Impacts of soil conductivity loss on plant transpiration regulation under drought

Andrea Cecere[1], Maud Henrion[1] & Mathieu Javaux[1]

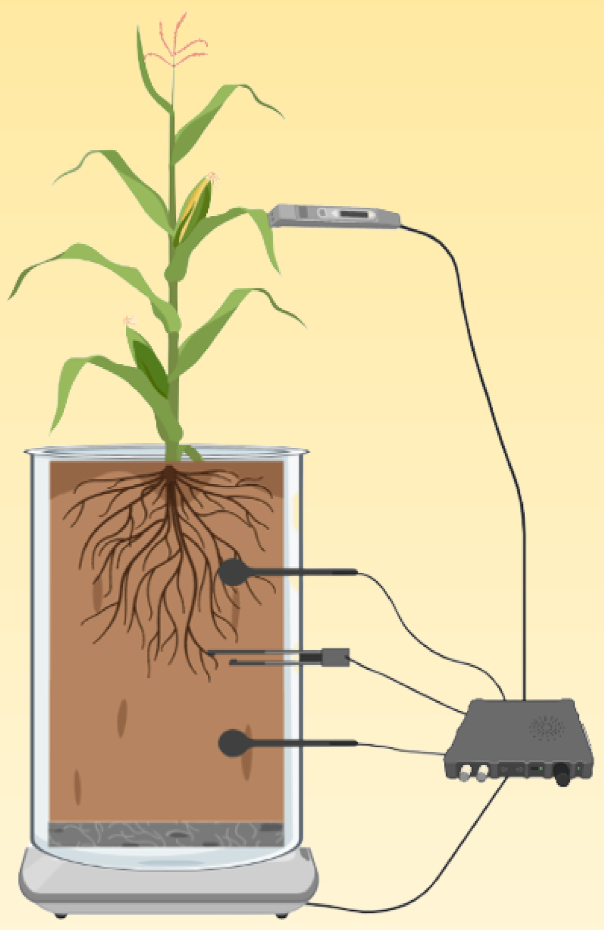
[1]Université catholique de Louvain, Earth and Life Institute
Contact : andrea.cecere@uclouvain.be

Objectives

- ➢Determine the impact of soil hydraulics and vapor pressure deficit on stomatal response under drought
- ➢(Re)define plant isohydricity as a function of the environmental conditions

Methods

- ✓Experimental approach in a controlled environment



- ✓2 contrasted genotypes, soil types, and 2 levels of vapor pressure deficit and soil water potential
- ✓Soil – Root – Canopy structure characterization

Project

This study is part of the UPSet project (Unravelling the impacts of Plant-Soil hydraulics on stomatal rEgulaTion), funded by the FNRS.

References

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Hayat, F., Ahmed, M.A., Zarebanadkouki, M., Javaux, M., Cai, G., Carminati, A., 2020. Transpiration Reduction in Maize (Zea mays L) in Response to Soil Drying. Front. Plant Sci. 10, 1695.

