Real-time spacial analysis of root water uptake in rhizotrons

Lobet, G.[1], Couvreur, V.[2], Javaux, M.[2], Pagès, L.[3], Chaumont, F.[4] and Draye, X.[1].

1. Crop Physiology and Plant Breeding, Université catholique de Louvain, Croix du Sud 2-11, 1348 Louvain-la-Neuve, Belgium
2. Environmental Sciences and Land Use Planning, Université catholique de Louvain, Croix du Sud 2-2, 1348 Louvain-la-Neuve, Belgium
3. Plantes et systèmes horticoles, INRA, Domaine Saint Paul - Site Agroparc - 84914 Avignon Cedex 9, France
4. Physiological Biochemistry, Université catholique de Louvain, Croix du Sud 5-15, 1348 Louvain-la-Neuve, Belgium

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 use and take up water in their cropping environment.

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

Experimental platform

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

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

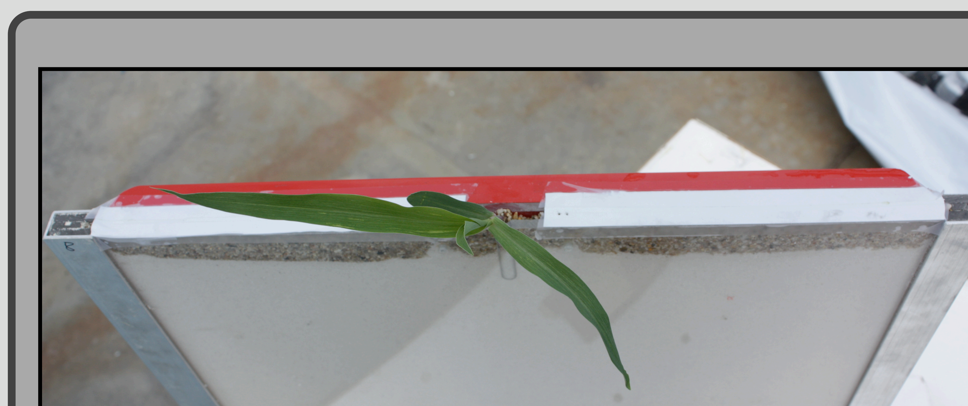

fig 1: Rhizotrons

The size of our rhizotrons is 500x500x4 mm

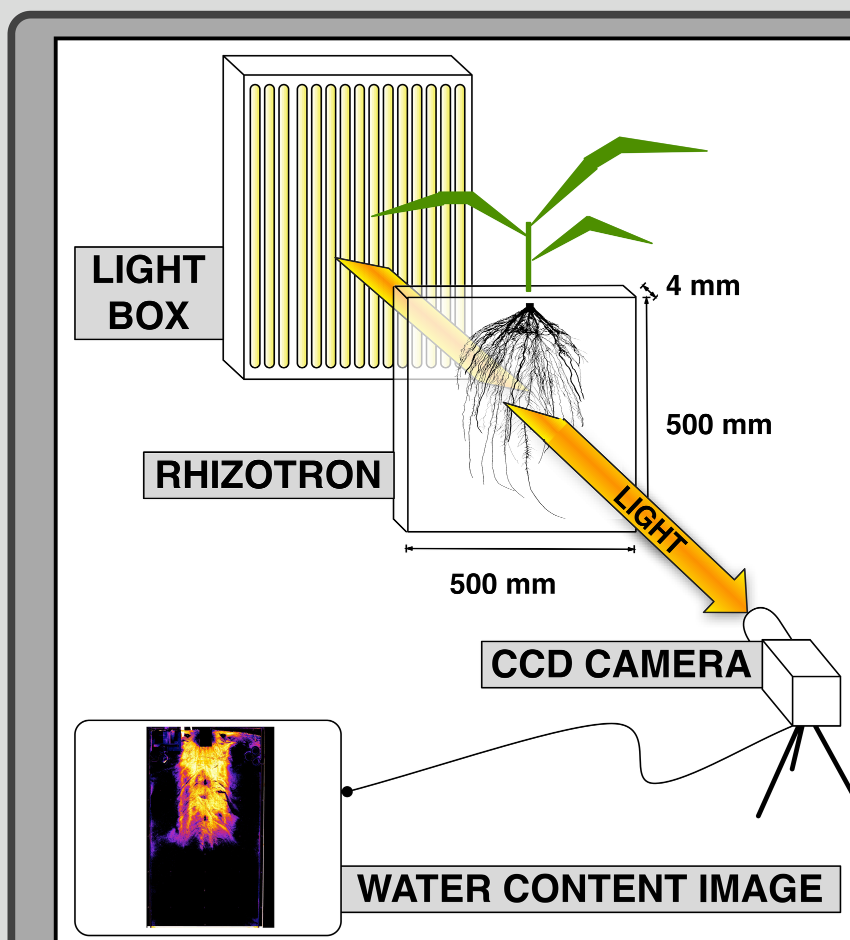

fig 2: Light transmission imaging experimental set-up.

