Rice for Dry Places

An international research project spearheaded by JIRCAS in Japan is promoting the development of rice and wheat that is resistant to dehydration-stress. **The Japan Journal** reports.

COURTESY OF JIRCAS

DREB transgenic rice (middle and right) shows a much higher level of tolerance to drought than wild types of rice (left).

Rice and wheat are indispensable for people throughout the world. It is said that each of these grains accounts for approximately 20% of the world's dietary energy supply. However, currently rice and wheat are being underproduced owing to water shortage. In the case of rice, of the 150 million ha of land under cultivation worldwide, half has no irrigation facilities, with the cultivation of rice relying on rainwater alone. In the case of wheat, of the 120 million ha of land under cultivation in developing countries, half comprises fields that receive inadequate precipitation. And the reduced yield as a result of water shortage is a cause of poverty among people in developing countries. Hence, the development of drought-resistant rice and wheat is a global research theme.

The Japan International Research Center for Agricultural Sciences (JIRCAS) in Tsukuba City, Ibaraki Prefecture, is one research institute that tackles such topics. In 2007, JIRCAS embarked on an international collaborative project called "Development of Abiotic Stress Tolerant Crops by DREB Genes," with a planned term of five years.

These DREB (Dehydration Responsive Elements Binding protein) genes were first discovered by the JIRCAS research team, and hold the key to the abiotic stress- (including drought) tolerance of plants.

"DREB genes are the genes that can switch other genes on and off, in other words transcription factors," says Takashi Kumashiro, director of the Biological Resource Division of JIRCAS. "Metaphorically speaking, it is akin to the way subordinates in a company move when ordered to do so by the department head."

Under normal conditions, DREB genes are not activated, but when plants are subjected to abiotic-stress, such as drought, they function to switch on several tens of types of gene. This causes proteins to be produced inside the plant, to protect itself from dehydration damage. DREB genes were initially discovered in *Arabidopsis thaliana*, with genes that function in the same way (OsDREB) later also being found in rice.

Normal rice dries up within days if it is not watered. However, rice into which these DREB or OsDREB were introduced did not dry up for twelve days even without water. Further, we know that even if the water has half the salinity of seawater, it still does not dry up. However, if these DREB genes are constantly activated, conversely the plant becomes somewhat dwarfed.

"We can liken it to the situation of taking out 'insurance' to cover every danger, with the high 'insurance premium' resulting in strained finances," says Kumashiro. "In other words, if DREB genes are activated only at times of dehydration stress, it is possible to grow dehydration-resistant plants that have high productivity."

For these DREB genes to function appropriately, the role of genes known as promoters is key. A variety of promoters exist, and the level of dehydration resistance changes depending on which promoters are combined in the DREB genes.

The current international collaboration project looks at how much dehydration tolerance is shown by paddy-rice, rice grown in a dry field, and wheat, into which genes that combine DREB genes with promoters were introduced, in an actual cultivated field.

Firstly, JIRCAS and the RIKEN research institute collaborate to compile genes that combine DREB and OsDREB genes isolated from *Arabidopsis thaliana* and rice with promoters, and send these to overseas collaborating research institutes. The International Rice Research Institute (IRRI) in the Philippines, the International Center for Tropical Agriculture (CIAT) in Colombia, and the International Maize and Wheat Improvement Center (CIMMYT) in Mexico introduce genes for paddy-rice, rice grown in a dry field, and wheat respectively to produce transgenic crops. These are cultivated in a greenhouse, a screenhouse and an isolated field, and evaluated for their drought tolerance.

To establish the effects of gene introduction within a limited period of time, the researchers selected the transgenic rice and wheat containing only one introduced gene. Accordingly, the research requires an advanced level of technology, and each of these research institutes has ample capability both in terms of technology and facilities. Further, since the countries themselves also face the problem of poor crops because of water shortage, it is an ideal collaborative research body.

"The mission of JIRCAS is to make a contribution to agriculture in developing countries, so we have no monopoly on the results," says Kumashiro. "We hope that the results of this project too will be global public goods that can be utilized by many people in developing countries."

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