"Impacts of soil conductivity loss on plant transpiration regulation under drought"

Cecere, Andrea ; Henrion, Maud ; Javaux, Mathieu

ABSTRACT

Between 60 and 90% of terrestrial precipitations go back to the atmosphere through plant transpiration stream and this huge flux is controlled by plant stomata. Yet, stomatal functioning is not fully understood and there is no consensus on a universal model for stomatal regulation. Recent studies have hypothesized that there is an intimate relationship between the hydraulics of the soil-plant continuum and the stomatal response to drought. It has been shown in silico that it is the drop in rhizosphere hydraulic conductance that is the main driver of leaf water potential decrease that leads to stomatal closure to protect the plant against cavitation. The soil conductance would be one of the first factors limiting the transfer of water to the plant under conditions of water deficit. On the other hand, physiologists have demonstrated that the stomatal regulation could differ between plant species and genotypes due to different sensitivities of stomata to chemical or hydraulic signals and have classified plant stomatal regulation into iso- or anisohydric regulation classes. In this project, we hypothesize that the degree of anisohydricity will be a function of the environment. The objective of this research is to elucidate the impact of soil hydraulics on plant transpiration regulation under drought. Two main experiments will be conducted on two genotypes of Zea mays L. with contrasted stomatal behavior. First, we will use small pressure ecotron to characterize the relationship between leaf potential, soil potential and transpiration from different combinations of vapor press...

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Impacts of soil conductivity loss on plant transpiration regulation under drought

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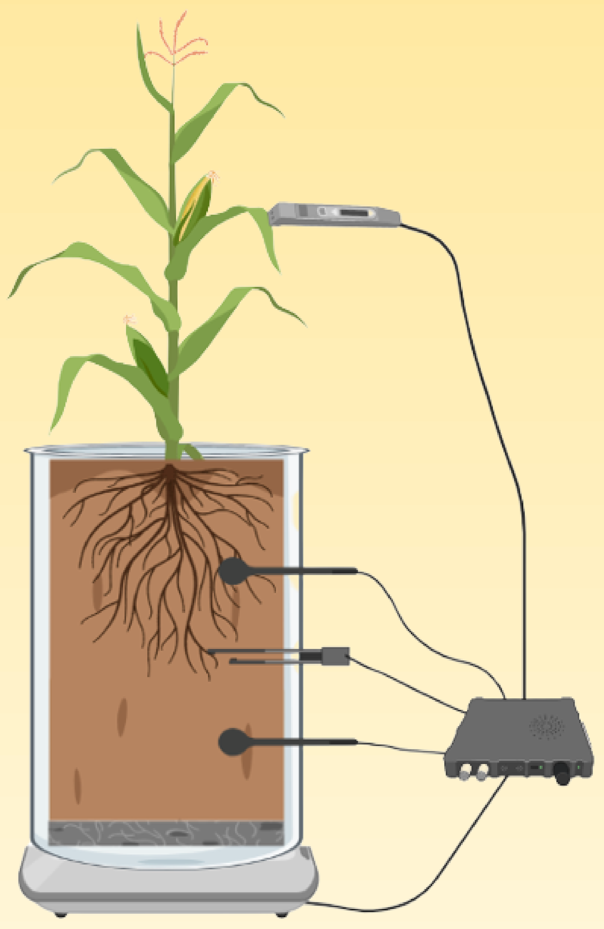
Objectives

