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The use of synchrotron X-ray fluorescence microscopy to study the "battle for nutrients" between plant and pathogen

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Metal homeostasis is essential to normal plant growth and development. The balance is potentially impacted during plant-pathogen interactions as the host and pathogen compete for the same nutrients. Our knowledge of outcome of the interaction in terms of metal homeostasis is still limited. Here, we visualise and analyse the fate of nutrients in wheat leaves infected with a devastating pathogen, by high-resolution X-ray fluorescence microscopy (XFM). We employed XFM, at the ANSTO Australian synchrotron, for a detailed time-course of nutrient re-distribution in wheat leaves infected with Pyrenophora tritici-repentis (Ptr) to (i) evaluate the utility of XFM for spatially mapping the essential mineral nutrients in wheat leaves at sub-micron level, and (ii) examine the spatiotemporal impact of a necrotrophic fungus on nutrient re-distribution in wheat leaves. The XFM maps of K, Ca, Fe, Cu, Mn, and Zn revealed substantial hyperaccumulation and depletion within and around the infected region relative to uninfected control leaf tissue. We were able to visualise fungal mycelia as threadlike structures in the Cu and Zn maps. The hyperaccumulation of Mn in the lesion and localised depletion in asymptomatic tissue surrounding the lesion was particularly striking. Interestingly, Ca accumulated within and closer to the periphery of symptomatic region, often observed as micro-accumulations aligning with fungal mycelia. These disruptions may reflect secondary strategies used by the fungus to induce cell death, localised defence mechanisms used by the plant or wound responses. Collectively, our results highlight that synchrotron-based XFM imaging provides capability for high resolution mapping of elements for probing nutrient distribution in hydrated diseased leaves in situ.

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