Arbuscular Mycorrhizal Fungal Biodiversity and Functionality: From Natural Grasslands to Agricultural Sustainability

In the face of continuous population growth and global climate change, ensuring food security remains a key challenge for humanity. Although traditional intensive agriculture has significantly increased crop yields, it has also caused serious threats to the environment and soil health. To avoid these threats or reduce their effects, it has been proposed to manage agriculture according to a sustainable system by limiting the use of chemical fertilizers and pesticides and instead using microorganisms capable of improving the uptake of nutrients by plants and increasing their resistance to stress. Such microorganisms can be arbuscular mycorrhizal (AM) fungi, which live in symbiosis with about 80% of terrestrial vascular plants and, e.g., (i) improve plant productivity, (ii) influence the cycling of carbon, nitrogen and phosphorus, and (iii) alleviate the effects of different stresses. Despite these facts, the knowledge of the diversity and distribution of AM fungi in the world and the possibilities of using these fungi in practice are very low. There are no answers to the questions, e.g., What are the characteristics of AM fungal communities? How do they interact with plants? How do AM fungal community structure and their functioning respond to climatic and environmental changes? These shortcomings make it difficult to provide scientifically based recommendations for the management of agricultural systems and the application of mycorrhizal technologies. Therefore, this research project intends to answer these questions, clarify other doubts, and characterize potential novelties based on comprehensive analyses of data from agricultural sites and natural meadows located in regions (China versus Poland) that differ greatly in terms of climate and soil abio- and biotic properties. By combining various techniques, including traditional collecting and identifying AM fungi, amplicon sequencing, reconstructing phylogenies, inoculation with mycorrhizal communities or single spores, and mycorrhizal functional tests, the project aims: (i) to characterize the structure and function of AM fungal communities in croplands and grasslands located in China and Poland, (ii) to reveal the mechanisms underlying agricultural impacts on AM fungal symbiotic functions, (iii) to explore the coupling mechanisms between climate, environment, AM fungal community structure, and mycorrhizal functions in agricultural and grassland ecosystems, and (iv) to establish the first transcontinental AM fungal resource bank by large-scale exploration and preservation of fungal strains. The expected outcomes will (i) advance theoretical frameworks for the relationship between AM fungal community structure and function, (ii) provide new insights into AM fungal adaptive evolution under human disturbances and climate change, (iii) offer scientific evidence for biodiversity conservation and mycorrhizal applications, and (iv) reveal new AM fungal taxa, allow for the verification of described taxa, and greatly facilitate the classification of Glomeromycota members. In addition, the vast amount of research material that will be collected during the project will allow for the continuation of joint research that was initiated with the description of two new species (*Glomus chinense*, *Dominikia gansuensis*) of Glomeromycota in 2022.