

Emerging effects of selected rhizosphere properties on transpiration and leaf water potential of two *Zea mays* L. genotypes in semi-arid environments

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Introduction

This study focused on the effect of belowground processes and rhizosphere traits on soil-plant water relations (Fig 1a and b). Therefore, experiments which investigate the effect of **root hairs** and water flow dynamics through different **soil textures** on transpiration, leaf water potential, soil-plant hydraulic conductance and stomata conductance have been tested in drying soils.

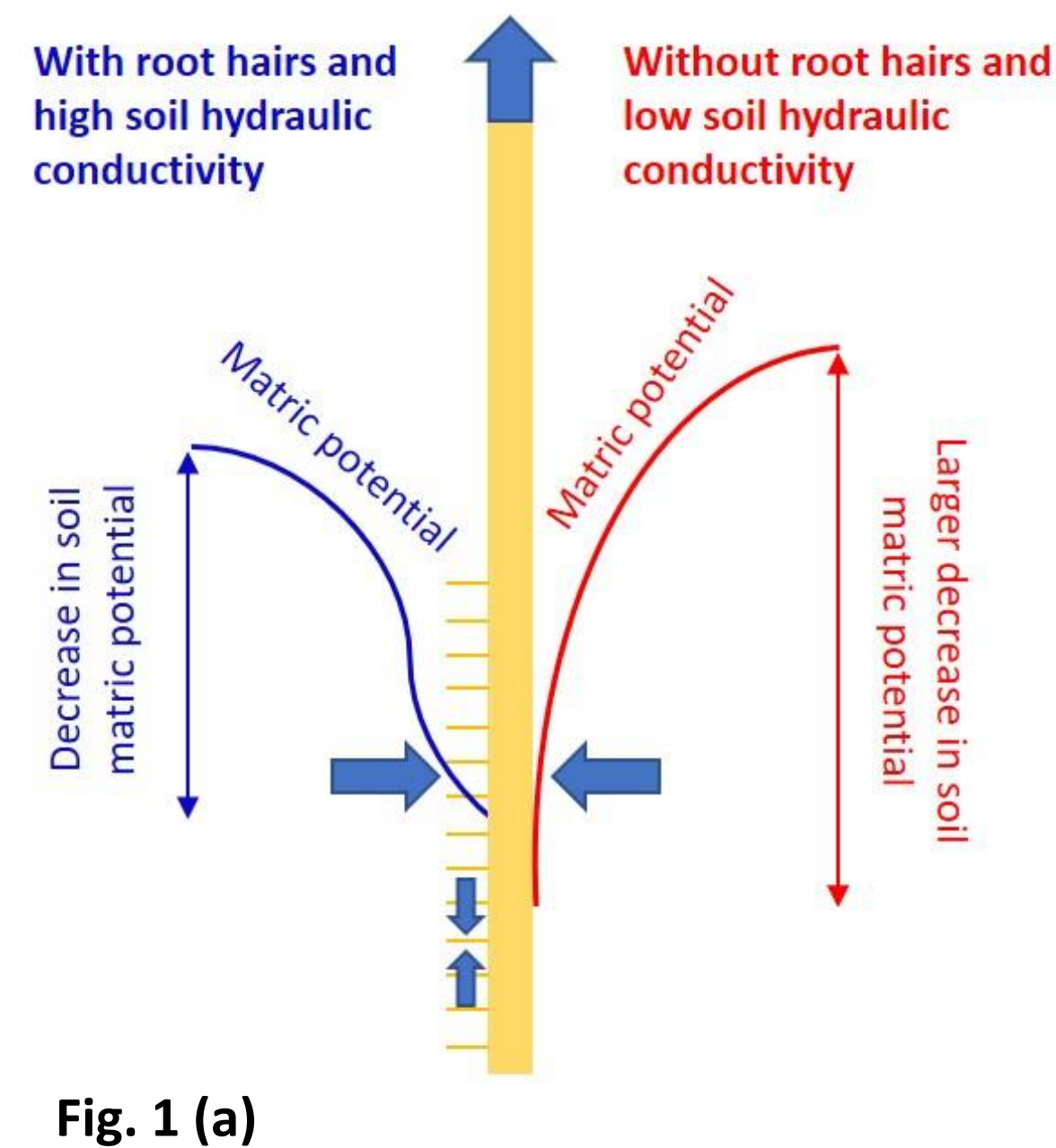


Fig. 1 (a)

