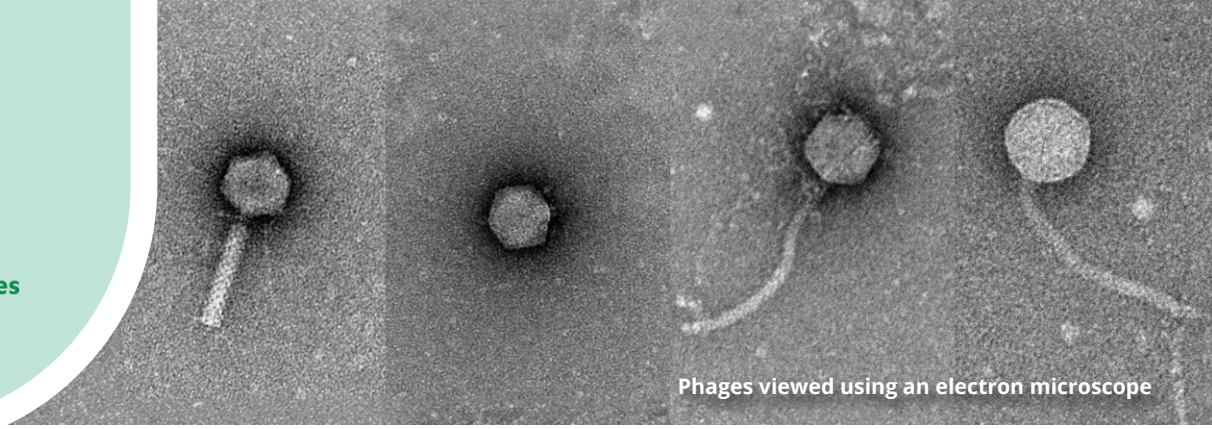
Bacterial Plant Diseases Programme



Phages viewed using an electron microscope

PHAGES SHOW PROMISE FOR CONTROLLING *RALSTONIA SOLANACEARUM*

Healthy tomato plant (back) and infected with *R. solancearum* (front)

Ralstonia solanacearum causes significant crop losses in many plant species, especially potatoes

Ralstonia solanacearum is a soil bacterium which causes wilt and rot diseases in a wide variety of economically important plants, including potatoes, tomatoes, pepper, aubergine, and tobacco. The most serious of these is brown rot of potatoes which affects 1.7 million hectares in approximately 80 countries, leading to worldwide crop losses of hundreds of millions of pounds.

The disease mainly spreads through contaminated tools, soil, and groundwater, and transport of infected plants. Although not currently a major problem in the UK due to strict quarantine and surveillance of the UK river network, it could be devastating if new strains are introduced (as recently happened in the Netherlands and elsewhere in mainland Europe).

Phages (also known as bacteriophages) are viruses which can infect and kill bacteria. Phages are found abundantly in nature, wherever bacteria are present, including soil, water reservoirs, and plant microbiomes. Phages are also very specific, only killing certain bacteria. This means they could potentially be used as biocontrol agents to treat *R. solanacearum* infections without adversely affecting other microbes.

This research studied the feasibility of using phages as biocontrol agents for *Ralstonia solanacearum*

Using tomatoes as a model system, we explored the potential of *Ralstonia*-specific phages to reduce bacterial wilt disease symptoms, decrease pathogen abundance, and observe the potential effects on the broader soil microbiome. First, we identified phages which could safely and effectively function as precision biocontrol agents against *R. solanacearum*.

As bacteria can evolve phage-resistance, we deliberately allowed the bacteria to become resistant to the phage by culturing them together. In collaboration with iMEAN (Toulouse, France) we created a metabolic model of *Ralstonia solanacearum*.

This helped us to understand how genetic changes, like phage-resistance mutations, might affect virulence and disease development.

To establish whether phage treatments are safe for plants, we compared differences in gene expression in tomatoes inoculated with phage-susceptible or phage-resistant pathogens. We also examined the soil microbiome before and after phage treatment.

In collaboration with APS Biocontrol (Dundee, UK) we assessed the feasibility of spray-drying phages as a first step to developing commercial phage products.

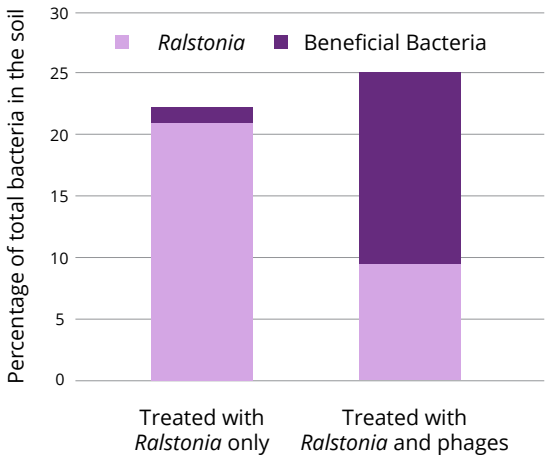
Clear spots on the culture plate show where phage has killed *Ralstonia*

Discoveries

Phages reduce disease burden, improve soil microbial diversity, and boost plant health.

- Treating infected tomato plants with *Ralstonia*-specific phages reduced disease symptoms and lowered the abundance of *Ralstonia solanacearum* bacteria in the soil from 21% to 9.5% on average.
- The bacteria can rapidly evolve phage resistance, but in doing so become less virulent. Fortunately, these less-virulent bacteria still trigger plant immune responses, enabling the plant to resist future infections.
- Treating plants with phages improved the microbial diversity of the soil. Several bacteria that promote plant growth actually increased in abundance.
- Phages remain effective and in high enough numbers when dehydrated and powdered meaning they could be manufactured and distributed for application to crops.

Abundance of bacteria in the soil following innoculation with either *R. solanacearum* only or *R. solanacearum* and phages



Recommendations

Phages show considerable potential for use as a biocontrol method for *Ralstonia solanacearum*.

- Fund further research, including international collaboration, to ensure these results can be replicated in other countries and plants, especially potatoes.
- Facilitate industry collaboration to investigate whether phage biocontrol can be safely and effectively manufactured and distributed at scale.
- Explore whether phage biocontrol could be effective for other bacterial plant diseases.


***Ralstonia solanacearum* growing on a culture plate**

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This document is based on this and other research:
Yang, K. et al. (2023) Rhizosphere phage communities drive soil suppressiveness to bacterial wilt disease. Microbiome 11, 16. https://doi.org/10.1186/s40168-023-01463-8

Bacterial Plant Diseases Programme

An interdisciplinary research consortium working together to understand bacterial plant diseases to protect UK farms, forests and gardens.

www.bacterialplantdiseases.uk

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