Light transmission imaging as a useful tool to decrypt soil-root interactions

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Introduction

Drought is becoming a major constraint on crop production worldwide. Water availability sets the limits for transpiration and is reflected in the evolution of stomatal conductance throughout plant life, which affects photosynthesis and yield. These effects are critical at given phenological stages, such as flowering and grain filling in maize, and may have irreversible effects on yield. It is therefore important to improve the ability of plants to manage water resources from their environment in optimal ways.

We present here a phenotyping platform designed to analyse various aspects of root system architecture and dynamics and how they interfere with soil water uptake, in a quantitative framework.

Experimental platform

Maize plants are grown in 2D-**rhizotrons** designed to allow 2D monitoring of soil water content by **light transmission** imaging (Guarrigues *et al*, 2006) (fig. 1).

Hydraulic properties of the substrate are precisely characterized and quantitatively linked with light transmission.

This setup enables a daily monitoring of **root growth** and **soil water content**.

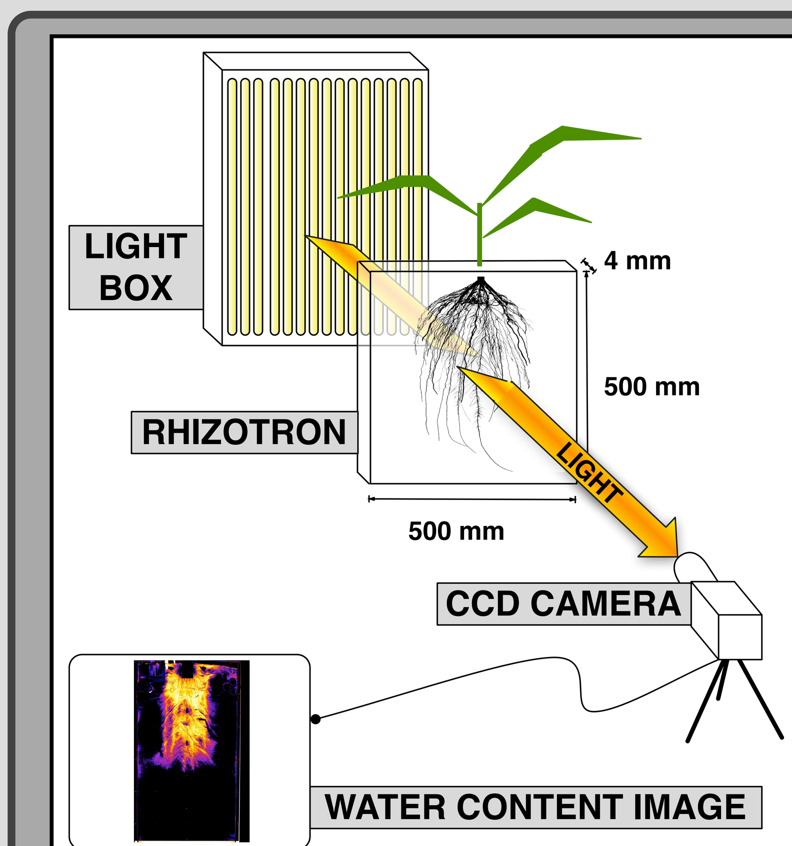

fig 1: Light transmission imaging experimental set-up.