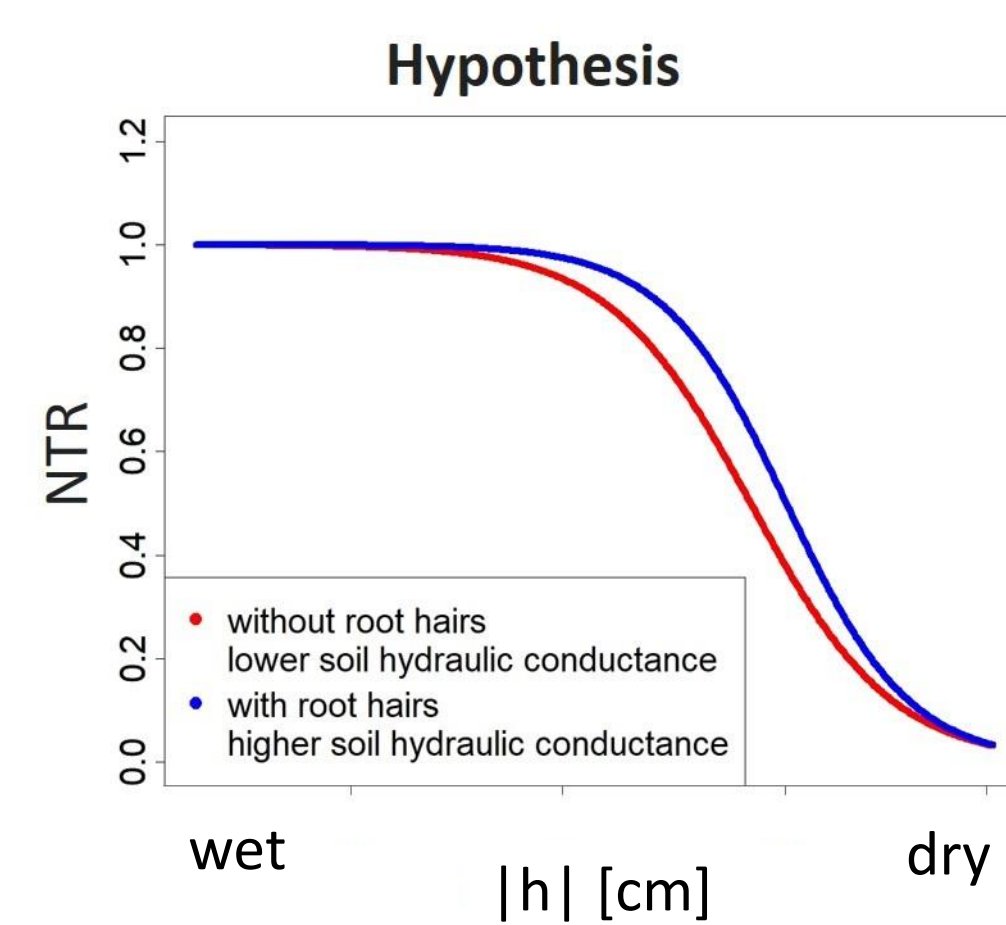


Fig. 1 (b)

Material and Methods

Two maize (*Zea mays* L.) genotypes, a hairy wildtype (Fig. 2a) and a root-hairless rth3-mutant (Fig. 2b) were grown in pots, filled with sandy loam, silty clay or sand. They were exposed to soil drying under glasshouse conditions. Soil water content (Θ) has been monitored by TDR-measurements. Soil water potential (h) was calculated from the soil water content. Daily transpiration (E) was measured gravimetrically and normalized to facilitate comparison (NTR, [1]). Leaf water potential has been measured at four water stress levels (WW-WS3) during the day (Ψ_{leaf}) and under pre-dawn conditions (=indicator for soil water potential, [2]), using the Scholander pressure chamber. Stomata conductance (g_s) has been calculated from the transpiration rate, normalized by leaf area and VPD, normalized by atmospheric pressure [3].

