New flood-tolerant rice offers relief for world's poorest farmers

August 9 2006

A gene that enables rice to survive complete submergence has been identified by a team of researchers at the International Rice Research Institute in the Philippines and at the University of California's Davis and Riverside campuses. The discovery allows for development of new rice varieties that can withstand flooding, thus overcoming one of agriculture's oldest challenges and offering relief to millions of poor rice farmers around the world.

While rice thrives in standing water, like all crops it will die if completely submerged for more than a few days. The development and cultivation of the new varieties is expected to increase food security for 70 million of the world's poorest people, and may reduce yield losses from weeds in areas like the United States where rice is seeded in flooded fields. Results of this study will appear in the Aug. 10 issue of the journal *Nature*.

"Globally, rice is the most important food for humans, and each year millions of small farmers in the poorest areas of the world lose their entire crops to flooding," said Pamela Ronald, a rice geneticist and chair of UC Davis' Plant Genomics Program. "Our research team anticipates that these newly developed rice varieties will help ensure a more dependable food supply for poor farmers and their families. And, in the long run, our findings may allow rice producers in the United States to reduce the amount of herbicides used to fight weeds."

Background

Rice is the primary food for more than 3 billion people around the world. Approximately one-fourth of the global rice crop is grown in rain-fed, lowland plots that are prone to seasonal flooding. These seasonal flash floods are extremely unpredictable and may occur at any growth stage of the rice crop.

While rice is the only cereal crop that can withstand submergence at all, most rice varieties will die if fully submerged for too long. When the plant is covered with water, its oxygen and carbon dioxide supplies are reduced, which interferes with photosynthesis and respiration. Because the submerged plants lack the air and sunlight they need to function, growth is inhibited, and the plants will die if they remain under water for more than four days.

During any given year, yield losses resulting from flooding in these lowland areas may range from 10 percent to total destruction, depending on the water depth, age of the plant, how long the plants are submerged, water temperature, rate of nitrogen fertilizer use and other environmental factors. Annual crop loss has been estimated at more than $1 billion.

"For half a century, researchers have been trying to introduce submergence tolerance into the commonly grown rice varieties through conventional breeding," said rice geneticist and study co-author David Mackill, who heads the Division of Plant Breeding, Genetics, and Biotechnology at the International Rice Research Institute. "Several traditional rice varieties have exhibited a greater tolerance to submergence, but attempts to breed that tolerance into commercially viable rice failed to generate successful varieties.

"We're especially pleased that we have been able to use the latest

advances in molecular biology to help improve the lives of the world's poor," Mackill added. "We're confident that even more important discoveries like this are in the pipeline."

Results of this study

Using genetic mapping techniques, the research team identified a cluster of three genes that appeared closely linked to the biological processes that either make rice plants vulnerable to flooding or enable them to withstand the total submergence that occurs during flooding.

The researchers then focused their attention on one of those three genes, known as the Sub1A gene. They found that when this gene is over-expressed, or hyper-activated, a rice variety that is normally intolerant of submergence becomes tolerant.

Further studies indicated that the Sub1A gene is likely successful in conferring submergence tolerance to rice because it affects the way the plants respond to hormones, such as ethylene and giberellic acid, that are key to the plant's ability to survive even when inundated with water.

Going one step further, the researchers introduced the Sub1A gene into a rice variety that is especially suited for growing conditions in India. The resulting rice plants were not only tolerant of being submerged in water but also produced high yields and retained other beneficial crop qualities. Development of submergence-tolerant varieties for commercial production in Laos, Bangladesh and India is now well under way.

In addition to providing a more stable supply of rice in developing countries, the researchers are hoping that the new gene will be useful in suppressing weeds and reducing herbicide applications for conventional and organic rice farmers in developed countries like the United States. If

water can be left on the rice for an additional week, it is expected that weed populations will be reduced.

The research team is now trying to identify all the genes that are regulated by Sub1A and to use this information to further improve tolerance to flooding and other stresses.

Source: University of California - Davis