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News Release

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Fundamental biology:

TUM researchers discover a new switch in resistance to plant diseases

Powdery mildew is a tricky pathogen: The fungus can manipulate barley in a way that it is not only granted entry into the plant, but also gets the plant's cells to supply it with nutrients. A team of researchers at the Chair of Phytopathology at Technische Universitaet Muenchen (TUM) has just identified, on a molecular level, how the fungus manages this feat – and how barley can fight back. The results have now been published in the renowned journal "The Plant Cell".

Plants, too, have an immune system that protects them against diseases. The early detection of pathogens and the subsequent immune response, in particular at the cell wall, work as a protective shield. However, the pathogens that cause plant diseases have their weapons, too. Some are able to suppress the natural cell wall reaction in plants. "One particularly ingenious attacker, powdery mildew, can even reprogram cells in such a way that they adapt their architecture and metabolism to accommodate the fungus. The plant thus actively fosters the in-growth of the harmful mildew and even supplies it with nutrients," explains Prof. Ralph Hückelhoven from the TUM Chair of Phytopathology. How the mildew manages this manipulation and which plant components are involved in the process is still largely shrouded in mystery.

Hückelhoven's team of researchers has now succeeded in unraveling a part of the mystery. With the support of colleagues from Gatersleben, Gießen and Erlangen, the Weihenstephan scientists identified two proteins in barley that powdery mildew takes advantage of during its "hostile takeover" of living plant cells. Together, the two protein substances steer development processes in the plant cell. In barley, for instance, they are responsible for the growth of root hairs. The one protein, called RACB, is a molecular switch, which reacts to signals from outside to initiate a structural and metabolic response in the plant cells. In particular, it is involved in enlarging the plant cell surface during the growth process. The other protein, called MAGAP1, serves as its counterpart and can prevent or locally limit these activities in the cell.

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The researchers observed just how the RACB protein supported the fungus during plant in-growth. A basic function of the protein, increasing the surface of the plant cell membranes, provides a gateway for attack: RACB fosters the increase in cell surface while the mildew is invading, thereby leaving the plant cell intact while still supporting the fungus. Hückelhoven's team was able to demonstrate that the plant becomes less susceptible to powdery mildew when the protein is missing. Hückelhoven explains: "That is how the fungus benefits from this barley protein. RACB makes it easier for powdery mildew to push its haustoria, or feeding organs, into the attacked cell, to then take control of the barley cell." The scientists suspect that the fungus manages to take control of the plant's signal chain from outside – remotely, so to speak – to open the door to the plant's nutrients.

The TUM researchers showed that barley is not entirely defenseless against this trick: MAGAP1 can effectively prevent such attacks from outside. This counterpart protein is normally found at the cytoskeleton of the plant cell, a dynamic network of protein fibers that is responsible, among other things, for reinforcing the cell wall to prevent fungal invasions. During an attack MAGAP1 migrates to the cell surface membrane where it then switches off the susceptibility factor RACB. This hinders the increase in cell surface, which the fungus needs to penetrate into the cell. The resilient barley cell may use this mechanism to slam the door in the face of powdery mildew.

The Chair of Pythopathology primarily does basic research. The scientists though, who are also members of the Hans Eisenmann Center of Agricultural Science at the TUM, had farmers in mind even at this early stage. "With a better understanding of the cause of diseases we hope, in the midterm, to find innovative approaches to maintaining the health of crops and grains by enhancing their immunity," says Prof. Hückelhoven.

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Literature:
Caroline Hoefle, Christina Huesmann, Holger Schultheiss, Frederik Börnke, Götz Hensel, Jochen Kumlehn, Ralph Hückelhoven (2011): A Barley ROP GTPase ACTIVATING PROTEIN Associates with Microtubules and Regulates Entry of the Barley Powdery Mildew Fungus into Leaf Epidermal Cells. The Plant Cell. Online pre-publication at www.plantcell.org/cgi/doi/10.1105/tpc.110.082131

Background:
The research project “Microbial reprogramming of plant cell development - RAC/ROP signaling in the interaction of Arabidopsis and barley with powdery mildew fungi” has been funded thus far with EUR 250,000 by the Deutsche Forschungsgemeinschaft.

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