Results and Discussion

The effect of root hairs

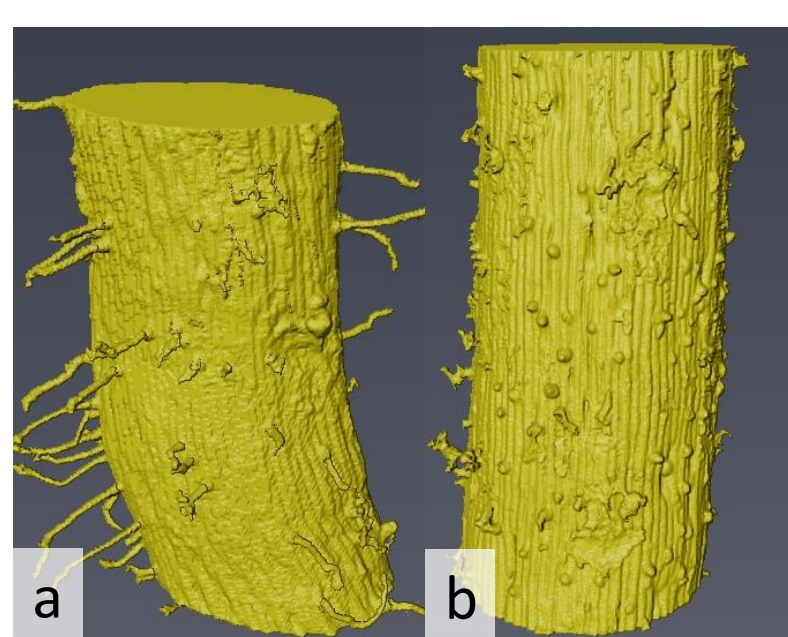


Fig. 2: Wild-type (a) and rth3-mutant (b) root. By courtesy of P. Duddek

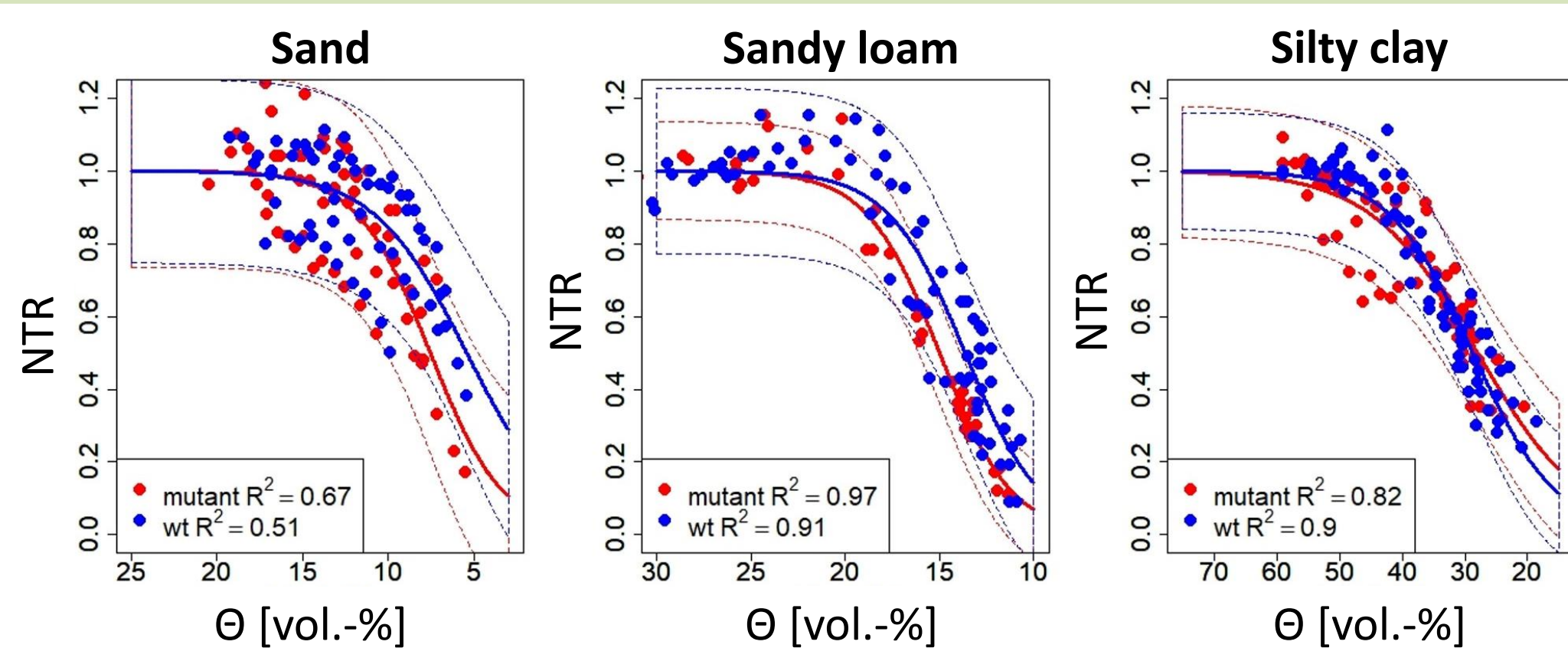