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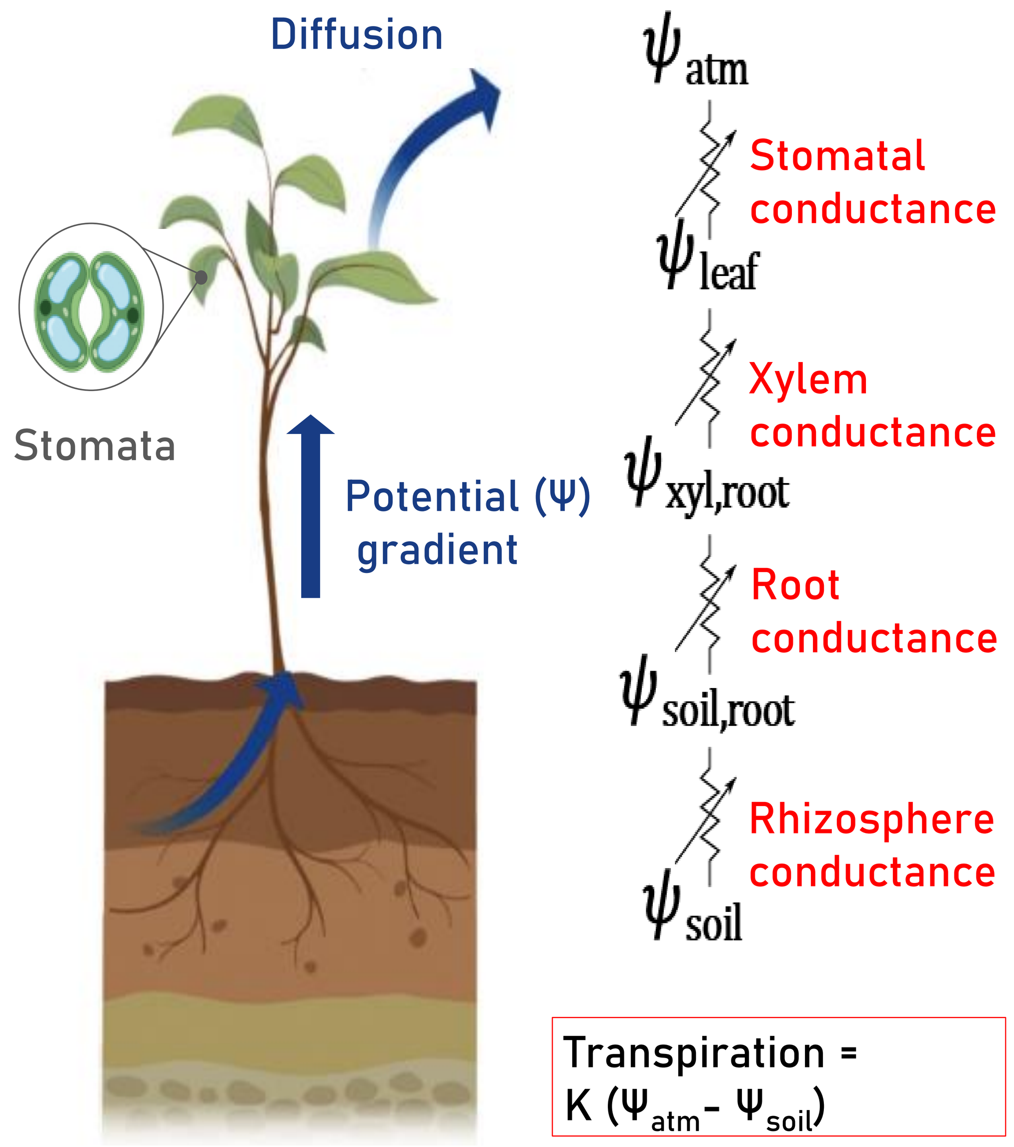
1 Between 60 and 90 % of terrestrial precipitations go back to the atmosphere through plant transpiration