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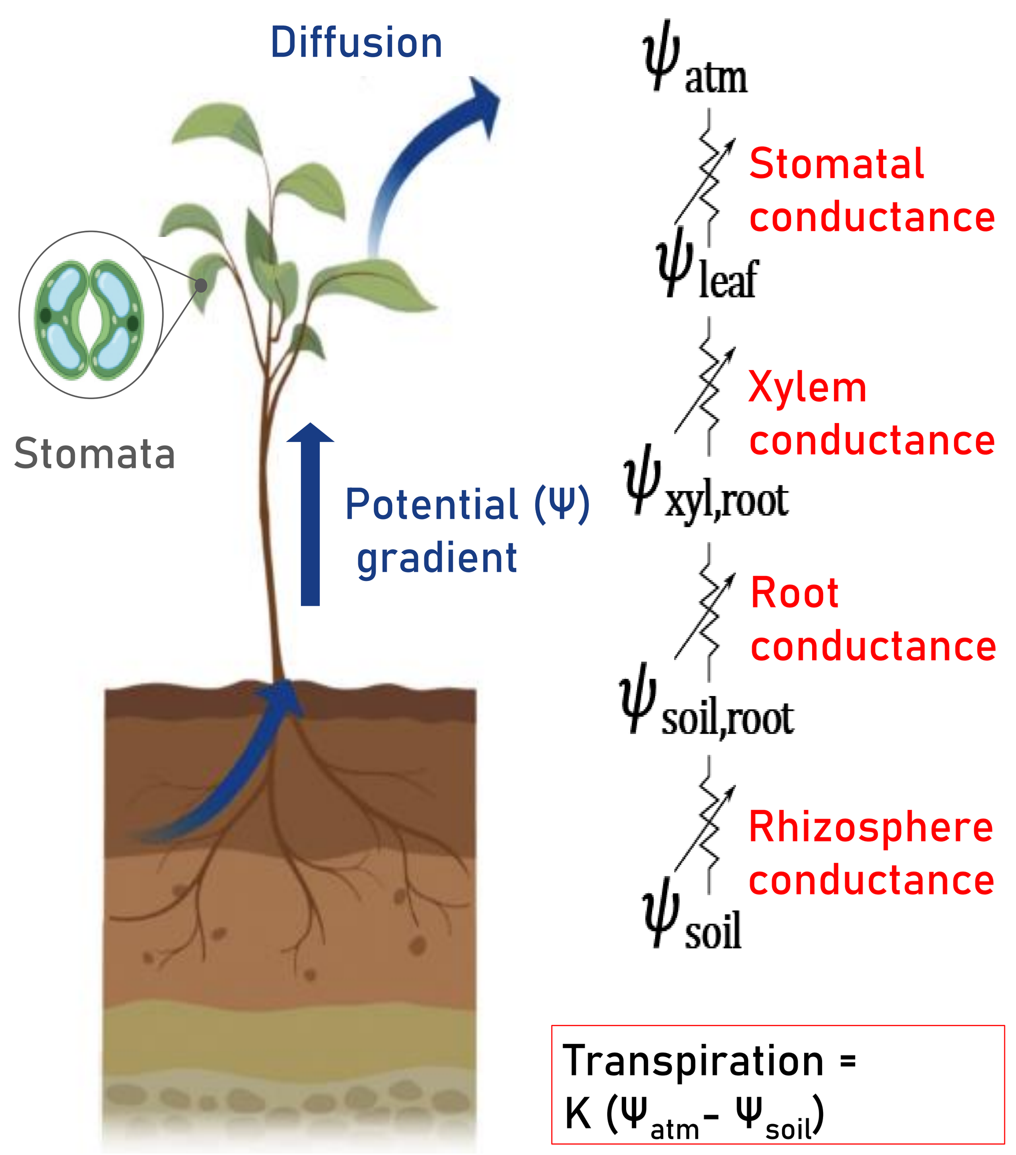
1 Between 60 and 90 % of terrestrial precipitations go back to the atmosphere through plant transpiration



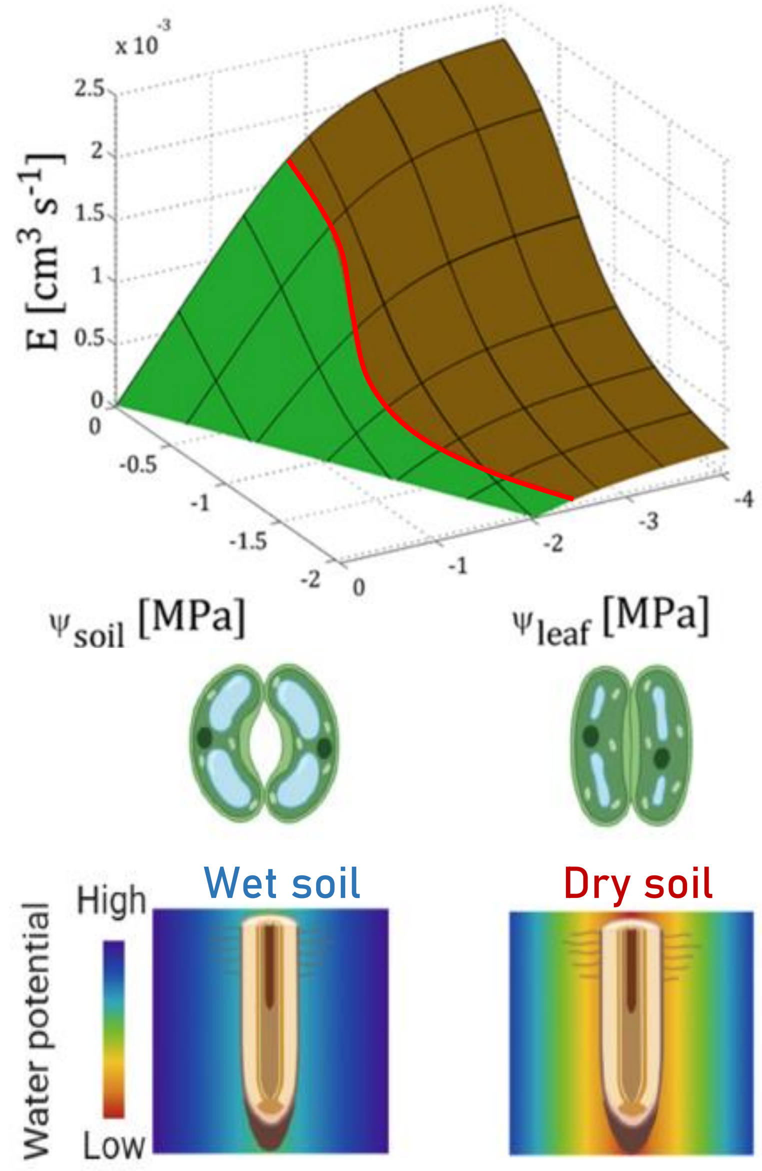
The process of transpiration, through stomata, is driven by the atmospheric demand.