Fig. 3: Relationship between normalized transpiration ratio (NTR) and soil water content (Θ) between genotypes.

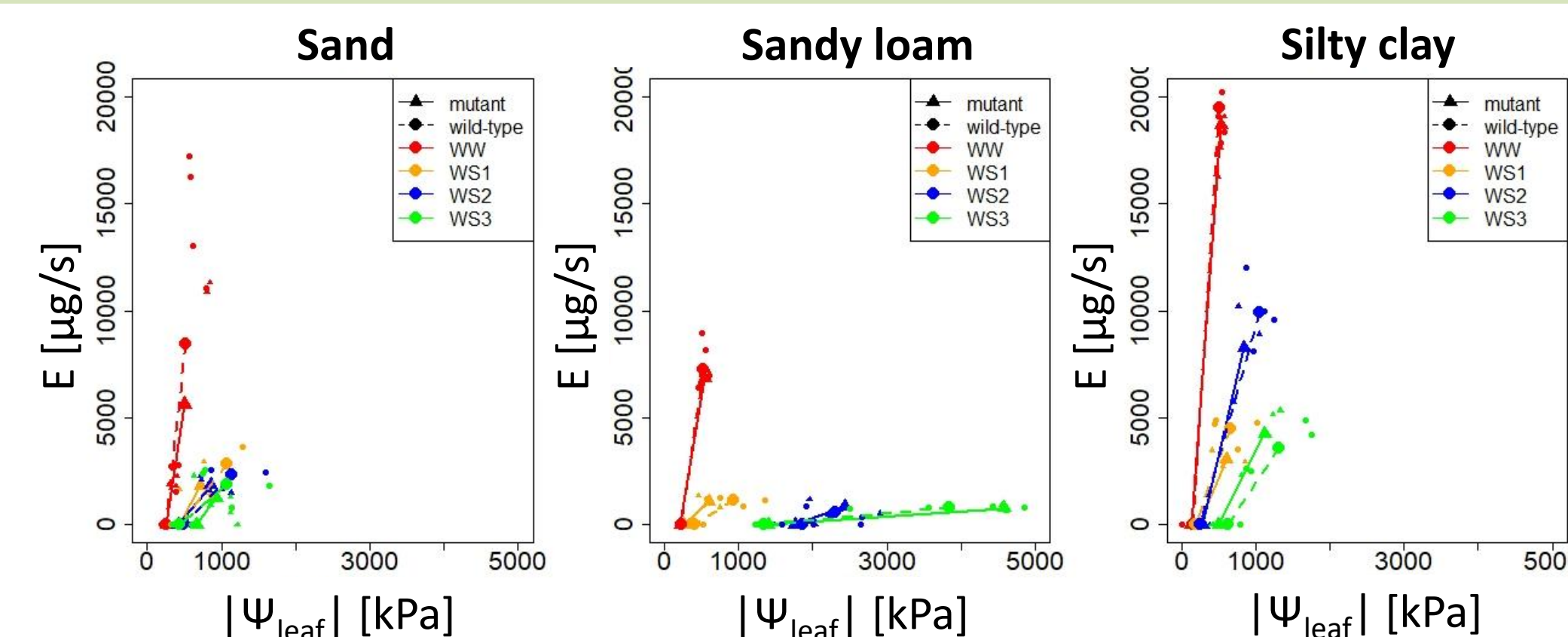


Fig. 4: Relationship between transpiration (E) and absolute leaf water potential ($|\Psi_{\text{leaf}}|$) between genotypes.

