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Stomatal closure under drought is controlled by below-ground hydraulics

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Stomatal closure allows plants to promptly respond to water shortage. Although the coordination between stomatal regulation, leaf and xylem hydraulics has been extensively investigated, the impact of below-ground hydraulics on stomatal regulation remains unknown.

We used a novel root pressure chamber to measure, during soil drying, the relation between transpiration rate (E) and leaf xylem water pressure ($\psi_{\text{leaf-x}}$) in tomato shoots grafted onto two contrasting rootstocks, a long and a short one. In parallel, we also measured the $E(\psi_{\text{leaf-x}})$ relation without pressurization. A soil–plant hydraulic model was used to reproduce the measurements. We hypothesize that (1) stomata close when the $E(\psi_{\text{leaf-x}})$ relation becomes non-linear and (2) non-linearity occurs at higher soil water contents and lower transpiration rates in short-rooted plants.

The $E(\psi_{\text{leaf-x}})$ relation was linear in wet conditions and became non-linear as the soil dried. Changing below-ground traits (i.e. root system) significantly affected the $E(\psi_{\text{leaf-x}})$ relation during soil drying. Plants with shorter root systems required larger gradients in soil water pressure to sustain the same transpiration rate and exhibited an earlier non-linearity and stomatal closure.

We conclude that, during soil drying, stomatal regulation is controlled by below-ground hydraulics in a predictable way. The model suggests that the loss of hydraulic conductivity occurred in soil. These results prove that stomatal regulation is intimately tied to root and soil hydraulic conductances.