How plants keep viruses from passing to their progeny

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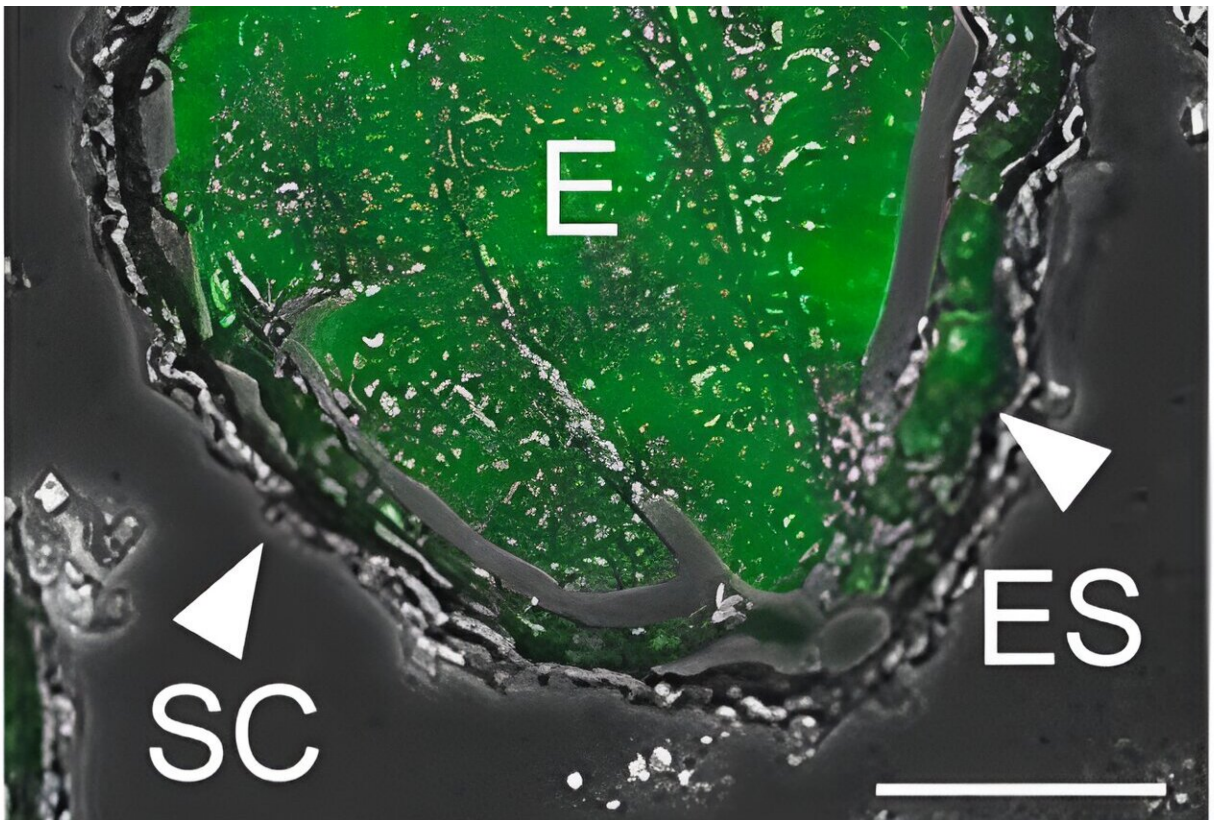

Immunofluorescence detection of cucumber mosaic virus in arabidopsis seeds. Credit: Shou-Wei Ding/UCR

Scientists have learned how plants keep viruses from being passed to their offspring, a finding that could ensure healthier crops. The discovery could also help reduce the transmission of diseases from mothers to human children.

Plant viruses are often able to spread from one country to another through the seed trade. As a result, parent-to-progeny disease transmission is of global concern.

"Viruses can hide in seeds for years, making this one of the most important issues in agriculture," said UC Riverside distinguished professor Shou-Wei Ding in the Department of Microbiology and Plant Pathology. Ding is corresponding author of a paper about the discovery in the journal *Cell Host & Microbe*.

When a mother plant with a virus makes, for example, 100 seeds, only between 0 and 5% of the seedlings are likely to become infected. For a century, scientists have wondered how the 'mothers' are able to stop the virus from spreading to all or most of the young plants.

The UCR-led team wanted to solve this mystery by pinpointing the immune pathway that prevents virus transmission from parent to progeny, also called vertical transmission. The team succeeded. The strategy they used, and the pathway they identified, are detailed in the paper.

Hundreds of varieties of Arabidopsis, a small plant in the mustard family, were inoculated with cucumber mosaic virus. Despite its name, the virus can infect more than 1,000 plant species, and cause yellowing, ring-shaped spots, and the appearance of patterns on leaf and fruit surfaces. Then, the researchers analyzed the plants to learn which genes make them, and their progeny, more resistant to the virus.

Two genes, both of which are only known to be functional during the early stages of seed development, appear to be most important for this purpose. These genes operate in what's called the RNA interference pathway.

Genetic information in cells is converted from DNA into RNA, and then into proteins. Sometimes, double-stranded RNA is cut into smaller fragments called small interfering RNA, or siRNA. These fragments are used to block the production of proteins, some of which may come from an invading virus.

"Many organisms produce siRNAs to control and inhibit viral infections," Ding explained. "We believe the reason these plants can prevent seed infections is because the antiviral RNA interference pathway is active when seeds are being developed within mother plants."

To examine their hypothesis, the researchers made mutant plants in which two key RNA interference pathway genes were deleted. These genes create enzymes called dicer-like 2 and dicer-like 4.

"Without these two enzymes, the plant cannot make siRNAs to inhibit viral infections. And without the siRNAs, the antiviral immune pathways are not functional," Ding said.

The mutant plants both grew and produced seeds normally. However, when the plants lacking these two enzymes were infected with cucumber mosaic virus, they developed very severe symptoms. They made fewer seeds, and more importantly, there was a tenfold increase in the rate of transmission to the seeds. Up to 40% of the new seedlings were infected.

"We got really excited by this result," Ding said. "This is the first time anybody has seen this major change in seed transmission after an immune pathway is eliminated."

The next question the researchers set out to answer was how, despite the strong immune suppression in non-mutant plants, can viruses still infect a small percentage of seeds? They learned that it's because the virus expresses a protein to block the RNA interference pathway in mother plants.

Moving forward, the research team is testing whether they can further decrease virus transmission rates by strengthening the immune pathway they identified in the seeds.

Because this pathway is widely conserved across a variety of organisms, including invertebrates, fungi, and mammals, the discovery could have broad implications for animal as well as human disease prevention.

The researchers have certain human viruses, like Zika, in mind as they continue their work. Zika infection during pregnancy can cause serious birth defects, including microcephaly and other brain abnormalities. The researchers hope to use what they learn to reduce the rate of vertical Zika transmission.

"We know that Zika virus expresses several proteins that block the RNA interference pathway, so it may be possible to prevent vertical transmission by inhibiting the function of these proteins with new drugs."

More information: Si Liu et al, Antiviral RNA interference inhibits virus vertical transmission in plants, *Cell Host & Microbe* (2024). DOI: 10.1016/j.chom.2024.08.009

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