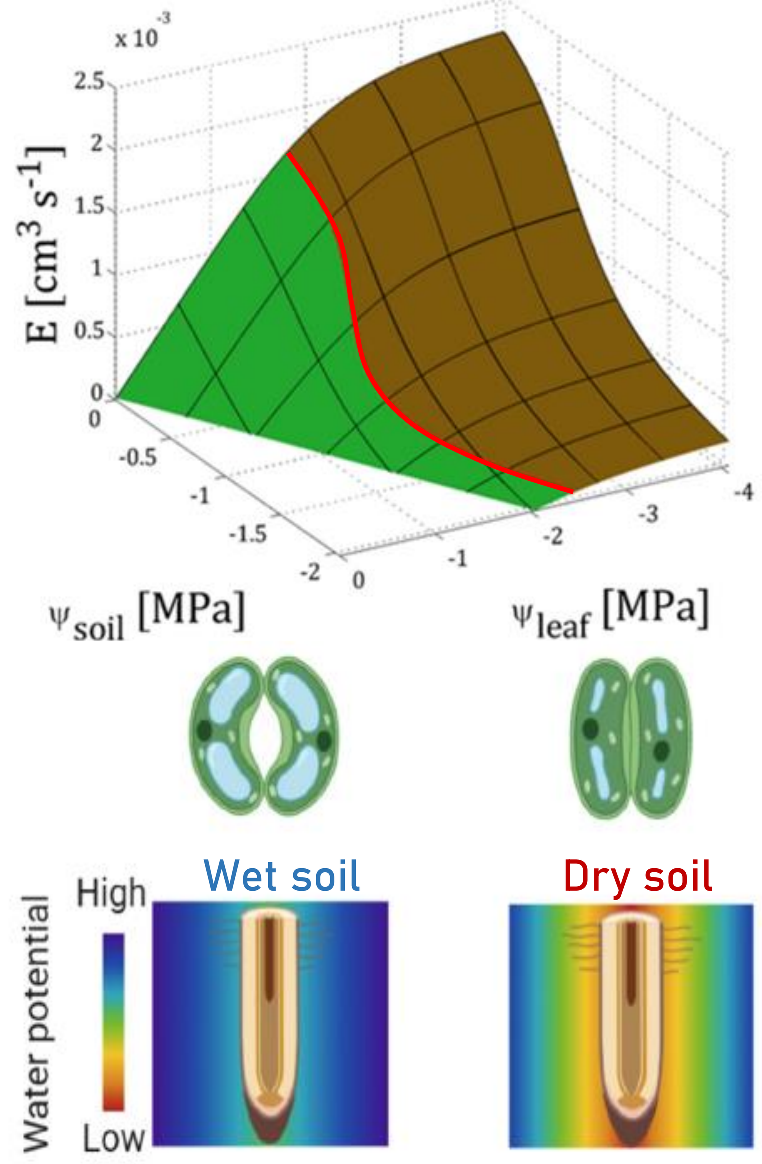
The process of transpiration, through stomata, is driven by the atmospheric demand.

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 Ψ_{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

