Scientists first to characterize barley plant-stem rust spore 'communication'

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Traditional thought has held that disease had to penetrate a plant to initiate resistance; however, two Washington State University scientists have established that a barley plant recognizes an invader and begins to marshal its defenses within five minutes of an attack.

The discovery, along with the scientists' successful cloning of disease-fighting genes and the pathogen signal recognized by the plant, could help to revolutionize the battle against cereal crop enemies, such as stem rust. Unless carefully controlled, stem rust has the potential to destroy a grower's entire crop, and historically, has caused the loss of millions of bushels of grain and millions of dollars. And, new threats are on the horizon. For example, Ug99 is an evolving wheat pathogen that poses a dangerous threat to global food security, especially in developing countries.

"Now that we understand how the plant-pathogen interaction mechanism works, we hope we can manipulate it to build resistance in plants," said Andy Kleinhofs, professor of molecular genetics in the Department of Crop and Soil Sciences. With further research, he added, that understanding could lead to new, more effective ways to battle crop diseases such as stem rust and Ug99.

"It will take time for research on Ug99 to see if the mechanism works the same as in this case," Kleinhofs said. "If it is the same, we could use the technology to defeat Ug99."

Kleinhofs and Assistant Research Professor Jayaveeramuthu Nirmala focused their research on understanding Rpg1, a gene that provides barley with resistance to the pathogen that causes stem rust. Rpg1 is unique in that it has provided durable resistance in barley over the past 60 years, Kleinhofs said. His laboratory team previously successfully cloned that resistance gene, which when combined with the recently discovered genes that activate it, delivers a one-two punch against stem rust.

It was while monitoring the activity of those combined genes that Kleinhofs and Nirmala observed and documented "communication" between the barley plants and stem rust spores.

In the process, the researchers identified the proteins recognized by the Rpg1 resistance gene and saw the series of signals that tell the plant to protect itself. "It is clear that the plant recognizes the pathogen within five minutes of the spore touching the leaf," said Camille Steber, a research geneticist for the U.S. Department of Agriculture's Agricultural Research Service at WSU.

The plant's initial reaction to being attacked is invisible to the human eye, Nirmala said, but she succeeded in monitoring subtle changes in plant chemistry that demonstrated the plant not only recognized it was under attack but was starting to muster its resistance. Visible signs of the stem rust spore's impact come within an hour, when pad-like lesions connecting the spore to the leaf cell begin to appear.

A reviewer of Kleinhofs' and Nirmala's recent paper in the *Proceedings of the National Academy of Sciences* said the discovery "will probably open a whole new avenue of research of plant-pathogen interactions."

Steber said the discovery is a game-changer for plant scientists.

"This is the first example where the lock-and-key of cereal-pathogen response is clearly understood," she said.

Kleinhofs called his and Nirmala's understanding of the signaling that was going on between plant and pathogen "one of those 'Eureka!' moments."

"Three is still a lot to be learned," he added. "As with any new discovery, more questions arise than have actually been answered, but it is a good start."

Provided by Washington State University