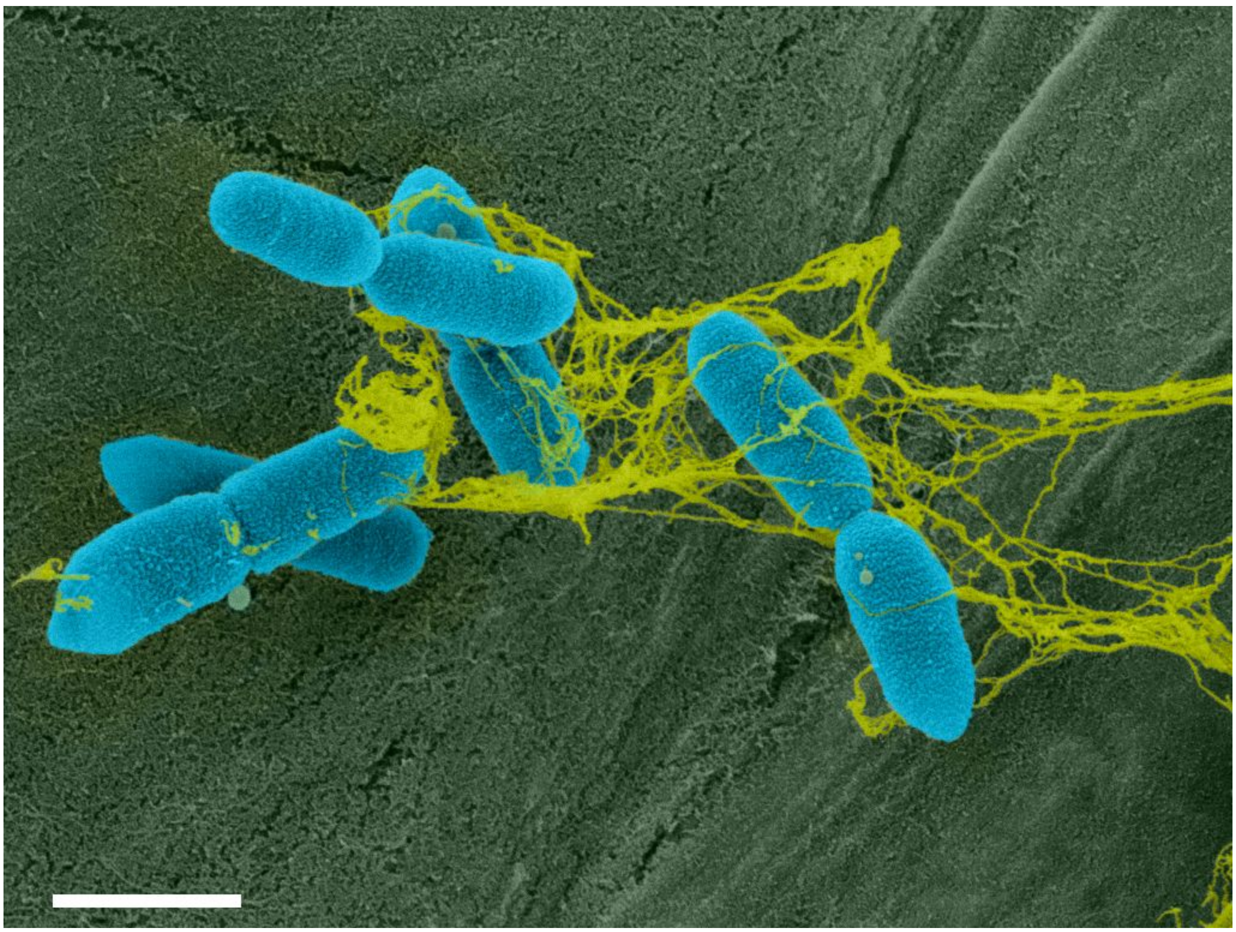
The arms race at the plant root: How soil bacteria fight to escape sticky root traps

June 23 2016



A false-color electron micrograph depicting bacteria (blue) and the DNA-based trap (yellow). Credit: Tran et al.

Soil is full of microbes. Specialized border cells at the outer surface of plant roots fight off these microbes as the roots penetrate the soil in search of water and nutrients. A study published on June 23rd in *PLOS Pathogens* reveals how plant pathogens fight back against entrapment by sticky root border cell secretions.

R. solanacearum is a soil-borne bacterium that causes destructive wilt disease in a wide range of plants, including economically important crops like potato, tomato, and banana. *R. solanacearum* lives in the soil, smells out roots, enters them through wounds or natural openings, then multiplies and spreads, eventually obstructing the water-transport system and causing the plant to wilt and die.

Caitilyn Allen, from the University of Wisconsin in Madison, USA, and colleagues, used pea, a model system for studies of root border cells, and tomato, an economically important natural host, to study interactions between border cells and the of *R. solanacearum* pathogen.

Upon contact with *R. solanacearum*, the researchers found, both pea and tomato root border cells respond by releasing DNA, thereby forming sticky traps that entangle the bacteria. The researchers observed that about 25% of the entangled bacteria were killed in the traps. The anti-bacterial activity depended both on the presence of extra-cellular DNA and of histone H4, a DNA-associated protein present in plant and animal cells.

When the researchers exposed pea roots to several types of harmless bacteria, no DNA was secreted, suggesting that the reaction is a specific defense against harmful attackers.

In the quest to identify the specific pathogen signals that trigger the extra-cellular trap response in the root, the researchers studied strains of *R. solanacearum* with mutations in a number of genes encoding candidate signals. Two of the strains that had mutations in genes that form the propeller-like tail of the bacterium failed to elicit trap formation, suggesting that this structure, the so-called flagellum, is recognized by the host as a danger signal.

The genome of *R. solanacearum* contains two genes (nucA and nucB) that encode so-called endonucleases, molecular scissors that can cut into DNA molecules and chop them up. Both of the endonucleases contain signals that cause them to be exported from the bacterial cell and released into the environment. To test whether these endonucleases can destroy the traps set by the plant roots, the researchers created *R. solanacearum* mutants that lacked either one or both of the nuc genes.

They found that while non-mutant *R. solanacearum* bacteria quickly escaped from pea root border cell traps, mutant bacteria missing both nucleases remained immobilized. Mutant bacteria were also compromised in their ability to invade the roots of tomatoes, their natural host. Adding purified nucleases (NucA, NucB, or a non-bacterial version called DNase I) resulted in bacterial escape from the traps. Together these results demonstrate that plant pathogens use nucleases to escape extracellular DNA traps generated by host root border cells.

"To the best of our knowledge", the researchers say, "this is the first report that DNase contributes to plant pathogenesis". They discuss this in the context of the apparently independent evolution of similar DNA based defenses in animal and plants: plant root border cells and animal macrophages both deploy DNA-containing extracellular traps and kill pathogens. In response, the pathogens use secreted enzymes that destroy the DNA.

Understanding the host-pathogen interactions at the plant root might help in breeding or engineering disease-resistant plant variants.

More information: Tran TM, MacIntyre A, Hawes M, Allen C (2016) Escaping Underground Nets: Extracellular DNases Degrade Plant Extracellular Traps and Contribute to Virulence of the Plant Pathogenic Bacterium Ralstonia solanacearum. *PLoS Pathog* 12(6): e1005686. DOI: 10.1371/journal.ppat.1005686

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