"Experimental investigation of the relationship between root:shoot ratio and soil-plant hydraulics."

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ABSTRACT

In a context of global change, it is crucial to understand the factors and processes by which plants respond to drought and by which crops may limit the development of their aboveground biomass. Experimental studies have showed that soil water status, soil structure and soil texture impact carbon allocation within plant and in particular the root:shoot ratio. We used a conceptual soil-plant hydraulic model to analyze the results of a meta-analysis gathering literature data of root:shoot ratio measured in controlled conditions. For each paper, information on soil water status, soil and plant traits and abiotic factors were collected. Soil hydraulic conductivity was estimated based on pedotransfer functions, when unavailable. The results feature that the root:shoot ratio is an adaptation strategy that depends on the soil conductance in order to balance the water availability with the transpiration demand. The partitioning response varies between plant types. This study gives an explanation to current observations and shows the necessity to collect accurate soil measurements and information for further experiments.

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Is the Root:Shoot surface ratio a function of the soil hydraulic conductivity?

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1 The challenge in understanding the Root:Shoot ratio drivers

The Root:Shoot ratio (RSR) is an indicator used to quantify plant plasticity to its environment. It has been used to understand plant drought tolerance and to predict belowground carbon input.

If many papers studied the influence of the species and various biotic factors on this parameter, latest reviews showed the importance of abiotic factors to predict RSR and more specifically the soil water content (Poorter et al., 2012 ; Eziz et al., 2017 ; Qi et al., 2019), the soil texture (Poeplau & Kätterer, 2017) and the vapor pressure deficit (Lopez et al., 2020). However, these abiotic predictors and the mecanisms driving the RSR are still not well understood.