Models: Root model / R-SWIMS

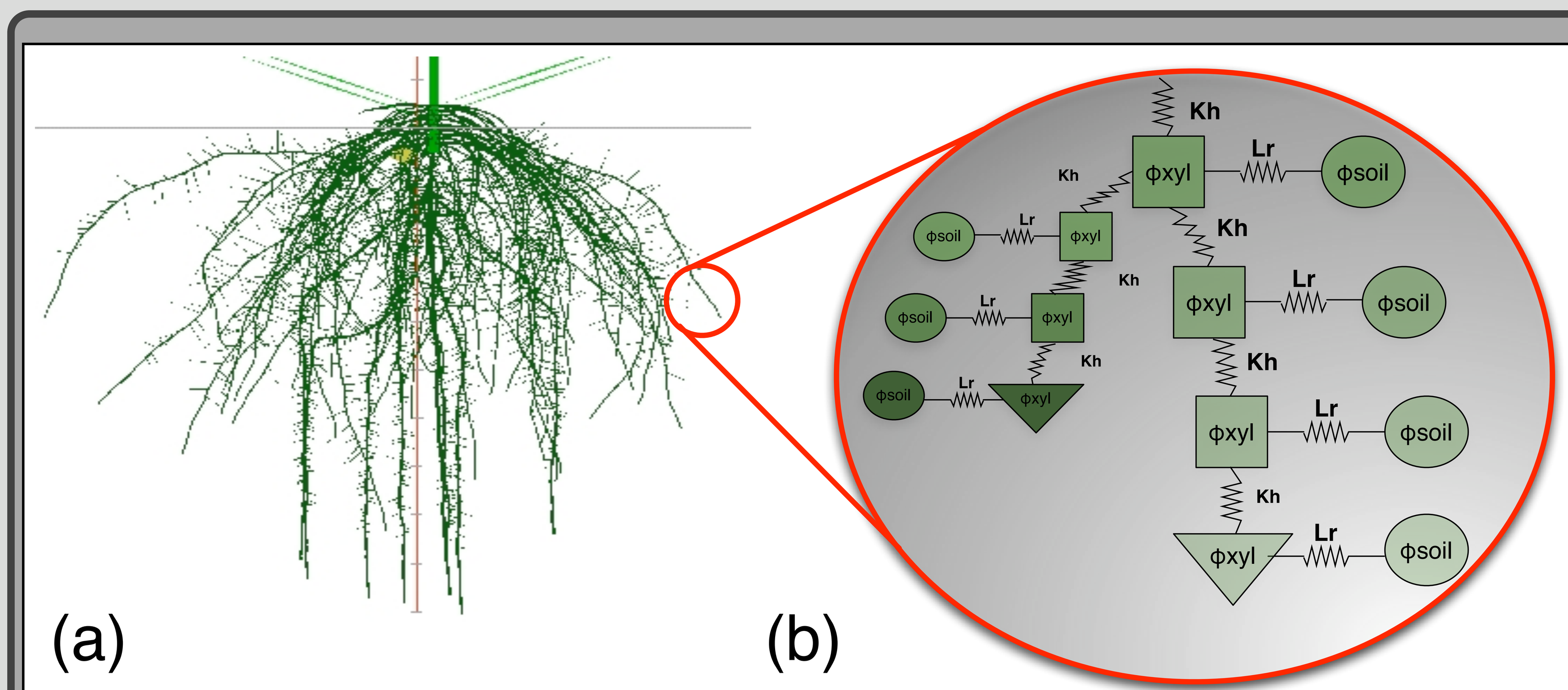

fig 3: Root model

(a) Simulated root system architecture. (b) Internal topological structure of the model

The **root model** simulates the growth and development of the root system in 3D. Each segment is characterized by given axial and radial conductivities.

The **R-SWMS model** simulates water dynamics in a 3D system comprising roots and the soil. Water flows in this composite model are computed following Doussan et al. (1998).

The methodology consists in testing assumptions built in the models by comparing their simulated output (predictions) with experimental data.

