Plant pathogen genetically tailors attacks to each part of its host (w/ Video)

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A maize tassel infected with corn smut. The tumors are the large white, bulbous growths, some of which have turned yellow or brown.

(PhysOrg.com) -- A tumor-causing maize fungus with the unsavory-sounding name "corn smut" wields different weapons from its genetic arsenal depending on which part of the plant it infects. The discovery by Stanford researchers marks the first time tissue-specific targeting has been found in a pathogen.

The finding upends conventional notions of how pathogens attack and could point the way to new approaches to fighting disease not only in plants but also in people, according to Stanford researchers. Corn smut is a plant cancer.

"This establishes a new principle in plant pathology, that a pathogen can

tailor its attack to specifically exploit the tissue or organ properties where it is growing," said Virginia Walbot, professor of biology and senior author of a paper published in Science detailing the study. A summary of the study will be published in the May issue of *Nature Cancer Reviews* as a Research Highlight.

"It would be as if a pathogen of a human could recognize whether it is in muscle or kidney or skin, and activate different genes to exploit the host more effectively," she said.

Up until now, pathologists had always assumed that when a pathogen went on the attack, it used every weapon it had, no matter which part of an organism it was infecting. But Walbot's team found that only about 30 percent of the genes in the corn smut genome are always activated, or "expressed," regardless of whether it is in seedlings, adult leaves or the tassel.

The other 70 percent of the genome is what the fungus would pick and choose from, depending on the tissue it was infecting. Some of those genes were expressed in only one of the three organs the researchers studied; the others were activated in two of the three.

"This is a revolutionary finding," Walbot said.

Her team also discovered that different parts of the maize plant activated different genes in response to being attacked.

"We hope that other people working on pathogens of all types will go back now and ask, 'when the pathogen is found in different parts of the body, is it actually using different weapons?'" Walbot said. "We think this discovery will stimulate many new experiments with existing pathogens."

Pathologists generally collect their samples from the same, characteristic place on the organism they are studying. For a plant, that is typically the leaves or fruit, while in an animal, it is usually a spot where the pathogen of interest is clearly flourishing. But as a result, Walbot said, when researchers happen to find the pathogen in another place in the organism, they generally don't test whether the pathogen is doing different things.

"It may be just the specialization of modern pathology which has resulted in the 'whole organism' context being overlooked," she said.

Walbot hopes that her team's work on corn smut will also inspire new experiments on human disease such as cancer.

"Medicine has made the same assumption that pathogens use all of their weapons wherever they are attacking a human," Walbot said.

But it may be that human pathogens are also situationally selective, genetically modulating the nature of their attack to whatever part of the body they are infecting.

"If that is the case, then we could develop drugs that are specific for the particular organ or tissue where the pathogen is found," Walbot said. "I think that holds great promise for reducing the damage done to the patient in the course of drug treatment."

Walbot got interested in researching the possibility that pathogens might vary their attack while doing fieldwork on a different project for which she was evaluating some mutant strains of maize. She noticed that certain kinds of mutants were resistant to corn smut.

Through a series of experiments with different maize mutants, she determined that the key factor in determining whether - or how intensely

- corn smut infected a given part of a plant was the potential for growth of that particular type of tissue. Greater potential for continued growth correlated with more intense infections of corn smut and bigger, more plentiful tumors.

The key aspect was the potential - if a mutant grew only small leaves and then quickly stopped growing, the corn smut wasn't interested, even if there was sufficient area to host some tumors.

Walbot tested how various mutant strains of corn smut behaved when infecting normal maize plants. She discovered that a strain that was highly effective in causing tumors in, say, the tassels might be completely ineffective in triggering tumors in a seedling. That told her that different genes in the fungus were involved depending on which part of the maize the fungus was attacking.

"We found genetic evidence from both the pathogen and the host that depending on the growth potential, in an organ-specific way, of both the pathogen and the host, you could modulate the number of tumors," Walbot said.

The team then set to work with DNA microarrays, lab tools that can screen thousands of genes at a time and determine which ones are active and which are not. The microarray work confirmed and quantified the results of their earlier experiments - corn smut was indeed situationally selective, to a high degree. Less than a third of its genes were consistently activated regardless of which organ of the maize plant it was infecting.

"We had proof from the microarray that paralleled the genetic proof; that is, that there is organ-specific expression by maize in response to corn smut, and corn smut expresses a specific suite of genes depending on where it is in the plant," Walbot said.

Corn smut, though a common pathogen, does not devastate maize crops and so relatively little work had been done by plant pathology researchers to study it. In Mexico, the fungus is called "huitlacoche," and the tumors, which are used in cooking, are sometimes purposely grown on ears of corn.

"If you order a mushroom omelet in Mexico, the fungus that you are eating is Ustilago maydis, or corn smut," Walbot said.

Though the new findings may not have much impact on those who savor corn smut for its culinary delights, Walbot said researchers are likely to take note.

"That is just a prediction," she said, "but I think pathologists will be quick to pounce on this."

Coauthors of the paper include David Skibbe, a postdoctoral fellow in biology, and John Fernandes, a bioinformaticist and research assistant in biology, both at Stanford. Coauthor Gunther Doehlemann is a research group leader in terrestrial microbiology at the Max Planck Institute for Terrestrial Microbiology, Marburg, Germany.

This project was funded by a special one-year grant for exploratory research from the National Science Foundation. Doehlemann received a short-term travel grant from the European Molecular Biology Organization to fund a 10-week visit to Stanford in spring quarter 2009. During his visit the key hypotheses were refined and most of the data obtained for the study.

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