FY2014

Molecular Basis of Symbiotic Networks and Its Application

Exploring the possibility of arbuscular mycorrhizal (AM) fungi as a substitute for finite fertilizer

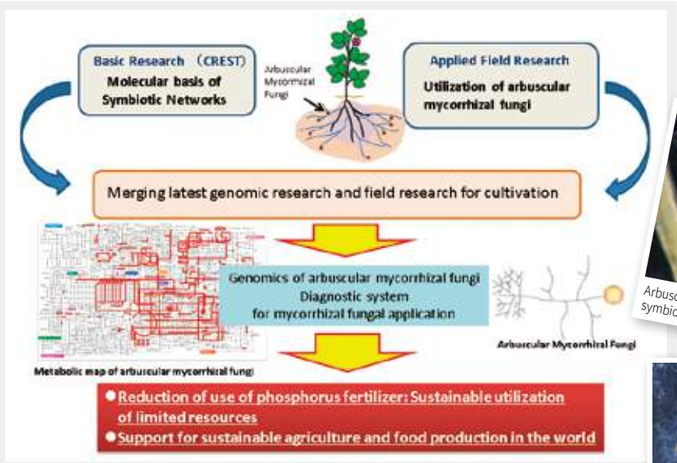
Agriculture supports our daily life, and one of the fertilizers used for agriculture is phosphorous fertilizer. The phosphate rock that is the raw material of phosphorous fertilizer is a limited resource. As Japan is 100% dependent on imports to meet its domestic demand, reducing its use is a major issue in consideration of future agriculture and the supply and demand of food. As a clue that might solve this issue, the focus is on arbuscular mycorrhizal (AM) fungi, which establish symbiotic relationships with 70 to 80 % of vascular plants on their roots.

We are trying to clarify the mechanism of the symbiosis between AM fungi and plants based on the idea that we can reduce phosphorous fertilizer use by making use of the characteristics of AM fungi. Previous CREST research has provided insights into the molecular infrastructure that clarified the symbiosis mechanism. For example, a group at Osaka Prefecture University found that the factor activating AM fungi is strigolactones, a substance produced by plants.

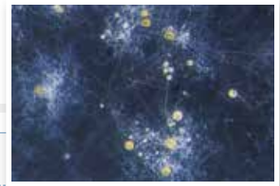
Developing technology to utilize AM fungi to bring revolutionary changes to agriculture

In the ACCEL project, we aim to develop the most suitable technology for utilizing AM fungi by bringing these findings to field-based research. We will sequence the genome of mycorrhizal fungi and perform field inoculation experiments to evaluate the efficacy of arbuscular mycorrhizal fungi in terms of the reduction of phosphorous fertilizer use. Based on these findings, we will develop a diagnostic technology for effective use of arbuscular mycorrhizal fungi.

The utilization of arbuscular mycorrhizal fungi and reduction of phosphorous fertilizer use will drastically change agriculture, contributing to solving the problems of food supply and demand which we must deal with on a global basis.



Arbuscular mycorrhizal fungi that live symbiotically with capillary roots from carrots



Multiplying arbuscular mycorrhizal fungi

Arbuscular mycorrhizal fungi

These are AM fungi that establish a symbiotic relationship with plants on their roots. The fungi receive photosynthetic products such as sugars from plants in exchange for nutrients such as phosphate and water, which the fungi extract from the soil through their hyphae. The arbuscular mycorrhizal fungus the present research deals with is an obligate symbiotic fungus that cannot live alone, and is useful, for example, in improving the disease resistance of plants.

Research Director

Masayoshi Kawaguchi

Professor, National Institute for Basic Biology, National Institutes of Natural Sciences

Arbuscular mycorrhizal fungi are ancient organisms that have even been found in fossils more than 400 million years old. Their biology is shrouded in mystery. My goal is to make the symbiosis mechanism clear, thus establish this as an effective culture technology and make both plant production and environmental preservation possible. So far, using *Lotus japonicus*, a model of legumes, we have isolated many mutants of arbuscular mycorrhizal fungi that are poor at symbiosis and identified the genes responsible, allowing us to clarify the mechanism.

In this ACCEL project, I am moving ahead with research in collaboration with many research institutions, including experts in the field. We, the mechanism clarification group, are going to sequence the genome of the most typical arbuscular mycorrhizal fungus, and then find why they cannot proliferate without plants and why they cannot live alone.

Program Manager

Masanori Saito

ACCEL Program Manager, Japan Science and Technology Agency

My research focus is in agriculture and soil science, and, as the Program Manager, I hope to play the role of applying the laboratory results to the field, or in other words, applying fundamental research results to agricultural fields.

In the ACCEL project, I am connecting state-of-the-art genome research with field-based research as well as organizing cultivation tests. Working with many other members, I am growing beans and corns on various kinds of soil from all over Japan that have different environmental factors, and diagnosing the effective use of arbuscular mycorrhizal fungi. Based on the analytical results, I would like to build a system that can offer the most suitable "prescription" for arbuscular mycorrhiza fungi for different locations. In the future, I would like to propose a new sustainable agriculture that utilizes the functions of various soil ecosystems in each location, and expand this new agriculture overseas.

Arbuscular mycorrhizal fungi are the most common symbiotic microorganism of land plants. I hope to reveal the mechanism of spore formation and growth that depend on symbiosis.

In this research, although differences in regional environmental factors and annual climate fluctuations have been an issue, the joy we experience when agricultural crops grow successfully makes it all worth it.

The reduction of phosphorous fertilizer use by the application of arbuscular mycorrhizal fungi will lead to solving one of the 21st century's biggest problems, that of food production.

PROFILE MASAYOSHI KAWAGUCHI

1992: Ph.D. (Science), Graduate School of Arts and Sciences, The University of Tokyo; worked for The University of Tokyo and Niigata University; 2009: appointed to current post. Research into analysis of host factor group controlling root nodule or fungus formation, and sequencing arbuscular mycorrhizal fungi genomes.

PROFILE MASANORI SAITO

1981: Ph.D. (Agriculture), Graduate School of Agriculture, The University of Tokyo. Joined Tohoku National Agricultural Experiment Station (now National Agriculture and Food Research Organization); worked for The University of Tokyo and Tohoku University; R&D and coordination work on ecology, function, utilization of arbuscular mycorrhizal fungi, and effective phosphorous resource utilization.