Online
Biología de Plantas
2021

XXIV Meeting of the Spanish Society of Plant Biology
XVII Spanish Portuguese Congress on Plant Biology
BP 2021
7th- 8th July 2021

CONNECTING THE DOTS BETWEEN ROOT, XYLEM AND STOMATA

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Abstract: Stomata are present on all land plants and are key features for vascular plant water content regulation on Earth. Their primary function, i.e., stomatal closure to control water loss under soil and atmospheric drought, is thought to prevent cavitation in the vascular system (Brodribb et al. 2017). However, stomata are found to close much before the xylem cavitates – i.e., the leaf water potential at which stomata close by 50% (ψ_gs50) is much less negative than the water potential at which the xylem loses 50% of its conductivity (ψ_x50) (Martin-St Paul et al. 2017). The mechanism that would allow stomata to close promptly to a decrease in transpiration in relation to a change in leaf water potential before the decrease in hydraulic conductance is still elusive. Our hypothesis is that the loss of root-soil hydraulic conductivity, more than xylem vulnerability to embolisms, is the primary constraint on transpiration during drought (Rodriguez-Dominguez and Brodribb 2020). Thus, stomata would close when the water potential around the roots drops more rapidly than the increase in transpiration. We investigated whether this loss of root-soil hydraulic conductivity, probably caused due to root shrinkage and the formation of air-filled gaps, and/or damage to fine roots, appeared to be an important constraint on transpiration during drought. We conducted physiological and imaging experiments on maize plants undergoing moderate drought. We performed high-resolution imaging (micro-CT) of leaves and the root-soil interface and measured in parallel the soil and plant water potentials. Transpiration, stomatal conductance, root hydraulic conductance and soil and plant water potential were also measured during soil drying in a similar set of plants. The formation of air-filled gaps along individual maize roots was visualized and quantified, finding an agreement between the soil water potential

at which roots shrank and root hydraulic conductance decreased, and the soil water potential at which stomata closed. These results proved the hypothesis that the loss of contact between roots and soil, and probably other root cortex modifications, triggered stomatal closure and transpiration reduction.

Key words: soil-root interface, maize, root-soil hydraulic conductance, stomatal closure

Acknowledgments: Microcomputed tomography measurements were conducted at the PSYCHE beamline at SOLEIL Synchrotron (Paris, France). C.M.R-D. was supported by a 'Juan de la Cierva - Incorporación' post-doctoral fellowship (Spain) and was granted a Junior Fellowship by the University of Bayreuth Centre of International Excellence "Alexander von Humboldt" for conducting this specific experiment.

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