Understanding stomatal regulation is a main challenge for anticipating plant response to climate change.

Stomatal response has long been seen as specific to the plant traits, classifying them into (an)isohydric types. However, a plant is part of a soil-plant continuum system.

Figure 1: Water transport in the soil-plant continuum and its electrical anology

2 The primary driver of stomatal closure during drought is the change of soil hydraulic conductivity



Carminati and Javaux model establishes a 3D hydraulic surface where E is a function of Ψ_{soil} and Ψ_{leaf}.

When the soil dries out, its potential decreases, as well as the Ψ_{leaf}.

They hypothesized that stomata close when $\Psi_{leaf}(E)$ becomes nonlinear, and this nonlinearity depends on the loss of soil hydraulic conductivity.

Figure 2 (a): The 3-D hydraulic surface of the plant soil system. The red line represents the onset of the non-linear E-Ψ_{leaf} relation.
(b): Stomata closure is driven by the soil water potential gradient.

3 Soil shows influence on stomatal response and (an)isohydricity is a dynamic concept

Drought experiments on sunflower with 2 soils and 2 stress intensities

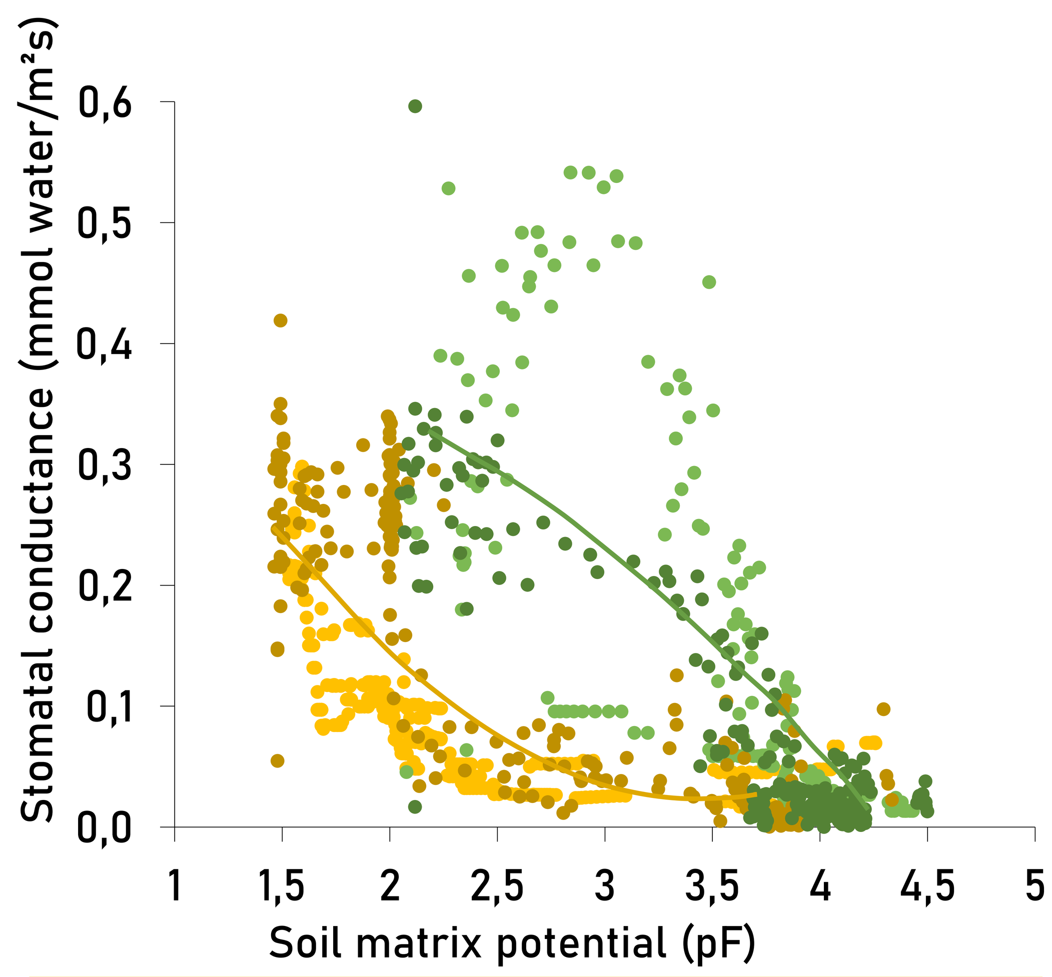


Figure 3: Steeper decrease of the stomatal conductance for the plants in sand because of a faster drop in soil hydraulic conductivity

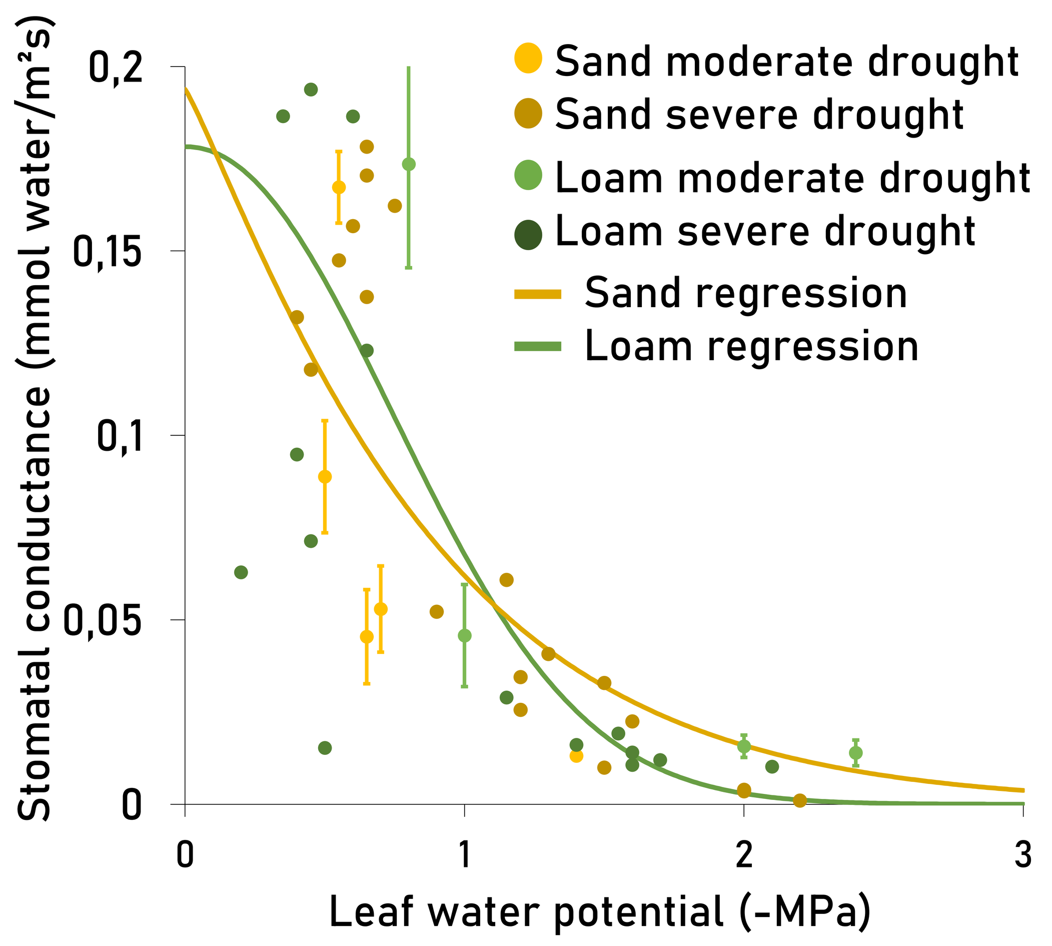


Figure 4: Early threshold of stomatal closure doesn't coincide with the anisohydric definition and might be affected by soil type

4 Perspectives to characterize the stomatal response

Phase 1 : PHYTOTRON Pre-experiment Soil type and genotype

Phase 2 : PHYTOTRON Soil water potential and vapor pressure deficit

Phase 3 : ECOTRON Ψ_{leaf} (E) relation for varying soil moisture

Phase 4 : RHIZOTRON Soil water potential spatial distribution

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