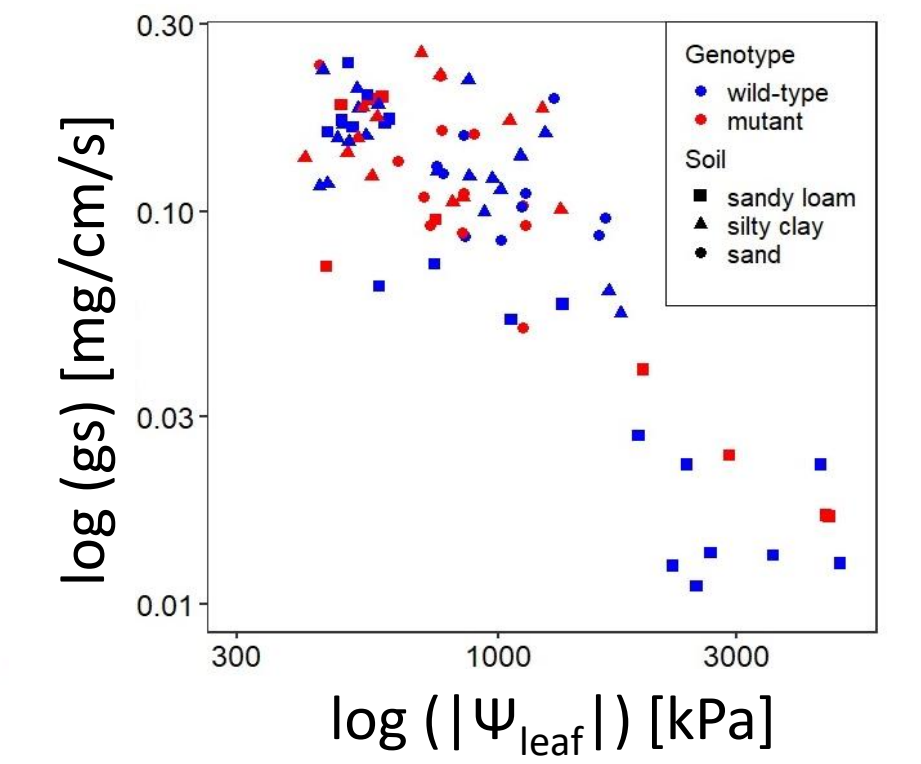


Fig. 5: Relationship between stomata conductance (g_s) and $|\Psi_{\text{leaf}}|$ between genotypes.

The effect of root hairs manifested in a delayed drop in NTR with decreasing Θ and/or higher NTR post the transpiration breakpoint in the presence of root hairs (Fig. 3). The effect of root-hairs might be especially pronounced in silty clay because of their ability to bridge the gap between roots and soil as originated by cracks (Fig. 7, [4]) and thereby maintained the connectivity of the liquid phase and water flow eventually [5]. In sand, root hairs are believed to have attenuated the gradients in matric potential around the roots [6], which developed with a drastic drop in soil hydraulic conductivity in coarse-grained soils. No obvious differences between the genotypes were visible in the relationship between Ψ_{leaf} and E (Fig. 4, which is equivalent to the soil-plant hydraulic conductivity (K_{sp}), as well as between g_s and E (Fig. 5). This is believed to be explained by the prompt stomata closure under natural conditions [7].

