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Title: "Pierce's Disease symptoms: Comparison with symptoms of water deficit and the impact of water deficits"

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Pierce's Disease (PD), caused the bacterium *Xyllela fastidiosa*, is widely attributed to blockage of the xylem vessels by the bacterium. But these authors show that this might not actually be the right explanation.

• The authors begin by pointing out that the 3 typical visual symptoms of PD ("green islands", "leaf scorch", and "matchsticks") are not the characteristic symptoms of water deficit. Also, certain symptoms of water stress associated with PD-infection (such as low water potential, low turgor, impaired water transport, and high stomatal resistance) had been observed in flooded plants as well. So they asked themselves if PD-infected vines were really water-stressed or not.

• The authors set out with 2 goals in mind: 1) find whether water deficits could produce PD symptoms, and 2) evaluate the impact of different water levels on PD symptoms.

• They needle-inoculated vines with *Xyllela fastidiosa* (infected) or with water (uninfected), and then subjected the vines to 3 daily watering regimes: well-watered (600 ml/vine), moderately water-stressed (335 ml/vine), or severely water-stressed (200 ml/vine). Just in case rapid, drastic stress would be able to mimic PD symptoms, they added a "rapid water deficit" treatment (no water whatsoever, or you could call it "fast death"). They used 7-8 potted plants per treatment.

• They assessed the development of symptoms using 2 parameters: **incidence** (percentage of plant showing leaf scorch), and **severity** (extent of leaf scorch, rated from 1 to 10). They evaluated water relations by measuring stomatal conductance, transpiration, and leaf water potential. Finally, they performed anatomical studies using a microscope.

• Two typical symptoms observed in water-stressed plants are leaf chlorosis (yellowing) and leaf abscission at the stem site. Researchers are able to identify a true abscission zone under the microscope by the formation of 2 types of layers: an internal area of enlargement (large, thin-walled cells), and an outer layer of protection (collapsed, suberized cells).

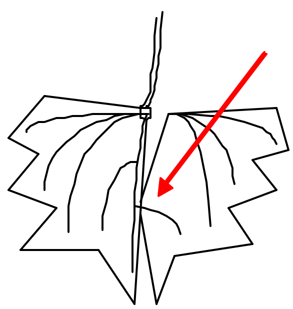
• So, how did the symptoms of PD compared to those of water deficit? As far as **green stem symptoms** go, water-stressed vines matured faster (more periderm formation, i.e. browning), and acropetally (starting at the base advancing towards the tip). PD vines showed the reverse cane-ripening pattern, starting more or less at the tip and proceeding towards the base. PD vines still developed the characteristic "green islands" (random spots without periderm) but only when well-irrigated. The fast periderm formation caused by water deficit seemed to have masked or eliminated the inhibitory effect on periderm formation caused by PD.

• As for **leaf abscission symptoms**, water deficit vines formed two sites of constriction and necrosis: a true abscission zone at the contact of the petiole with the stem, and a breakage zone (fractured and degenerated cells, not your typical programmed abscission) at the contact of the petiole with the blade (lamina). In water deficit vines, these areas never developed -leaves did not fall- until they were completely yellow and necrotic. PD vines, on the other hand, developed only one breakage area between the petiole and the blade. And the petioles were always still green when the blade fell off ("matchsticks"). **This suggests a completely different mechanism causing leaf drop during water stress and during PD.**

• **Leaf chlorosis symptoms.** The pattern of leaf chlorosis (yellowing) was more uniform in water deficit vines, whereas in PD vines it was localized in bands and bordered by necrosis (scorch). Leaf veins in water stressed vines were brown, whereas in PD vines they remained green until they eventually became necrotic. Additionally, in the field, we know that leaf senescence starts at the base and progresses towards the tip, whereas PD symptoms appear at the middle of the cane and progress in both directions.

• **Water relations**. There were no significant differences in stomatal conductance, transpiration, or leaf water potential, between the infected and uninfected vines. One exception was the severely water-stressed vines. So, strong water deficits did exacerbate reduced water transport in PD vines and the development of PD symptoms.

• To test the dependence between scorch symptoms and loss of vessel function, the authors carried the experiment of simulating xylem blockage by severing all the veins from half of the leaf, *except one*. This single secondary vein was the only water source for half of the leaf while the leaf was still attached to the vine. The authors compared both halves when the vines were placed under low or high evaporative demand.



The result was that this single vein was sufficient to supply water to the leaf halves, and avoid wilting and chlorosis for many weeks. The authors searched for leaf scorch symptoms, like those of PD, but they did not develop. **So vessel occlusion may not be sufficient to cause PD symptoms**.

In summary, symptoms of Pierce's Disease are qualitatively and quantitatively different from those of various water deficits. Even though water deficits exacerbated the development of Pierce's Disease symptoms, other factors seem to be involved. Could the bacteria be sending some sort of signal to the site of occlusion? The authors don't know yet. Continuing to learn about the site and nature of vessel blockages, and their relationship with water deficits and visual symptoms, is important to understand how to fight Pierce's Disease. Make sure you check out the numerous color plates in the original text.

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