DREB Genes to Boost Harvests

*University of Tokyo Professor and Japan International Research Center for Agricultural Sciences Chief Researcher **Kazuko Yamaguchi-Shinozaki** has developed a genetic modification technology that creates plants resistant to various changes in environmental conditions. Takashi Sasaki reports on this technology that is expected to have applications for increasing food production and, in the future, prevent desertification.*

To date, the European Union and countries such as the United States, Russia and Canada have led the world in cereal production, but in recent years South American nations such as Argentina and Brazil have also seen rapid growth in production. However, as such emerging nations are incapable of developing sufficient irrigation facilities in agricultural areas that extend into semi-arid land, large-scale droughts can suddenly occur in years of low rainfall, leading to a cycle in which there is a sharp decrease in the harvest yield once every few years. The genetic modification technology developed by Kazuko Yamaguchi-Shinozaki of the University of Tokyo's Graduate School of Agricultural and Life Sciences has garnered a great deal of global attention as a means of preventing such crop damage.

"Currently, rapid environmental change and abnormal weather is emerging all over the world," Yamaguchi-Shinozaki says. "This has led to the issue of how to stabilize crop harvests. The objective of our research is to resolve this problem using genetic modification."

Through a long evolutionary process since they first began growing on land, plants have developed a tolerance to a range of environmental stresses, such as high and low temperatures and aridity. When Yamaguchi-Shinozaki began her research nearly twenty years ago, about fifty resistance genes that build this tolerance had been identified. The figure now stands as high as 3,000. These genes work in ways such as closing stomata (pores that transpire water), making leaves thicker to store water, and forming special proteins that protect cells from aridity. However, this tolerance is normally inactive inside genes as it can impede plant growth.

This tolerance has to be activated to grow plants with a high resistance to environmental stress. However, to develop strong plants that can survive under various environmental conditions, such as sudden aridity or temperature changes, it is necessary to simultaneously activate all these innate tolerances.

"Genes have components that are like keyholes and can turn this function on and off," Yamaguchi-Shinozaki says. "Because of this, we narrowed our target down to command genes that work on these various resistance genes, or in other words, those genes that play the role of a common key when placed under stress."

Breakthrough with Thale

Yamaguchi-Shinozaki's research team studied thale cress, an annual which is part of the

Brassicales order of flowering plants. The plant's genome is small and simple, and furthermore, it is a fast-growing plant that seeds in six to eight weeks after germination. However, even thale cress, which was thought to be the smallest flowering plant, has more than 26,000 genes. Identifying the key command gene required a lot of patience and repeated laboratory cultivation and verification. After four years of research, the command gene—DREB, or Dehydration Responsive Element Binding protein—was discovered.


TAKASHI SASAKI

In her laboratory at the University of Tokyo, Kazuko Yamaguchi-Shinozaki holds a Petri dish containing thale cress, the key command gene for which her research team discovered and is now utilizing with a view to producing "mighty crops that have large harvests."

Yamaguchi-Shinozaki experimented with placing the thale cress that had been genetically modified to create large volumes of DREB in a range of environmental conditions. She found that 99.3%of the genetically modified thale cress did not wither when kept in cold conditions of -6°C for two days as opposed to 0% before genetic modification; 65% did not wither when not given a drop of water for two weeks (0% before genetic modification); and 79.7% did not wither when only given sea water (13.8% before genetic modification). When these research results were published in *Plant Cell*, a U.S. botanical journal, in 1998, Yamaguchi-Shinozaki was reportedly flooded with inquires and offers of joint research.

According to Yamaguchi-Shinozaki, the most advanced research on the applications of DREB is on soybeans resistant to aridity. Types of soybeans that have been genetically modified to have an innate tolerance of herbicides and pests have proliferated, and this technology is relatively easy to apply to new genes. Joint research with an institution in Brazil has reportedly got the technology almost at a level of practical implementation. While the implementation objectives have yet to be met, experiments are being carried out across the world on the application of DREB on a range of other plants, including rice, wheat, eucalyptus, tobacco and peanut plants.

"The application of DREB genes is leading to the birth of mighty crops that have large harvests, are resistant to pests and herbicide, and are also tolerant to aridity and low temperatures. If they can be stably harvested on land in severe environments, the world food situation will change significantly," Yamaguchi-Shinozaki says. "Perhaps DREB gene technology can help to prevent desertification in the future through the development of plants that are tolerant to extreme aridity."

Takashi Sasaki is a freelance writer.