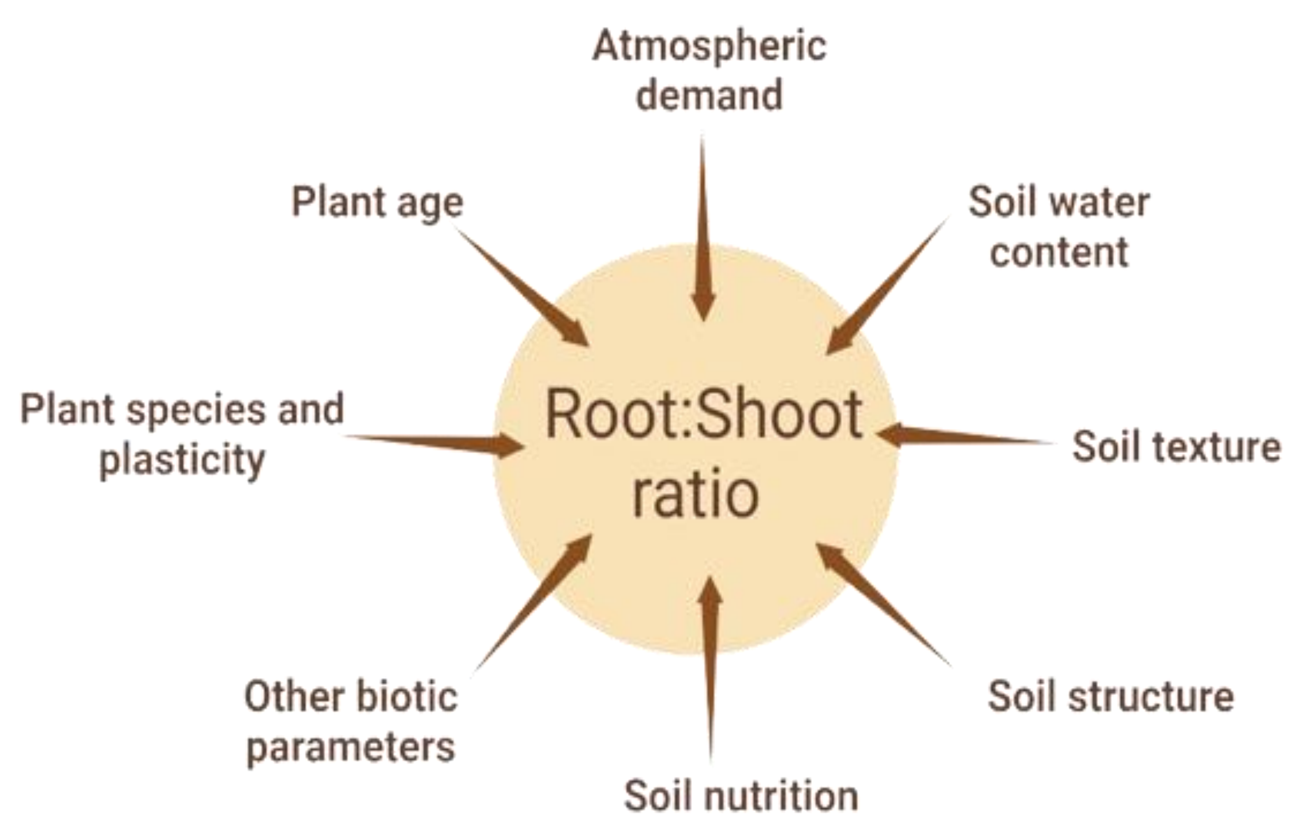
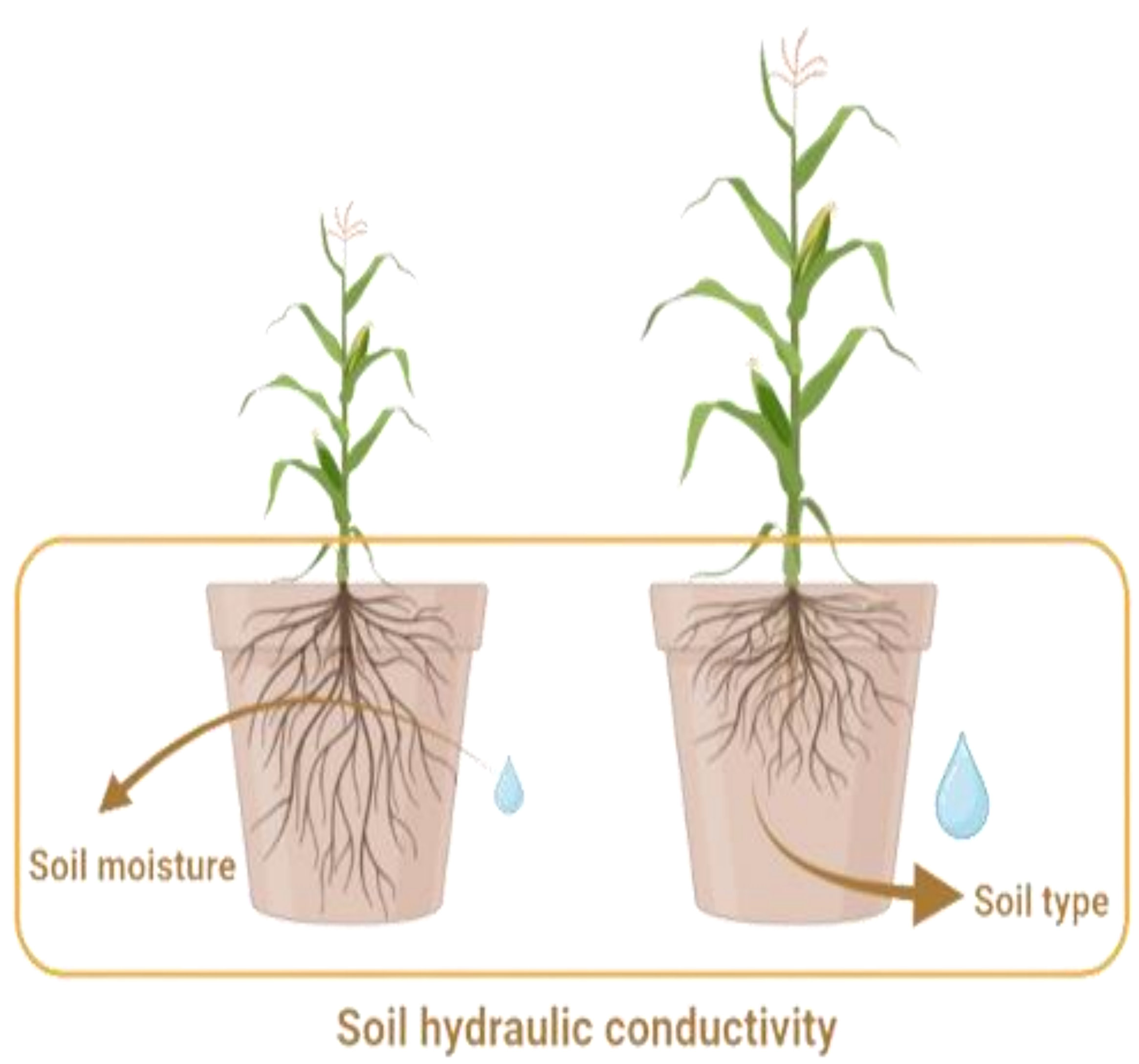


Figure 1. Predictors of the Root:Shoot ratio across litterature

2 Root:shoot surface ratio function of soil hydraulics?



As soil hydraulic conductance is the main limitation to water uptake (Carminati & Javaux, 2020), we hypothesize that it will control plant development. Soil hydraulic conductance is proportional to root surface, to soil conductivity (and thus water content) and inversely related to water uptake. Plants growing in a soil with low hydraulic conductivity will tend to increase their root-soil surface and decrease their leaf surface, thereby increasing their RS surface ratio. Our model allows quantifying the impact of soil hydraulics on this ratio.

