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Hydrosignalling : How air gaps in soils alter the distribution of root water and hormones fluxes, thereby blocking root lateral branching

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Plant roots exhibit plasticity in their branching patterns to forage efficiently for heterogeneously distributed resources, such as soil water. The xerobranching response represses lateral root formation when roots lose contact with water (e.g. in "air gaps"), and provides an experimental model to study root adaptive responses to transient water stress.

To discover the mechanistic basis of xerobranching, soil- and agar-based xerobranching bioassays were developed. As levels of the abiotic stress signal abscisic acid (ABA) increase in root tips during transient water stress, we observed that tomato, maize and Arabidopsis mutants deficient in ABA are disrupted in xerobranching response. Using novel ABA biosensors and mutants, we showed that when reaching an air gap, it takes about half a day for ABA originating from phloem tissues to radially travel through the unloading zone and accumulate in epidermal tissues.

When root tips lose contact with water, could the direction of water flow across root tissues change, and trigger the outwards accumulation of ABA, acting as a "hydrosignal" ? Our 3-dimensional root micro-hydrological model of solute advection-diffusion "MECHA" supports the following hypotheses :

- Such a reversal of radial water flow direction may happen in the root elongation zone, as cell elongation may not be fed by water absorbed at the root surface anymore, and therefore water for cell elongation (e.g. in the epidermis) entirely relies on phloem as a water source.
- If water soluble hormones such as ABA "ride" on water fluxes through plasmodesmata and along cell walls, it would take them about 8 hours to accumulate to levels comparable to concentrations observed in phloem cells. This timing is compatible with our experimental observations.

From there on, our Arabidopsis mutants reveal that ABA uses plasmodesmatal closure to lock up the symplastic radial pathway that is necessary for auxin to initiate lateral root branching.

In conclusion, our study reveals how roots might adapt their branching pattern to heterogeneous

soil water conditions by linking changes in hydraulic flux with dynamic hormone redistribution.

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