailed

environmental monitoring networks supported by international collaborations. New technological advancements, such as drone surveys, can also be applied in remote regions to benefit disaster mitigation, land degradation recovery, and food security. Accordingly, the Mountain Societies Research Institute of University of Central Asia is collaborating with TUAT and University of Tsukuba in a proposal to SATREPS to assess the impacts of climate change and variability on local water resources, hazard vulnerability, and agriculture production in Pamir mountain communities.

Publications directly related to this 3-year GIR award:

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GaN-on-GaN technology - challenges and perspectives

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Abstract

GaN-on-GaN technology will be described. Bulk GaN crystallization by halide vapor phase epitaxy (HVPE) and ammonothermal method will be presented. Scenarios for the further development of crystallization and wafering processing (GaN substrates preparation) will be shown. The best technologies for preparing of electronic device structures will be discussed.

Time Series and Image Reconstruction using Block Hankel Tensors and Tensor Networks Completion

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Abstract

Tensor completion is a problem of estimating the missing or corrupted by outliers entries of partially observed tensors.
Tensor and matrix completion algorithms have received recently wide attention due to many potential applications in areas like image enhancement, denoising and image reconstruction. In this talk, we provide a modern overview of recent advances in tensor completion algorithms from the perspective of specific practical applications.
We will discuss and overview efficient approaches for tensor completion for time series/image reconstruction using hankelization and several ways of construction of high -order block Hankel tensors.
The original noisy and/or incomplete data sets are represented by high order tensors and next the tensor completion is performed in embedded space using low-rank tensor decompositions, especially tensor train and tensor ring.
In the next stage, original data are reconstructed by converting block Hankel tensors back to original formats.

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Changing the Molecular Zip Code: Addressing Small Molecules to Subcellular Compartments Using Chemical Modifications

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Abstract

We recently demonstrated, for the first time, that targeting of an antifungal drug to a particular organelle can significantly improve the therapeutic properties. Azole antifungal drugs are amongst the very few classes of antifungal drugs and are often the first line of antifungal infection therapy. We developed antifungal azoles that were designed to localize to the endoplasmic reticulum (ER), which harbors the target of the azole class of antifungals, the cytochrome P-450DM. The antifungal activity of these azoles against a panel of *Candida* pathogens was over two orders of magnitude more potent than those of the commonly used antifungal azole drug fluconazole and of antifungal azoles that were found to localize to the mitochondria, which does not harbor cytochrome P-450DM. Moreover, unlike fluconazole and the mitochondrially-directed antifungal azoles, ER-directed azoles evoked significantly lower tolerance amongst *Candida* pathogens, which is associated with clinically persistent fungal infections. Taken together, this implies that the improved antifungal activity of ER-directed antifungal azoles results from the higher local concentration of this azole in proximity to the ER-localized target enzyme.

The results of this study suggest that adoption of the "target-organelle directed drug" approach in general, and the design of the ER-directed antifungal azoles in particular, has the potential to markedly improve the potency of antifungals and to combat the rapid emergence of drug resistance.