The effect of soil texture

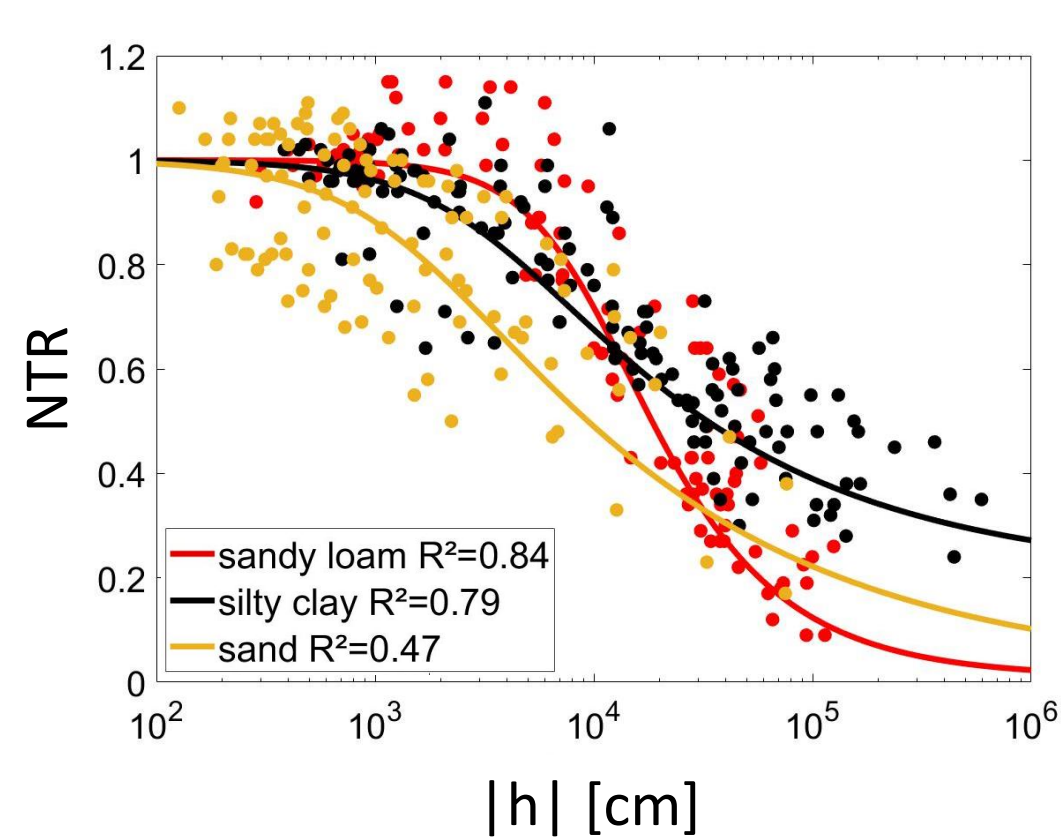


Fig. 6: Relationship between normalized transpiration ratio (NTR) and absolute soil water potential ($|h|$) between soil textures.

