Study gets to root of rice's resilience to floods

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The Deal lab experimented on barrel clover (Medicago truncatula) as part of the study. Credit: Marko Bajic

Climate change is increasing both the severity and frequency of extreme weather events, including floods. That's a problem for many farmers,

since rice is the only major food crop that's resilient to flooding. A new study, published in *Science*, however, identified genetic clues to this resilience that may help scientists improve the prospects for other crops.

"Our work is the most comprehensive look yet across species into what's really going on under the hood as plants respond to flooding," says Roger Deal, associate professor of biology at Emory University and a lead author of the study. "Understanding the mechanism for flooding tolerance is the first step in understanding how you might increase it in plants that lack it."

Rice was domesticated from wild species that grew in tropical regions, where it adapted to endure monsoons and waterlogging. The *Science* research looked at how other crops compare to rice when submerged in water. The plants included species with a range of flooding tolerance, from barrel clover (which is similar to alfalfa), to domesticated tomato plants, to a wild-growing tomato that is adapted for a desert environment.

The results showed that, although evolution separated the ancestors of rice and these other species as many as 180 million years ago, they all share at least 68 families of genes that are activated in response to flooding.

"That was surprising," Deal says. "We thought we'd see different gene expression responses among these species related to their adaptation to wet or dry conditions. Instead, what was really different was that rice had far and away the most rapid and synchronous response. In comparison, the other plants' responses were piecemeal and haphazard."

Deal's research focuses on how plants build and adapt their bodies. By digging deep into the developmental biology and genetics of plant systems, he hopes to unearth secrets that could benefit both agriculture

and human health.

Marko Bajic, an Emory graduate student in the Department of Biology and the Graduate Program in Genetics and Molecular Biology, is co-author of the *Science* paper.

The study was an international collaboration funded by the National Science Foundation's Plant Genome Research Program. The authors include scientists from the University of California, Davis; the University of California, Riverside; Argentina's National University of La Plata and the Netherland's Ultrecht University.

UC Riverside researchers conducted flooding experiments and analysis of rice plant genomes, scientists at UC Davis did the same with the tomato species while the barrel clover work was done at Emory.

The results suggest that the timing and smoothness of the genetic response may account for the variations in the outcomes for the plants during the experiments.

The wild tomato species that grows in desert soil withered and died when flooded.

The team examined cells that reside at the tips of roots of plants, as roots are the first responders to a flood. Root tips and shoot buds are also where a plant's prime growing potential resides. These regions contain cells with the ability to become other types of cells in the plant and serve as a repair system in plants and other living things.

Drilling down even further, the team looked at the genes in these root tip cells, to understand whether and how their genes were activated when covered with water and deprived of oxygen.

"We looked at the way that DNA instructs a cell to create particular stress responses in a level of unprecedented detail," says Mauricio Reynoso, one of the lead authors from the University of California, Riverside.

The group is now planning additional studies to improve the survival rates of plants that currently die and rot from excess water.

This year is not the first in which excessive rains have kept farmers from being able to plant crops like corn, soybeans and alfalfa. Floods have also damaged the quality of the crops they were able to grow. This trend is expected to continue due to climate change.

"We as scientists have an urgency to help plants withstand floods, to ensure food security for the future," says Julia Bailey-Serres, another lead author of the study and a professor of genetics at the University of California, Riverside.

More information: Mauricio A. Reynoso et al. Evolutionary flexibility in flooding response circuitry in angiosperms, *Science* (2019). DOI: 10.1126/science.aax8862

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