By switching 'bait,' biologists trick plants' bacterial defense into attacking virus

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Two *Arabidopsis* plants that were used in the study. The left plant, infected by turnip mosaic virus modified with fluorescent jellyfish protein, glows greenish blue under ultraviolet light three weeks after infection in the lower left corner. The uninfected plant on the lower right glows purple due to chlorophyll in the green leaves. Credit: Tom Ashfield

Scientists at Indiana University have modified a plant gene that normally fights bacterial infection to confer resistance to a virus.

The method, described in a paper to be published Feb. 12 in the journal *Science*, is the first time a plant's innate defense system has been altered to deliver resistance to a new disease. It is also the subject of a patent filing by the IU Research and Technology Corp.

"Our results suggest this method, which involves a single, minor alteration to an existing gene, is broadly applicable to a wide swath of diseases affecting plants of economic importance," said Roger Innes, professor in the IU Bloomington College of Arts and Sciences' Department of Biology, who led the study.

This not only includes viral and bacterial infections but also diseases caused by fungi, oomycetes—fungus-like microorganisms that caused the Irish potato famine—and nematode worms. Globally, crop diseases affect billions of people each year through lost revenue and food supply.

The results are the outcome of nearly 20 years of investigation into plant immunity by Innes. His work has been continuously funded by the National Institutes of Health or National Science Foundation since 1991, including an NSF grant awarded in January to apply the technology used in this study to crop plants.

Also contributing to the research were Sang-Hee Kim, Dong Qi and Tom Ashfield, who were postdoctoral associates in the Department of Biology at the time of the study reported today, as well as Matthew Helm, who was a graduate student.

Unlike the human immune system, which creates specific antibodies that directly bind to pathogen molecules, plants detect the presence of pathogens indirectly by sensing the damage they cause within a cell. Once a pathogen is detected, plants mount a strong defense response that walls off the pathogen, depriving it of food and water.

Innes' lab investigates the plant proteins that sense this pathogen-induced damage. They have found that these sensors are highly specific, with most recognizing only a very small subset of pathogens. Other groups have tried—with little success—to broaden the specificity of these sensors to develop crops with stronger immune systems.

Rather than trying to build a better sensor, the IU team chose to create "decoy" proteins that would be targeted by the enzymes that pathogens use to cause disease. When existing sensor proteins detect modification of these decoy proteins by the pathogen's enzymes, resistance is activated. And it's a relatively easy task to modify these decoy proteins to detect a diverse array of pathogens, Innes said.

Using this decoy approach, the IU team was able to broaden the recognition ability of a sensor protein that normally detects the bacterial pathogen Pseudomonas syringae to detect two different viral pathogens, turnip mosaic virus and tobacco etch virus, expanding the disease resistance of the plant.

"We liken this approach to switching the bait in a mousetrap," Innes said. "Except rather than catch a mouse, the modified bait allows us to catch a completely different animal. And because most pathogens use similar enzymes to cause disease, this general 'decoy' approach should enable the engineering of durable resistance to many types of plant viruses, as well as fungi and other pathogens."

The IU team's experiments were conducted in *Arabidopsis thaliana*, a mustard plant also known as thale cress, mouse-ear cress or *Arabidopsis*. The team is currently working to reproduce its results in soybeans and barley, since both crops respond to P. syringae using the same mechanism as *Arabidopsis*.

A major source for food and biofuel, soybeans are the sixth most common crop in the world. In the U.S., Indiana ranked second for soybean production in 2012, according to a report from the Indiana Business Research Center at the IU Kelley School of Business.

Soybeans are also one of many crops facing rising disease threats from climate change. These include soybean mosaic virus, now spreading rapidly northward by the soybean aphid, and Asian soybean rust, a fungal disease from South America whose arrival in the U.S. in 2005 is currently kept under control by pesticides toxic to fish and invertebrates.

"As temperatures rise, new insect and fungal diseases will increasingly migrate into North America," Innes said. "By developing new genetic methods to resist these pathogens in crops, we're hopeful our work will play a role in reducing these threats without introducing new chemicals into the environment."

More information: "Expanding the recognition specificity of a plant disease resistance protein using decoys" science.sciencemag.org/cgi/doi … 1126/science.aad3436

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