Root growth results

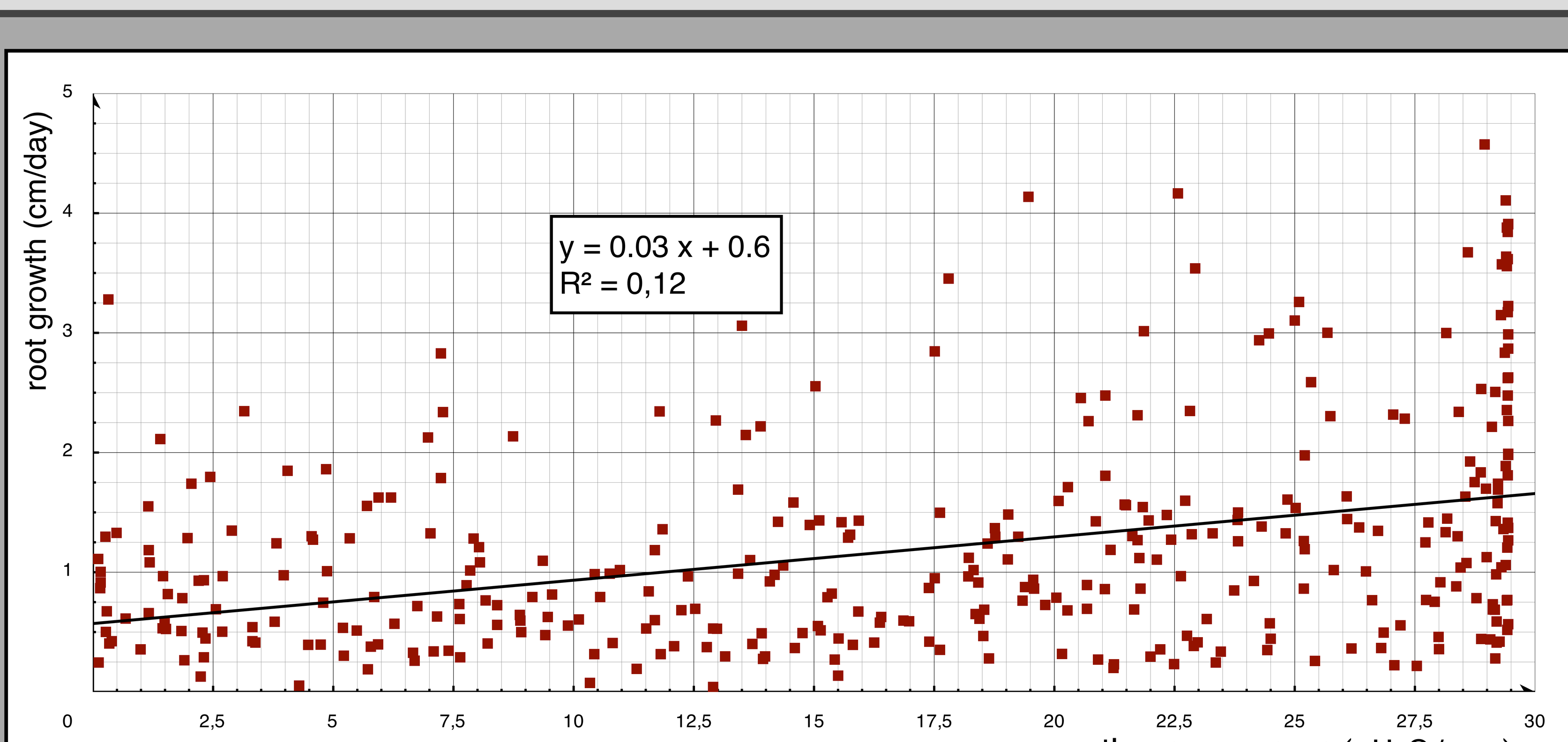

fig 2: Root elongation vs local soil water content. Soil water content is calculated directly around the apex of the root (0.4 cm³)

A weak positive correlation is observed between **local soil water content** and **daily root growth**

Hypothesis:
- increased availability of water
- soil impedance decrease as soil water content increase with positive effect on growth (Clark *et al.*, 2003)

This observation is consistent with those of Kuchenbuch *et al.* (2006)

Water uptake results

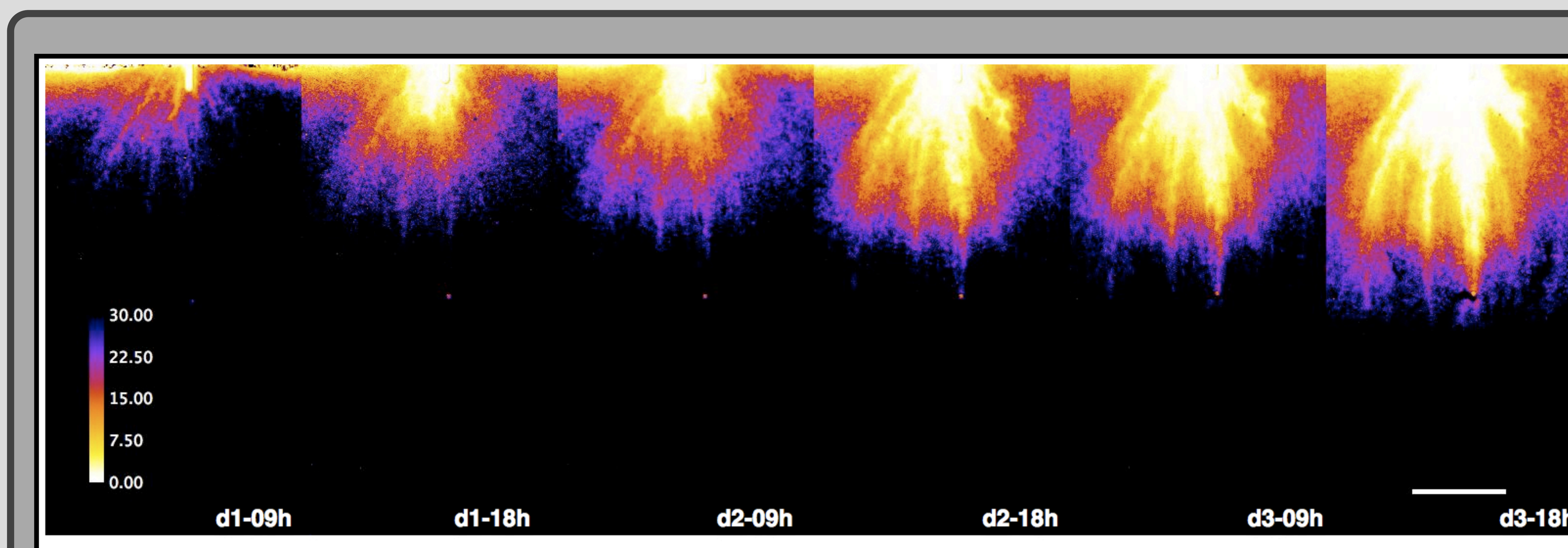

fig 3: Evolution of soil water content during a 3-day long water deficit episode. The maize plant is 21 days old at the moment of the treatment. Time-step between images is 12 hours. Scale bar is 10 cm

Figure 3 shows:
- a **downward progression** of the uptake zone.
- a quick apparition of a **dry zone** near the plant collar.