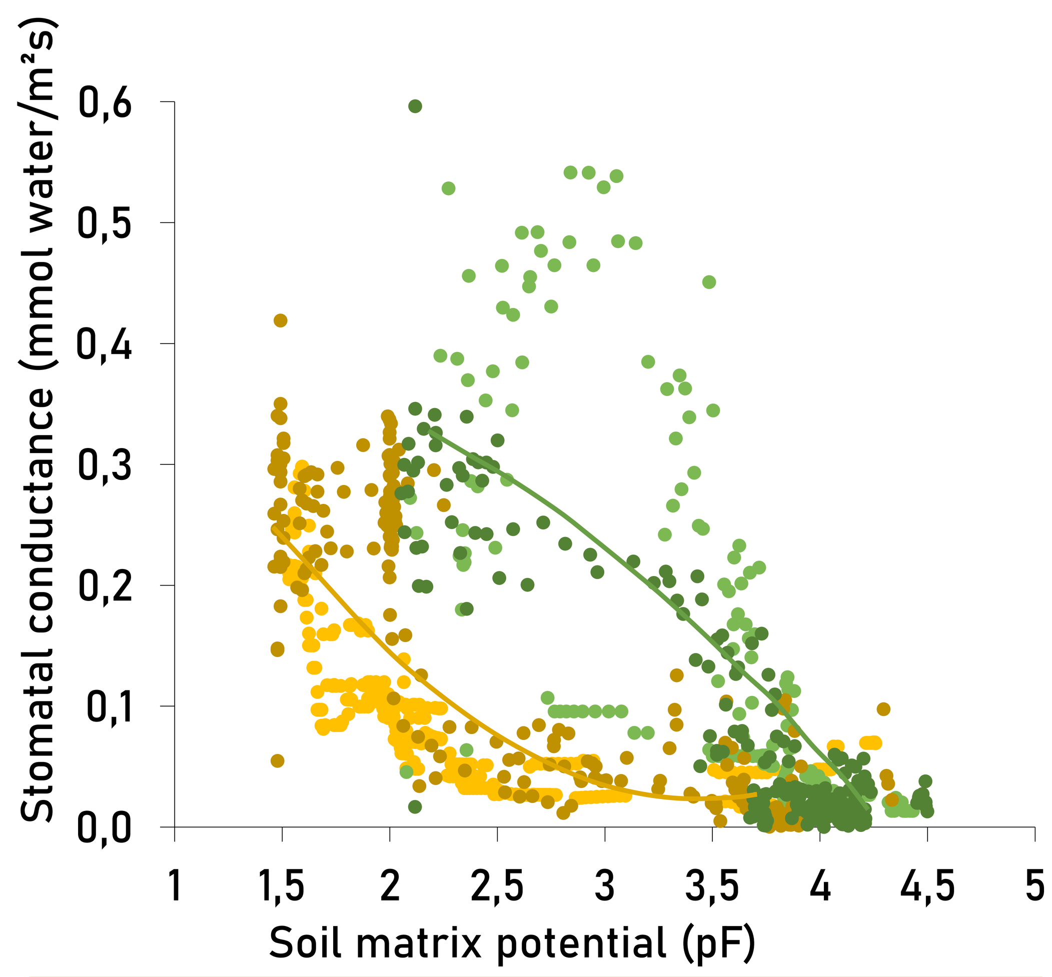


Figure 3: Steeper decrease of the stomatal conductance for the plants in sand because of a faster drop in soil hydraulic conductivity

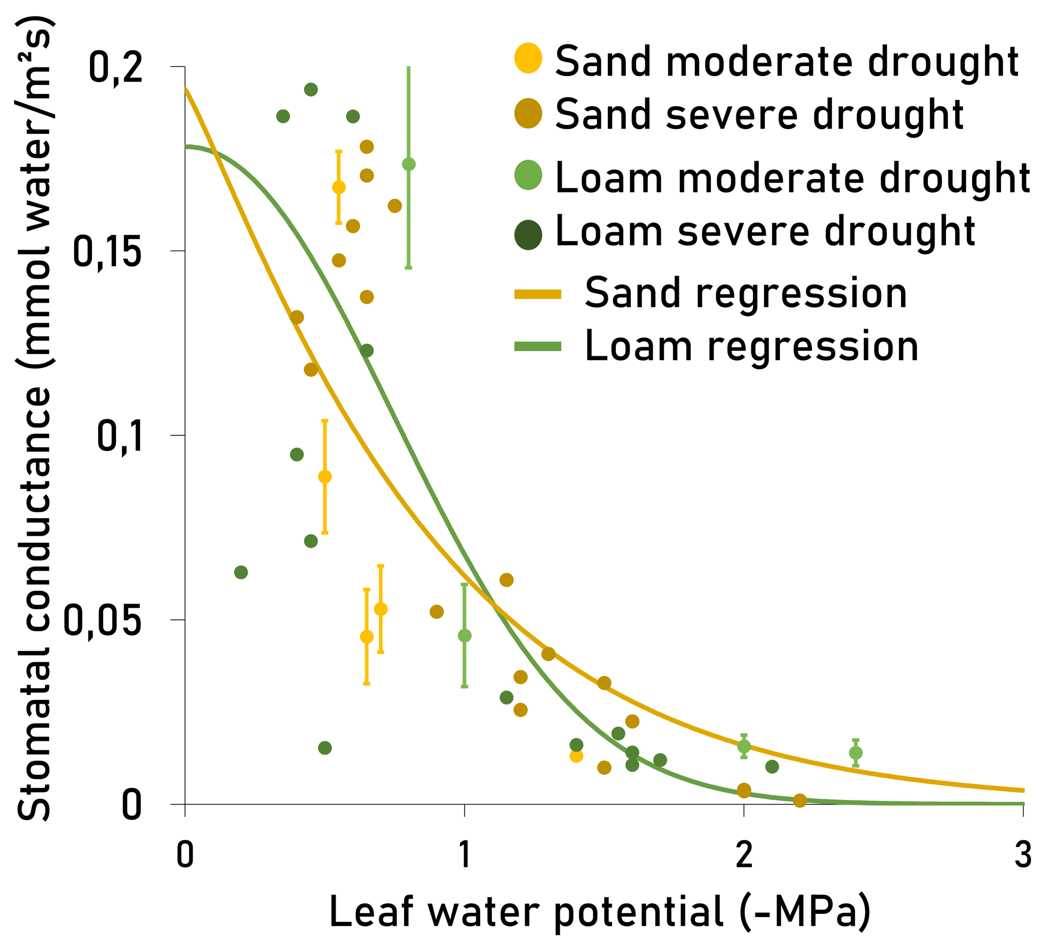


Figure 4: Early threshold of stomatal closure doesn't coincide with the anisohydric definition and might be affected by soil type

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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