Figure 2. Hypothesis of RS surface allocation with the soil hydraulic conductivity. The RS surface ratio will increase with a decreasing soil hydraulic conductivity.

3 A meta-analytic approach

In February 2023, a research on Google Scholar was led for Maize and had 399 results. Experiments with pots or in controlled conditions, gathering the following information, were selected: soil water status, soil texture, transpiration rate and root and shoot surfaces. From 15 relevant papers, we started to extract or estimate soil hydraulic conductivity data, experimental conditions and physiological information.

4 First observations

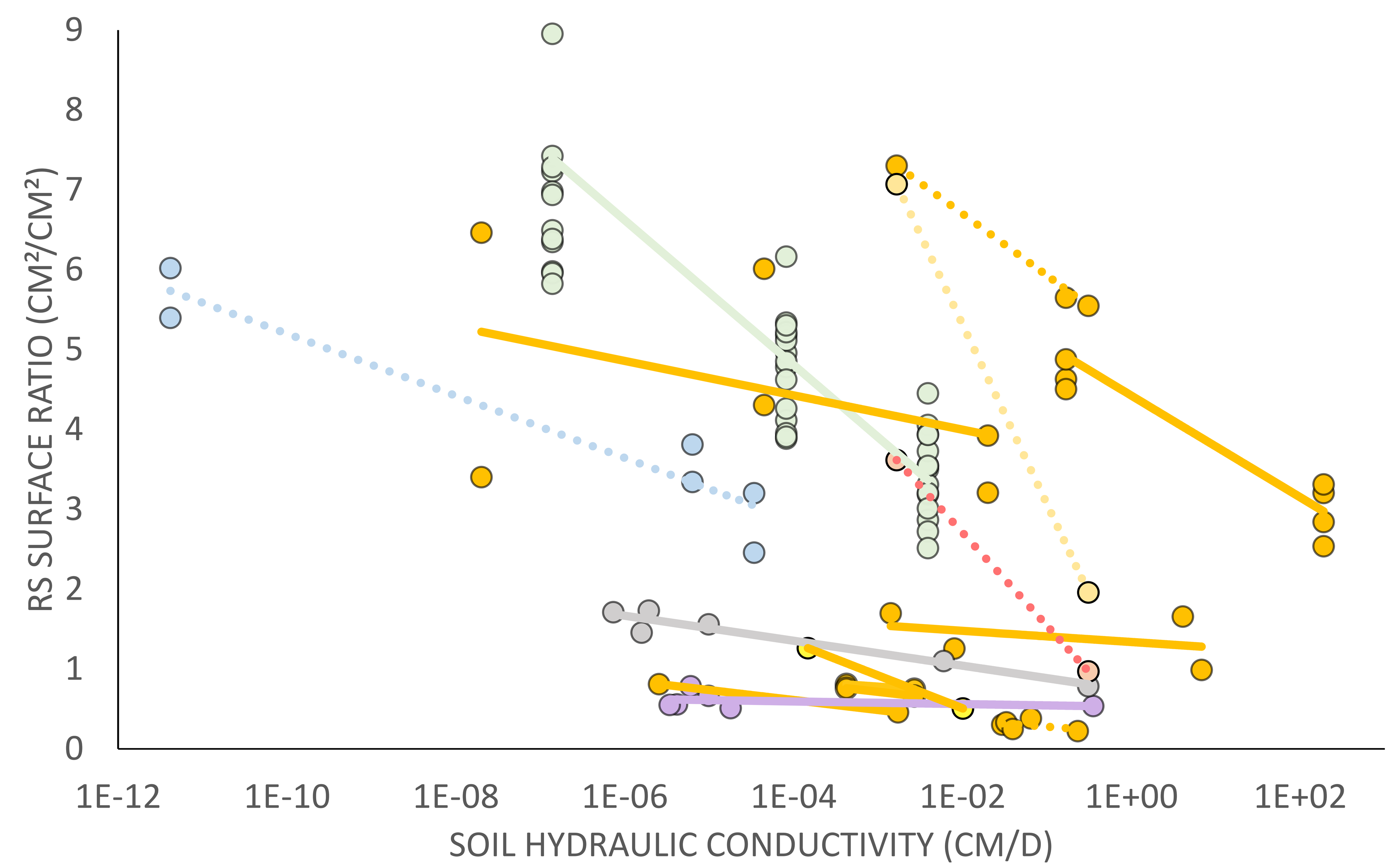


Figure 3. The relationship between soil hydraulic conductivity and RS surface ratio for multiple studies: Maize (orange), cotton (blue), pea (purple), sesbania (grey), rice (green), sorghum (red), millet (yellow). Studies comparing soil textures are in dotted lines.

5 Perspectives

The first results feature that the RS surface ratio responds negatively to the soil hydraulic conductivity in order to balance the water availability with the transpiration demand. The partionning varies among species.

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