

Arabidopsis studies: a faster way to discover genes

Finding traits for salt, drought and cold tolerance

By Susan McGinley

Many of the world's food crops grow in marginal soil. As desertification and erosion increase, cropland is reduced, forcing people to grow crop plants under conditions they are not traditionally adapted to, including high salt concentrations in soil and water, low water availability, and cold temperatures.

As crops fail and human populations begin to starve, the search for better adapted plants becomes more urgent. A novel technique for gene identification, under development at the University of Arizona, may help speed the development of more stress-hardy crop plants. Jian-Kang Zhu, a professor in the Department of Plant Sciences, has spent the last five years identifying and isolating genes from arabidopsis plants—a type of crucifer, the plant group that includes broccoli, cauliflower and cabbage—that can be used for biotechnological applications to make hardier crops. His research concentrates on how this particular plant adapts to stressful environments.

"We wanted to identify, out of 20,000 to 30,000 genes in a typical plant, how many actually help the plant cope with stressful environments," Zhu says. "Using arabidopsis, we have identified about a dozen genes so far that are of critical importance—several for salt, quite a few for chilling and freezing, and a few for drought." For some of these genes, the university is applying for patents.

Zhu needed to find a way to communicate with plants, to know what was going on inside them. He knew that genes in a plant could be turned off and on, expressing themselves in reaction to the environment, but wasn't sure exactly when this happened. "By the time you see drought symptoms in the plant, it's usually too late to do anything about it," he says. He has turned to fundamental science, specifically to genome studies (the analysis of the full gene complement in a set of chromosomes) to do this.

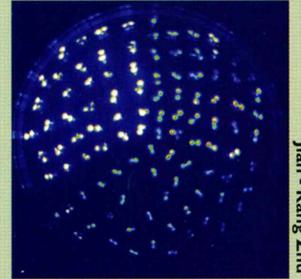
Zhu and his team use certain gene promoters in arabidopsis plants to help turn the genes on and off in response to stress. He puts the promoter together with something to make it glow—in this case, the firefly enzyme luciferase—and

introduces it into the arabidopsis plant to make it glow steadily when subjected to stress. This way he can identify the genes that control stress responses and isolate them. He puts the small plants, which are anchored on growth media plates, under temperature, water, or salt stress. In the case of chilling or freezing stress, the plants go into a refrigerator, to trigger the cold-response gene.

Since the luciferase enzyme induces a glow too weak to be seen by the naked eye, Zhu uses a camera to view the steady glow. To test which genes are responsible for the glow, he puts chimeric agrobacterium genes into the plant to induce mutations in the genes and make them nonfunctional, then observes the consequences of that plant's response to the environment. He keeps screening to find plants that are reacting abnormally, and separates them from normal plants.

"With 30,000 genes, you want to know which is important," Zhu says. "If a plant is not glowing, or glowing too brightly, we know a particular gene is involved." This process is painstaking, and yields results slowly, but works much faster than traditional breeding methods, which can take years as different plant generations are grown out and evaluated.

"The important thing is to know which genes are important for each trait," Zhu says. They may express themselves in both the leaves and the roots. "When we find those genes, we put them back into normal arabidopsis plants to make them better. If they do, they are ready to be put into crops, but doing that takes more effort." While arabidopsis takes six to eight weeks to reach maturity, crop plants take much longer. For this reason, Zhu is sending those genes to cooperative institutions where researchers are testing them on crop plants. "We've provided several genes to Cornell University to put into rice," he says. "We've also worked together with a group at Purdue to introduce some of these genes into tomatoes." In addition, commercial firms are interested in licensing patents to use these genes. Zhu cautions that it could still take years to make sure the genes express themselves consistently. ☐



Jian-Kang Zhu

Tiny arabidopsis plants glow in petri dish.

GENE USES

"The genes we find can be used to improve cereals, vegetable crops, and horticultural or fruit crops," Zhu says. "But making these transgenic crops isn't the only objective. The information we generate can be important for traditional plant breeding. If there's a concern for or an objection to using a transgenic approach for food plants, the gene knowledge can be used in traditional plant breeding methods as well."

Zhu notes that each gene's expression continues in future generations of the plant, unlike hybrids, which must be grown from new seed each year. However, these salt, drought, and cold-tolerant genes can also be combined with hybrid traits for other characteristics in a plant, and those would require new seed for each generation.

"Science just never ends," he says. "You could spend your whole life just on the characteristics of one gene."

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