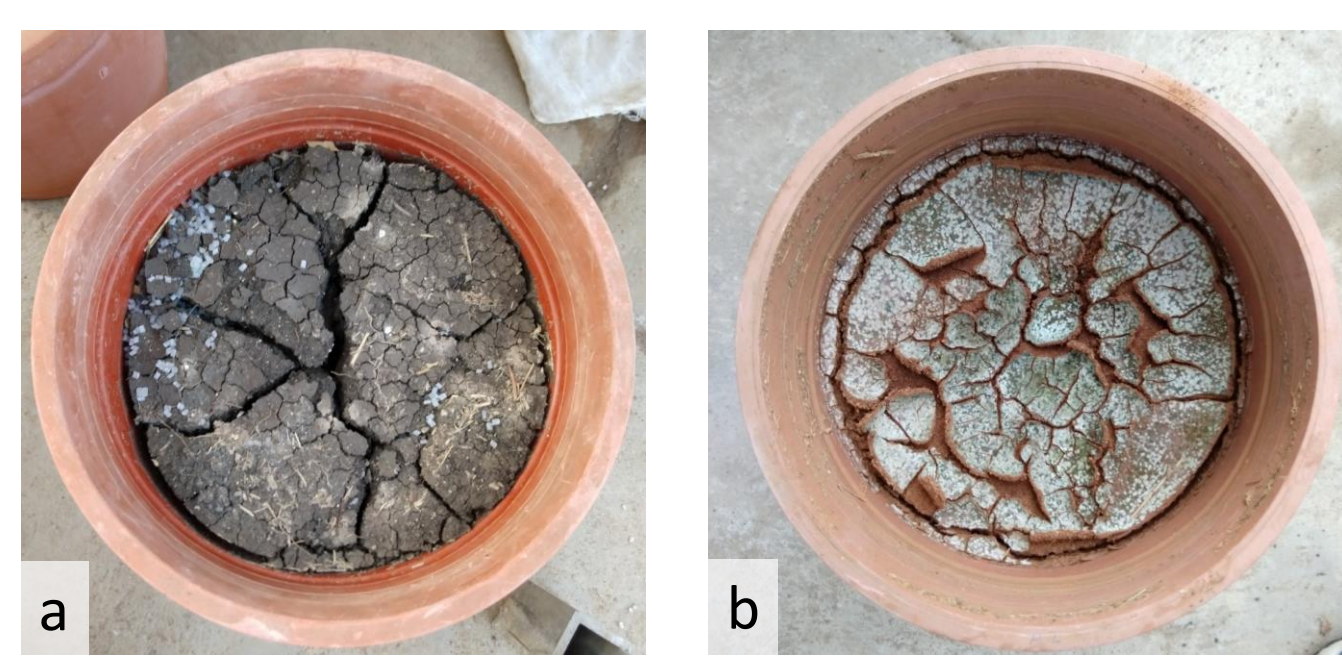


Fig. 7: Cracks in silty clay (a) and crust formation in sandy loam (b). By courtesy of D.-S. Moser

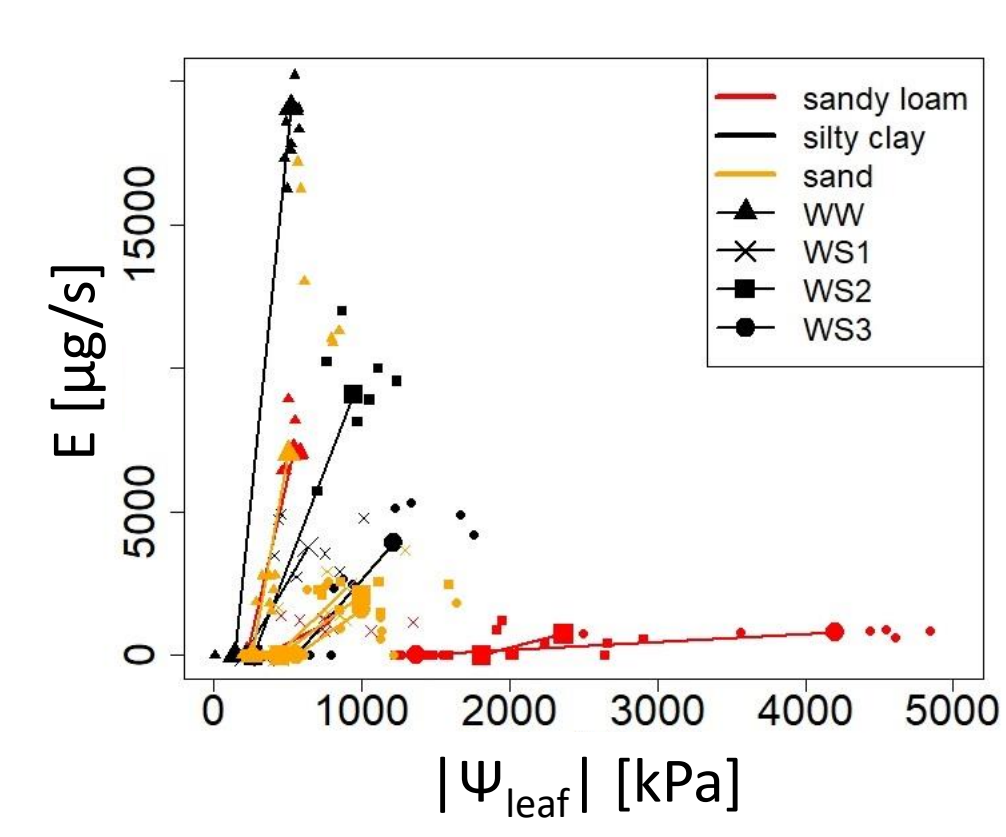


Fig. 8: Relationship between transpiration (E) and absolute leaf water potential ($|\Psi_{\text{leaf}}|$) between soil textures.

