RESEARCH UPDATE:

Pseudomonas syringae pv. actinidiae (Psa)

Psa: Pretty pictures of a gruesome subject
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We can see the disease symptoms that Psa causes, but we cannot see the bacteria with our naked eye, so microscopy has been used to enable us to examine, in detail, the location and behaviour of the bacteria within the plant. Both a Light (LM) and Scanning Electron Microscope (SEM) have been used. These types of microscopy have clearly showed Psa entering the leaf and vine and the progression through the tissues of the plant.

Leaf infections

In inoculated leaf material, bacteria can be found over the leaf surface (Figure 2A); however, within 2-3 days they can be seen aggregated around openings such as stomata (Figures 1A, 1B, 2C), and in large numbers on both sides of the stoma. It is unclear whether this represents division and entry through the stoma, or exudation of bacteria from within. In later stages, the bacteria can be seen throughout the intercellular spaces of the spongy mesophyll (Figures 1B, 1C, 2D). However, the compact cells surrounding the vascular bundles, which have no or very small intercellular spaces, appear to act as a barrier to bacterial movement (Figure 1C), explaining the angular nature of the lesions, which are delimited by minor veins. Associated with the bacteria in the intercellular spaces are copious amounts of fibrillar material: extracellular polysaccharide (EPS).

![Image 1](image1.png)

Figure 1: Resin section of inoculated kiwifruit leaves stained with toluidine blue. Arrows indicate aggregations of bacteria in stomata (A and B). Red dots indicate position of bacteria on one side of a vascular bundle (C).
Figure 2: Scanning electron micrographs of inoculated kiwifruit leaves. A) Undersurface of leaves, B) bacteria on the undersurface of the leaf (arrowed), C) aggregations of bacteria over stomata (arrowed), D) bacteria adhering to surface of spongy mesophyll (arrowed) after removal of the lower epidermis.
Proposed Function of EPS
The function of EPS is not yet fully understood, but it is thought to be involved with:

- Adhesion of bacteria to plant surfaces
- Protection from desiccation
- Hygroscopic – may cause water to flow from cells
- Mask bacteria from plant recognition responses
- Detoxify plant defence compounds.

Cane Infection
In vines and canes, early bacterial growth occurs in the intercellular spaces of the parenchyma tissue outside the ring of fibres (Figure 3C). Eventually cell walls break down and the bacteria spread through the entire cortex and into the phloem region.

Initial cane infection can occur through the lenticels on the canes where the bacteria enter through minute cracks in the suberised layers. Cellular breakdown and browning occur, initially, in a lens-shaped region underneath the lenticels, before spreading through the cortex of the cane (Figure 3E).

Figure 3: A. Anatomy of uninfected kiwifruit cane (resin sections stained with toluidine blue. B. Cut surface of infected cane.
Figure 3: C- D. Resin sections of infected kiwifruit cane stained with toluidine blue. Arrows show progress of bacteria through tissue. Circles show pockets of infection in the inner parenchyma. E. Penetration of bacteria through a lenticel. Arrows indicate the lens shaped region with breakdown of cell walls (F).

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