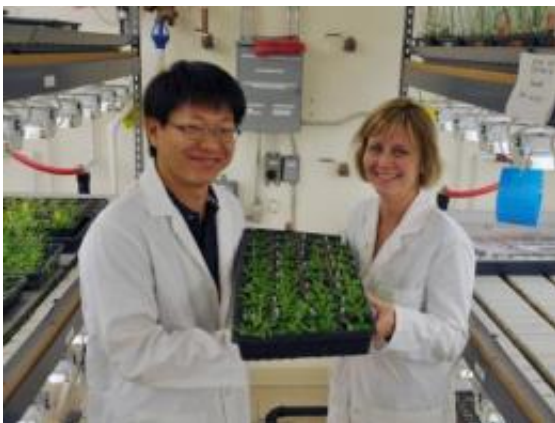


# Breakthrough in the production of flood-tolerant crops

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UC Riverside graduate student Seung Cho Lee (left) and his advisor Julia Bailey-Serres seen in the lab with a tray of *Arabidopsis* plants. *Arabidopsis* is a small flowering plant used widely by plant biologists as a model organism. Credit: UCR Strategic Communications.

As countries such as Pakistan, Bangladesh, Vietnam and parts of the United States and United Kingdom have fallen victim to catastrophic flooding in recent years, tolerance of crops to partial or complete submergence is a key target for global food security. Starved of oxygen, crops cannot survive a flood for long periods of time, leading to drastic reductions in yields for farmers.

Experts at the University of California, Riverside and The University of Nottingham now report they have discovered how plants sense low

oxygen levels to survive flooding – a finding that could lead eventually to the production of high-yielding, flood-tolerant crops, benefiting farmers, markets and consumers everywhere.

Specifically, the researchers identified the molecular mechanism involved. This mechanism controls key plant proteins, causing them to be unstable when oxygen levels are normal. When roots or shoots are flooded and oxygen levels drop, these proteins become stable.

"When a plant cell is starved for oxygen, it cannot efficiently generate adenosine triphosphate or ATP, the high-energy molecule plants use for energy storage," explained Julia Bailey-Serres, one of the key researchers participating in the study and a professor of genetics in the Department of Botany and Plant Sciences at UC Riverside. "Because the plant cannot generate enough energy to sustain normal growth, it tries a different approach: it taps into its energy reserves, resulting in more sugars breaking down, as opposed to when oxygen is available, in order to produce ATP. These subtle changes in metabolism are characteristic of low oxygen stress in plant and animal cells. It's similar to the production of lactic acid in our bodies when we exercise. We produce lactic acid as a by-product because we are not producing energy aerobically."

The study describing the oxygen-sensing protein turnover mechanism appears online Oct. 23 in Nature.

"The mechanism controls key regulatory proteins called transcription factors that can turn other genes on and off," explained Michael Holdsworth, a professor of crop science at the University of Nottingham who co-led the research project with Bailey-Serres. "It is the unusual structure of these proteins that destines them for destruction under normal oxygen levels, but when oxygen levels decline, they become stable. Their stability results in changes in gene expression and

metabolism that enhance survival in the low oxygen conditions brought on by flooding. When the plants return to normal oxygen levels, the proteins are again degraded, providing a feedback control mechanism."

Bailey-Serres, a member of UCR's Institute for Integrative Genome Biology and an international expert in plant responses to flooding, has been working since 2003 on the cellular mechanisms that regulate submergence tolerance in rice. Her lab has focused on SUB1A, a gene responsible for tolerance of complete submergence in rice and found only in some low-yielding rice varieties in India and Sri Lanka. Her lab is renowned for having characterized the roles of the SUB1A gene that has been bred into modern rice varieties to allow plants to survive two weeks or longer of complete submergence caused by Monsoon rains.

In the current work, the researchers performed their experiments on *Arabidopsis*, a small flowering plant used widely in plant biology laboratories as a model organism. SUB1A-like proteins are present in other plants, including *Arabidopsis*. While the protein turnover mechanism targets SUB1A-like proteins in *Arabidopsis*, the researchers found, to their surprise, that rice SUB1A is resistant to the protein turnover mechanism.

"We think that SUB1A's ability to evade destruction by the protein turnover mechanism under normal oxygen levels may allow it to provide its benefit to submerged rice plants," Bailey-Serres said. "The SUB1A gene is switched on by ethylene gas that accumulates inside cells during submergence. Since the protein does not require a scarcity of oxygen to be stable, it can go to work early to aid the plant."

Holdsworth, an international expert in seed biology and a protein turnover mechanism called the "N-end rule pathway of targeted proteolysis," had the first hint of the discovery while investigating the regulation of gene expression during seed germination. He connected the

N-end rule pathway to the Arabidopsis SUB1A-like proteins and their regulation of genes associated with low oxygen stress that Bailey-Serres has studied extensively in Arabidopsis.

"The puzzle pieces fell quickly into place when the expertise of the two teams was combined," he said.

The research team expects that over the next decade scientists will be able to manipulate the protein turnover mechanism in a wide range of crops prone to damage by flooding.

Provided by University of California - Riverside

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