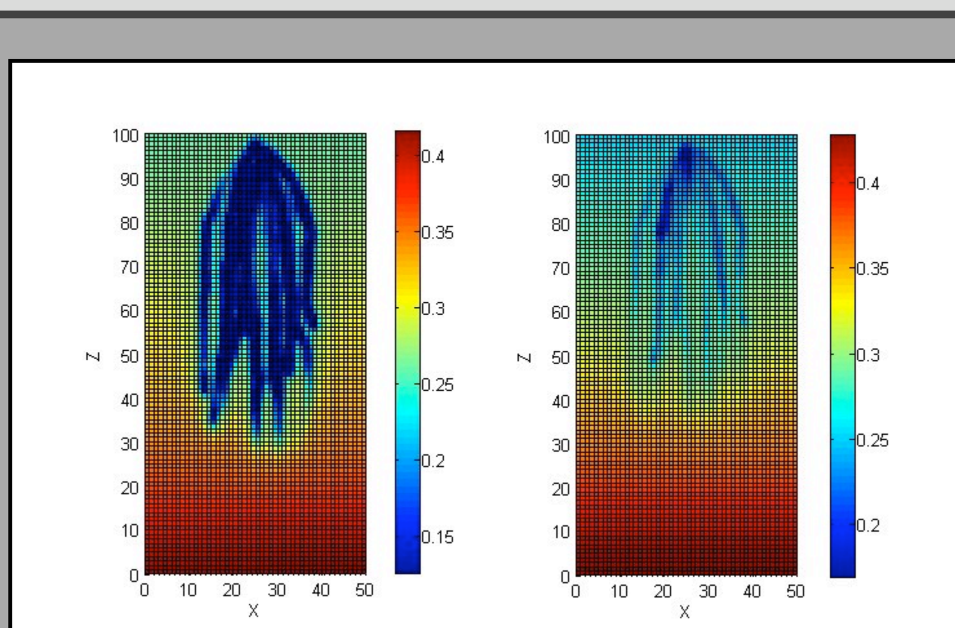

fig 4: Water content profile generated by the R-SWIMS model.

These figures show the water content of the soil at two different time step..

Preliminary results and current studies

Preliminary results

-**Experiments** reveal a localized uptake zone moving downwards (fig. 5) during a water deficit episode
-**Simulations** indicate a strong influence of the soil on the water uptake behavior.

Current studies

Different genotypes and techniques are currently being tested:

- **lrt1** : lateral rootless mutant (Hochholdinger et al. 1998)
- **ZmPIP2:5**: mutant lacking the aquaporin ZmPIP2:5 (Hachez et al, 2006)
- Use of **GPR** (Ground Penetrating Radar) and **infrared** light.

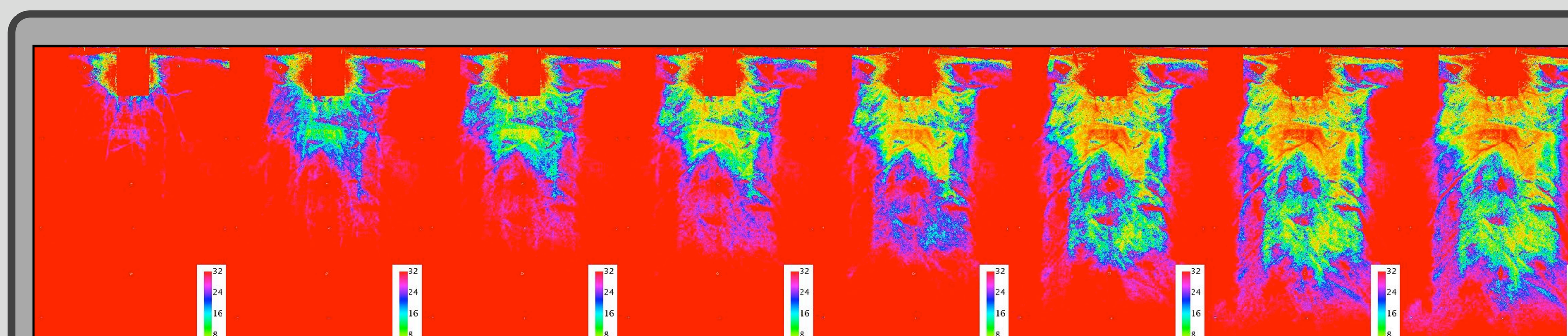

fig 5: Evolution of soil water content during a water deficit episode with a 30-day old maize root system. Time-step between images is 2 hours.

Conclusions

This new experimental platform allows:
- to record a large volume of root data...
- to record the evolution of the 2D water content
- to compare the water uptake behavior of various genotypes

By combining these dynamic data in a mathematical modeling framework, one can test various hypotheses implemented in the models. As models reflect a vision of current knowledge, this methodology enables to identify gaps. Models and experimental data can also be used to estimate hidden parameters by means of inverse modeling.

References

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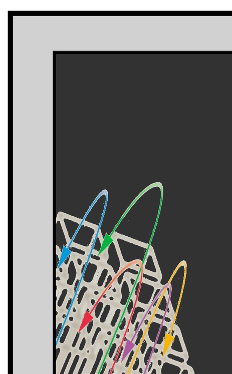
Garrigues et al [2006], Plant and Soil 283, 83-98
Hachez et al [2006], Plant Mol. Biol. 62, 305-323
Hochholdinger et al. [1998], Pl. Journ. 16 (2), 247-255



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