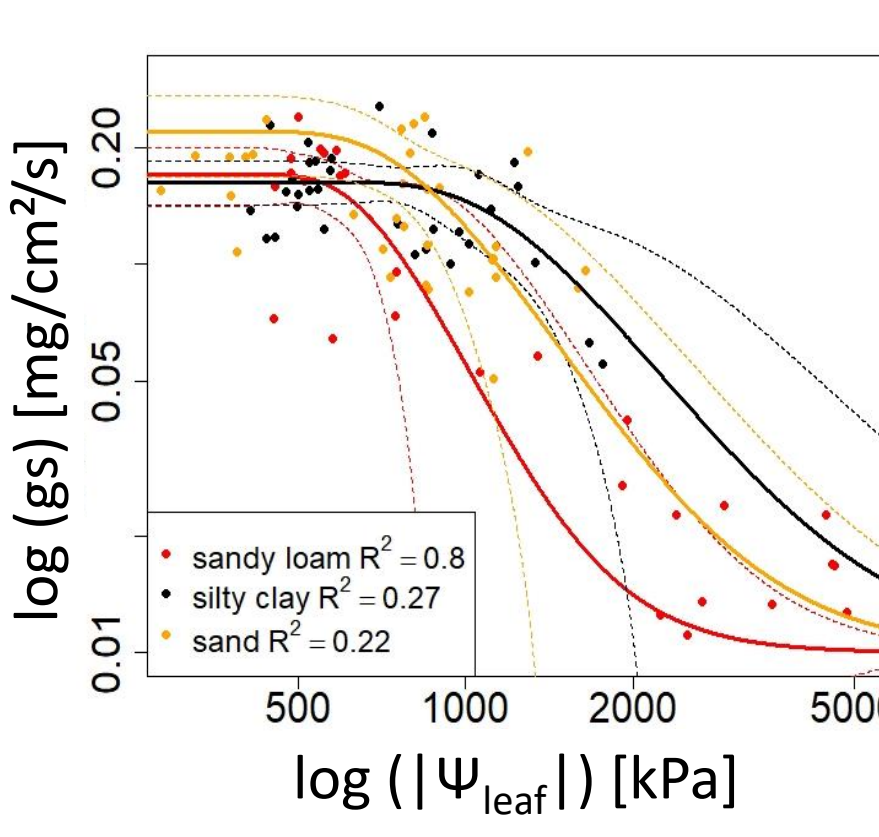


Fig. 9: Relationship between stomata conductance (g_s) and absolute leaf water potential ($|\Psi_{\text{leaf}}|$) between soil textures.

Plants grown in different soil textures decreased NTR at different h , although not exactly as expected (Fig. 6). This was attributed to soil features like soil cracking or crust formation that might have changed the expected soil hydraulic conductivity (Fig. 7). Moreover, soil texture seemed to have mattered for the development of plant- as well as soil hydraulic conductivity, which can be deduced from the differences in K_{sp} at all WS-levels between soils (Fig. 8). Overlapping confidence intervals are suggesting that differences between soil textures in g_s response to Ψ_{leaf} were not significant (Fig. 9).

Conclusion and References

We conclude that: 1.) **root hairs** had a positive impact on root water uptake and therefore transpiration. However, a different experimental setup will be needed to investigate genotypic differences in soil-plant hydraulic conductivity, as they are expected to become pronounced in dry soils under high transpiration rates, when the relationship between leaf water potential and transpiration becomes non-linear [8]. Furthermore, we have found that: 2.) **soil texture** had an effect on transpiration with soil drying. Soil texture likely mattered by determining soil hydraulic conductivity, which affected the resistance to water flow between soil and roots and consequently transpiration. There were no clear differences between soil textures in the relationship between g_s and Ψ_{leaf} but in K_{sp} . We conclude that soil texture indirectly affected stomata by changing the soil-plant conductance.

Acknowledgments

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