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Non-invasive imaging of hydraulic function in leaves, stems and roots

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Plants have evolved a water transport system that relies on water sustaining a tensile force. Counter intuitively, this means water moves through the plant as a liquid under negative absolute pressures. This mechanism is made possible by the intricate plumbing system that constitutes the xylem tissue of plants. However, water under tension is prone to cavitation, which results in the formation of a gas bubble (embolism). Embolism reduces the capacity of the xylem tissue to deliver water to the canopy, eventually causing dieback and whole plant mortality. Xylem embolism is exacerbated by environmental stresses and is now considered one of the leading causes of plant mortality resulting from drought stress. Non-invasive imaging techniques offer the potential to make direct observations on intact plants at high resolution and in real time. In this presentation, I discuss recent exciting developments in the application of non-invasive imaging technologies such as X-ray Micro Computed Tomography (microCT) and optical imaging to studies of plant vascular function. This includes visualisation of xylem networks during drought stress and recovery in leaves, stems and roots. MicroCT imaging of stems and roots indicated that significant embolism formation occurs at similar time points and levels of water stress in dehydrating plants. This result was observed in herbaceous and woody species, and is surprising given previous hydraulic measurements indicating that, within a plant, roots were more vulnerable to drought-induced embolism than stems. A newly developed optical technique indicates that leaf vasculature is also similar in vulnerability to stems and roots. The overlap in vulnerability suggests that induction of embolism occurs at the same time in different organs or is propagated rapidly through the plant. In examining recovery from drought stress, we saw little evidence of embolism refilling in the xylem of woody plants, except in cases where substantial root pressure is produced. These results suggest that embolism refilling is less widespread than previously thought.

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