This rice refuses to panic in floods

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UCD researchers help develop a variety that can survive in conditions that take a huge toll on a basic crop vital to millions

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As lifeguards say: If you're in trouble in the water, don't panic -- you'll tire yourself out.

Turns out, the same advice works for rice.

If submerged, the staple crop for half the world's population will use up energy reserves trying to grow above the water and die in a matter of days.

That's a big problem in many parts of Asia, where deep flooding damages an estimated 25 million acres of rice each year.

Now, a team of scientists, including several researchers at the University of California, Davis, has bred a rice that "knows" to save its energy when underwater. It can wait out floods of two weeks or longer.

The new breed's special ability also could prove useful in California by giving rice farmers another tool for killing weeds without using herbicide. Most weeds, like most standard varieties of rice, can't survive for long underwater. With the new flood-tolerant rice variety, farmers could drown their weeds without killing their crop.

The submersible rice marks one of the first successful uses of a new plant-breeding method that may someday allow researchers to develop food crops able to withstand not only flooding, but also cold weather, drought, disease and salty soil -- without the use of controversial genetic engineering techniques.

Here's how the flood-tolerant rice knows to stay calm under water:

When rice is submerged, the gas ethylene builds up around the plant.

In most varieties of rice, ethylene triggers a series of reactions that cause the plant to grow rapidly toward the surface. But if the water is too deep, the rice will exhaust its energy reserves and die before it can reach the water surface. Being underwater inhibits photosynthesis, meaning that the rice plant has a hard time generating more energy for itself.

The new rice variety contains genes that keep the plant from responding to the buildup of ethylene. Instead of growing rapidly, it shuts down for two weeks or more, conserving energy until -- it is hoped -- the water subsides and photosynthesis can start up again.

The idea to develop a flood-tolerant rice sprouted about 50 years ago, when researchers realized that a variety grown by farmers in eastern India could survive long periods under water.

But it tended to yield only a small amount of poor-quality grain. So plant breeders tried to cross it with higher-yielding rice varieties to create a new, best-of-both-worlds strain.

For decades, though, scientists couldn't manage to breed in the submersible trait without also bringing along the eastern Indian rice's undesirable traits.

That's a common problem in plant breeding, said Pam Ronald, a UC Davis plant pathologist who began working on the problem a decade ago. A paper she co-authored describing the rice research appears in the Aug. 10 issue of the scientific journal Nature.

"Using traditional breeding, it takes a long time to get rid of the traits that you don't want," she said. Enter the new technique: marker-assisted breeding.

With this method, pioneered by a Cornell University plant scientist, researchers first identify the genetic "fingerprint" of the genes that they'd like to bring from one variety to another.

Then, just as in traditional plant breeding, the two varieties are cross-pollinated, producing many offspring.

Next, the breeder identifies which of the offspring appears to have the desirable trait, but not the undesirable ones, and then the process is repeated, over and over.

Without the genetic fingerprint, selecting for complex traits is extremely difficult. With the new technique, though, researchers look directly at the DNA of the offspring to determine exactly what has been inherited.

"If you can do that in the lab, it's very helpful -- instead of having to flood a rice field 4 feet deep" to see if the offspring resist flooding, said Kent McKenzie, director of the nonprofit Rice Experiment Station in Biggs in Butte County. McKenzie did not work on the submersible rice project.

It's similar to what viewers see on the television show "CSI," he said, "where you can apply a (test) and tell how people are related," he said.

Marker-assisted breeding is important because it is considered by most countries to be an extension of conventional plant breeding. So-called genetic engineering is much more controversial. While researchers have used genetic engineering to develop many rice varieties, none is widely planted.

The flood-tolerant genes have been bred into two varieties of rice, one popular with California farmers, the other grown in south Asia.

It will likely take several more years of testing before California farmers adopt the new rice, Ronald said.

But farmers in India and Ban-gladesh already are using the Indian variety, said David Mackill, a plant breeder at the International Rice Research Institute in the Philippines and a former UC Davis professor.

Its ultimate success, Mackill said, will depend primarily on whether farmers find its special ability useful, and, of course, whether it tastes good.

"When you release a new variety, you just cross your fingers and hope that the farmers will like it," he said.

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Sacramento Bee / Michael A. Jones

UC Davis researcher Kenong Xu was part of a team that helped develop a variety of rice that can endure lengthy submersion in water.

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Professor Pam Ronald, a UC Davis plant pathologist, has co-authored an article describing research she did to help develop flood-tolerant rice. The article appears in the Aug. 10 issue of the scientific journal Nature. A new technique called marker-assisted breeding helped speed up the lengthy plant-breeding process.

(Chart) Sacramento Bee / Nathaniel Levine

Flood-tolerant rice

How the enhanced breed compares with most rice varieties:

1. In most Asian countries, rice is transplanted into shallow water. When rice is above the water level, it uses photosynthesis to generate energy – a process that is inhibited when the rice is submerged.

Conventional rice

New rice

2. If floods raise the water depth, water traps ethylene gas around the plant. This triggers growth in conventional rice.

Growing quickly to reach surface, rice exhausts its energy in a few days.

New version ignores ethylene build up and shuts down.

3. After two weeks or more, the floodwaters recede.

New rice is still alive after conserving energy; photosynthesis resumes

Traditional rice is dead.

Source: Professor Pam Ronald, UC Davis