NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NEWS RELEASE

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NTU Singapore scientists identify how 'crop killer' bacteria infects plants, paving the way to prevent plant disease

An interdisciplinary team of scientists from **Nanyang Technological University, Singapore (NTU Singapore)** has identified, for the first time, a key mechanism by which a dangerous plant disease can infect crops.

The *Xanthomonas* bacteria, known as the "crop killer", is a globally prevalent bacterium capable of infecting 400 different plant species.

The NTU researchers identified the exact cellular-level mechanism by which the bacteria can penetrate and hijack a plant's immune system, therefore leaving them vulnerable to infection.

The advance sheds light on this longstanding mystery and provides new insights on how to stop bacterial infections that can lay waste to important crops such as rice, wheat, soybean, and tomato.

The study, led by **Associate Professor Miao Yansong** from the **School of Biological Sciences**, together with **Assistant Professor Yu Jing** from **NTU's School of Materials Science and Engineering**, has important implications for food safety and sustainability.

"*Xanthomonas* is a plant pathogen that infects a variety of plants, including food crops, so understanding this mechanism is important for controlling crop diseases," said **Assoc Prof Miao**. "This is relevant to Singapore's and the world's goals of growing more food."

The team's findings were published in the journal *Nature Communications* in July.

Based on their published study, the interdisciplinary team has also successfully reverse-engineered the infection mechanism and have obtained a **provisional patent for a 'toolkit'** that may help in the development of new methods to make plants more resistant against bacteria.

The team's findings, which have the potential to help boost food security, are part of NTU's ongoing efforts to address humanity's grand challenges on sustainability under its **2025 strategic plan**, which seeks to strengthen deep disciplinary discoveries and high-impact interdisciplinary research for the benefit of humanity.

Study solves long-standing mystery of bacterial infection in plants

The *Xanthomonas* bacteria infects and damages plants by injecting toxic 'effector proteins', called Type III effectors, into the plant host. These toxic effector proteins hijack and take over the plant's normal biological processes, preventing them from mounting an immune response.

Plants normally resist infection at the cellular level using a protective layer of plasma membrane to shield their actin cytoskeletons, which serve as the structure of a cell. The actin cytoskeleton is responsible for how a cell mounts a defence against pathogens. During a successful infection, the pathogen breaks through the membrane and 'overwrites' the cytoskeleton with new instructions telling it not to fight it.

How the bacteria hijacks the plant host plasma membrane and actin cytoskeleton in order to infect the host has been a mystery since research started into the *Xanthomonas* bacteria in the late 20th century.

Understanding the infection mechanism

The team studied a specific type of effector protein called XopR, which behaves like a molecular "glue". They discovered that XopR hijacks the host cytoskeleton by undergoing what is called a liquid-liquid phase separation process on the surface of the plant's plasma membrane.

This phase separation process is similar to the way that oil and water can merge into each other, yet can also be easily separated into two distinct liquids. Both the XopR protein and the host plant cell interact with each other like liquid droplets, allowing the toxic effector proteins to "glue" onto the plant cell and merge into it.

Once this has happened, the inter-connected XopR proteins can infiltrate and invade the plant cell's actin cytoskeleton network, giving it access to cell behaviour. When this happens, the XopR protein can overwrite the existing cellular instructions to mount an immune response, thus leaving the plant vulnerable to infection.

Asst Prof Yu Jing said: "Our study was not only a biological study of bacteria protein, but also about the biochemistry behind the infection mechanism. By studying the physico-chemical properties of XopR liquid droplets, we were able to further understand its unique protein sequence. This inter-disciplinary approach allowed us to reveal the underlying molecular mechanisms by which XopR subverts the immunity of its plant host."

This newly discovered mechanism of how effector proteins hijack plant cells through phase-separation can be broadly applied to other plant-pathogen interactions as many other microbial pathogens also inject effectors into the plant host and provides new avenues for future research.

Study offers hope for strengthening food and agriculture security

Xanthomonas causes bacterial spots and blights in the leaves and fruits of the plants it infects. In some cases, once the disease takes root, a farmer's only recourse is to cut down and burn the entire crop of plants to stem the spread of disease.

Understanding exactly how plants and crops are infected by bacteria is a crucial step in developing methods to prevent their infection and produce crops that can resist the disease.

"Our research greatly advances our knowledge of previously-unknown mechanisms by which bacterial effectors cause damage in plant host cell. By understanding the exact mechanism of infection, our study sets the foundation for future research on how to prevent such infections through non-invasive means, such as changing plant growth conditions or using new nutrients. This allows us to better treat infected plants and explore ways to grow resilient crops with greater immunity to the disease without using genetic engineering," said **Assoc Prof Miao**.

The team has obtained a provisional patent for a toolkit they have developed that allows scientists to replicate the process by which the XopR interacts with plant cells. This will allow researchers to test potential solutions for strengthening crop immunity in laboratory settings. It also has potential applications for future synthetic biology and agri-food technology.

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Note to Editors:

Paper titled *"Xanthomonas effector XopR hijacks host actin cytoskeleton via complex coacervation"*, published in *Nature Communications*, 1 July 2021. DOI: 10.1038/s41467-021-24375-3

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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Humanities, Arts, & Social Sciences, and Graduate colleges. It also has a medical school, the Lee Kong Chian School of Medicine, set up jointly with Imperial College London.

NTU is also home to world-class autonomous institutes – the National Institute of Education, S Rajaratnam School of International Studies, Earth Observatory of Singapore, and Singapore Centre for Environmental Life Sciences Engineering – and various leading research centres such as the Nanyang Environment & Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N).

Ranked amongst the world's top universities by QS, NTU has also been named the world's top young university for the past seven years. The University's main campus is frequently listed among the Top 15 most beautiful university campuses in the world and it has 57 Green Mark-certified (equivalent to LEED-certified) building projects, of which 95% are certified Green Mark Platinum. Apart from its main campus, NTU also has a campus in Singapore's healthcare district.

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

For more information, visit www.ntu.edu.sg