SOLVING GLOBAL FOOD PROBLEMS WITH ETHANOL

Ethanol, one of the most commonly used alcohols in our daily life, may help to solve salinity stress problems that damage farm products.

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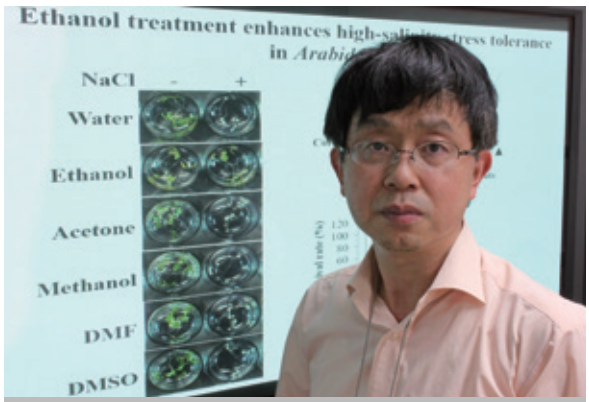
In recent years, global warming and continued abnormal weather have been spreading agricultural damage worldwide through drought, salt damage and high temperatures. In particular, the damage to wheat, soybeans, corn and other cereal crops is said to be equivalent to nearly 30% of the world's total amount of farm production. The development of farm products that are resistant to such climate changes is becoming increasingly important.



Motoaki Seki, team leader of the Plant Genomic Network Research Team, RIKEN Center for Sustainable Resource Science
PHOTO: AKIRA UMEZAWA

Against this backdrop, one of the problems in irrigation agriculture is salt damage, which occurs from the movement of underground salt to the topsoil. This has occurred in nearly 20% of the irrigation farms around the world. The exposure of plants to stress from a high concentration of salt limits their absorption of moisture at the root, inhibits photosynthesis and significantly damages the growth or yield of crops. As the global population continues to increase, the development of crops and fertilizer that are resistant to salt damage is one of the major challenges urgently needed to maintain sustainable food production.

A group of researchers including Motoaki Seki, team leader of the Plant Genomic Network Research Team at RIKEN Center for Sustainable Resource Science, Kaori Sako, a postdoctoral researcher, and Hong Mai Nguyen, a graduate student at the Department of Nanosystem Science, Yokohama City University, have discovered that ethanol increases plant resistance to salt. The study results were published in July 2017 as a research report in the online flash version of *Frontiers in Plant Science*, an international journal on plant science.

The discovery stems from the process of searching for compounds that make plants resistant to stress.

"In general, experiments on compounds use organic solvents such as ethanol, acetone and

Figure 1. Ethanol enhances high-salinity stress tolerance in *Arabidopsis thaliana*

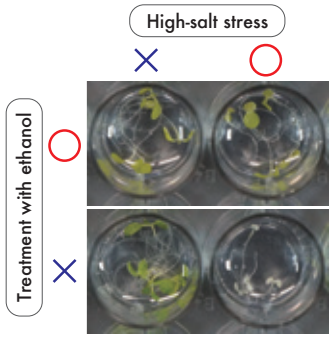
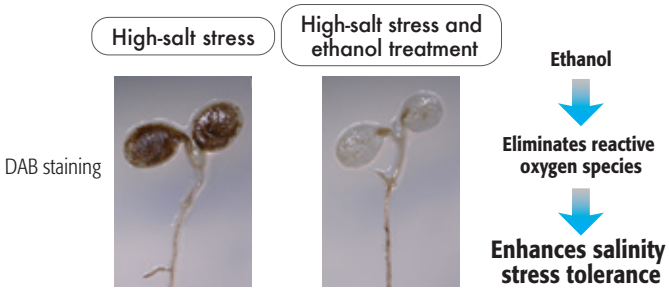


Figure 2. Accumulation of ROS in the cotyledon under high-salinity stress condition in the presence or absence of ethanol



Treatment with ethanol increases salt resistance

Ethanol treatment works to control the accumulation of reactive oxygen species

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methanol to dissolve insoluble substances. A recent experiment also used several kinds of organic solvents and obtained data that made us suspect that the organic solvents, not the compounds, could have a property that makes plants stress-resistant," Seki explains.

First, the team conducted an experiment using *Arabidopsis* (rockcress), and found that the administration of ethanol strengthened salt resistance. When stress was applied as a high-concentration salt (0.6% sodium chloride), the *Arabidopsis* plants turned white and died. When treated with ethanol, however, the *Arabidopsis* plants were shown to survive, even under conditions of salt stress.

Next, gene expression analysis was performed to clarify the mechanism of strengthening salt resistance. This analysis led to the finding that ethanol treatment increased the expression of the genes that work to eliminate the reactive oxygen species* that are generated under the stress of high salt. The analysis also showed an increase in the activity of ascorbate peroxidase, an enzyme that eliminates hydrogen peroxide, which is a type of reactive oxygen species. Moreover, an experiment using rice also showed the effects of ethanol treatment to control the accumulation of reactive oxygen species and reinforce salt resistance.

Ethanol is one of the most common types of alcohol. It is extensively used in food additives and fuel as well as for sterilization and disinfection. Available at low prices, it has minor effects on the human body and is easily transportable and storable. For these reasons, making plants more salt-resistant through the use of ethanol is very advantageous in commercializing the substance.

"The effects of climate change on farm products and the food problem from the increasing population are becoming more severe year after year. Although some verification on farms will be necessary, application based on the outcome of the recent study can be expected to enhance the resistance to stress from causes such as drying and high temperatures, and to increase the yield of farm products. We would like to contribute to solving the global food problems through our study of stress adaption and resistance," says Seki.

The commercialization of this technology can be expected to help develop fertilizer for growing farm products that are resistant to salt damage, and increase yields in areas where the installation of irrigation systems is difficult.

** Reactive oxygen species: Unstable molecules that contain oxygen and that react with other molecules in a cell. Reactive oxygen species may occur as a result of in vivo energy metabolism and during the process of protection against infectious diseases. It may also be generated in plants subjected to environmental stress such as a high concentration of salt, high temperatures, drying and strong light. Reactive oxygen species play important roles in various life phenomena. However, an excessive accumulation of reactive oxygen species poses toxicity to cells.*