The root system is divided in two parts, one in a dry zone, one in a wet zone.
➙ this system is close to Partial Root Zone Drying (Dodd, 2005)

Figure 4 shows the evolution of the **relative depth of the uptake zone**. We can see that the downward progression is quickly decreasing.

Hypothesis:
- deep roots are less able to take up water
- fewer lateral roots in deep soil layer

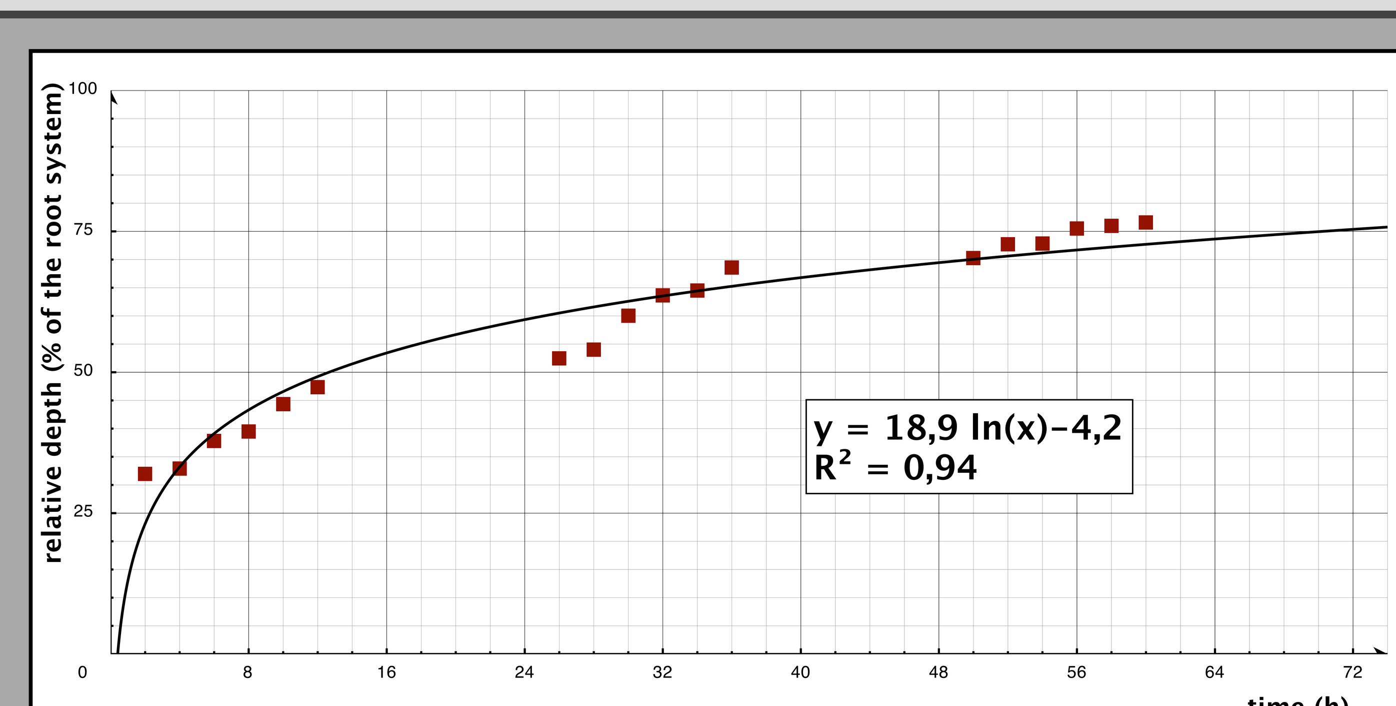

fig 4: Relative depth of the water uptake front vs time. The maximal depth at which the uptake influences the water content of the soil is defined as the *absolute* depth. The *relative* depth is expressed in percentage of the root system maximal depth. This allows us to compare the uptake behavior of root system of different sizes.

Conclusions

This new experimental platform allows:
- to record detailled dynamic root morphological information
- to record the evolution of the 2D water content
- to easily link those two kind of data

The first results show that:
- relative progression of uptake profile follows exponential relation
- local soil water uptake positively influences daily root growth only weakly

References

Clark *et al.* [2003], Plant and Soil, 255, 93-104
Dodd [2005], Plant and Soil, 274, 251-270
Garrigues *et al* [2006], Plant and Soil 283, 83-98
Kuchenbuch *et al* [2006], J. Pl. Nut. Sol Sc., 169, 841-848