Integrating soil and plant knowledge at different scales to better understand the dynamics of water in SPAC

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Plan

- Context
- Material and methods
- Results
- Discussions
- Conclusions

Context

Water movement in plants

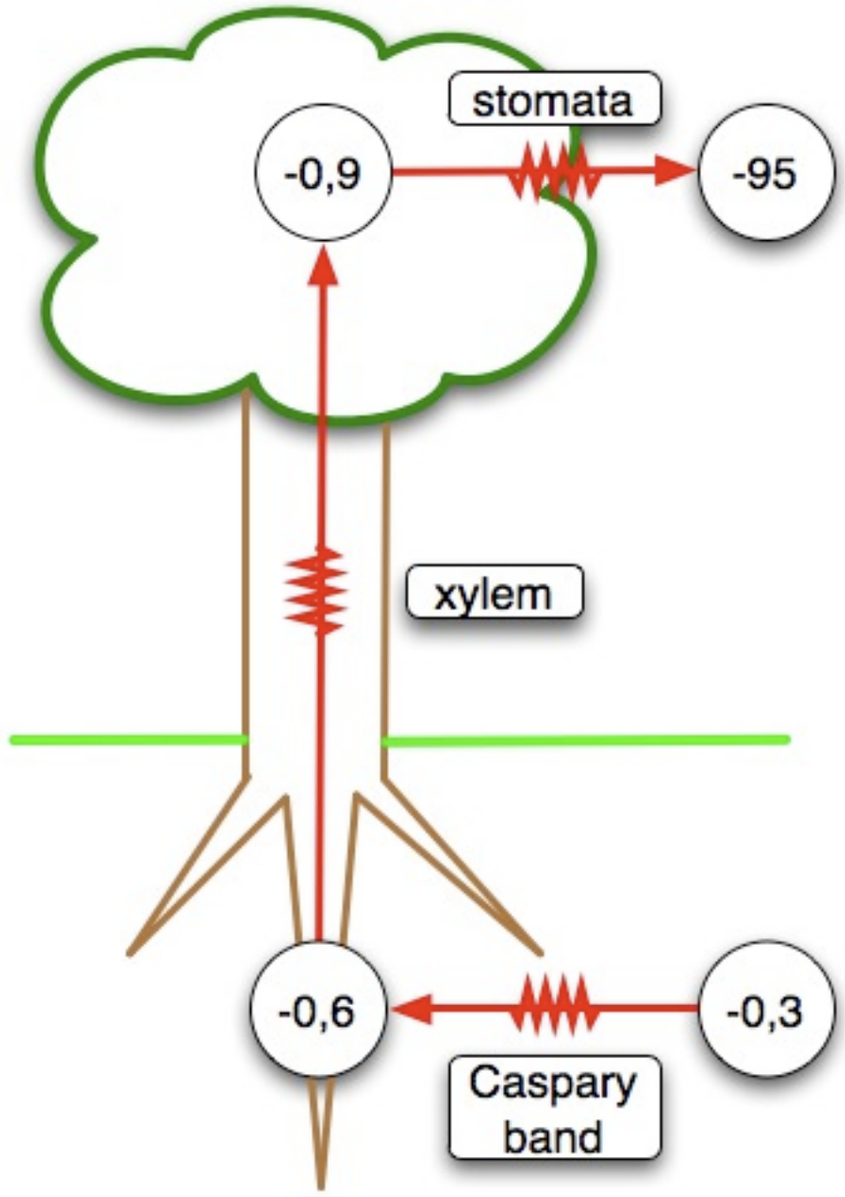
Soil-Plant-Atmosphere Continuum

+

Water potential gradient

↓

Water movement



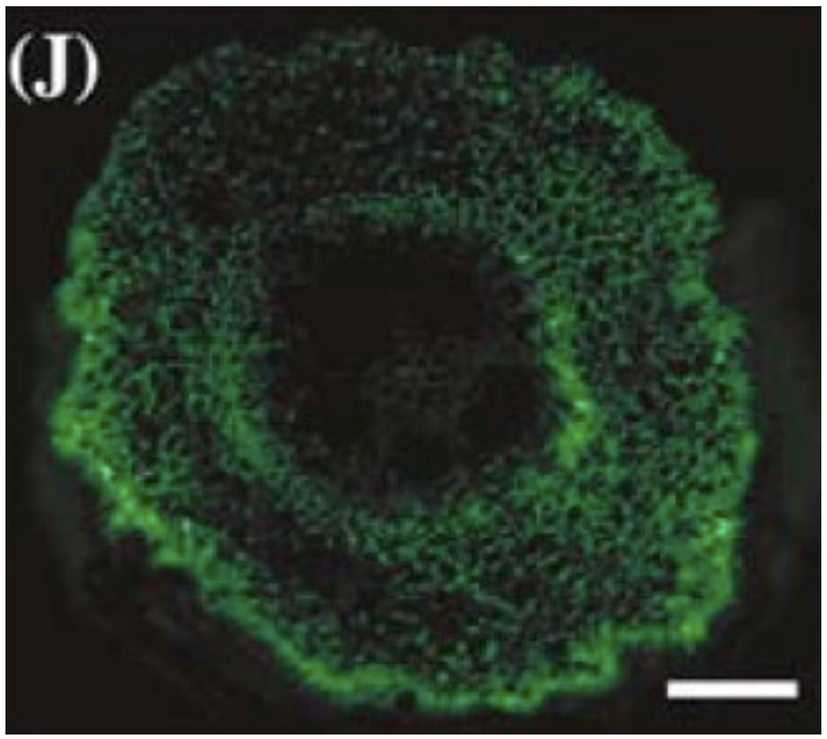
Several resistances:

- in the stomata
- along the xylem vessels
- uptake by the roots

Aquaporins

- Aquaporins increase membrane permeability

  - increase the water flow rate through the membranes
  - *Zm*PIP2:5 mainly present in endoderm and exoderm of maize roots



From: Hachez et al., 2006

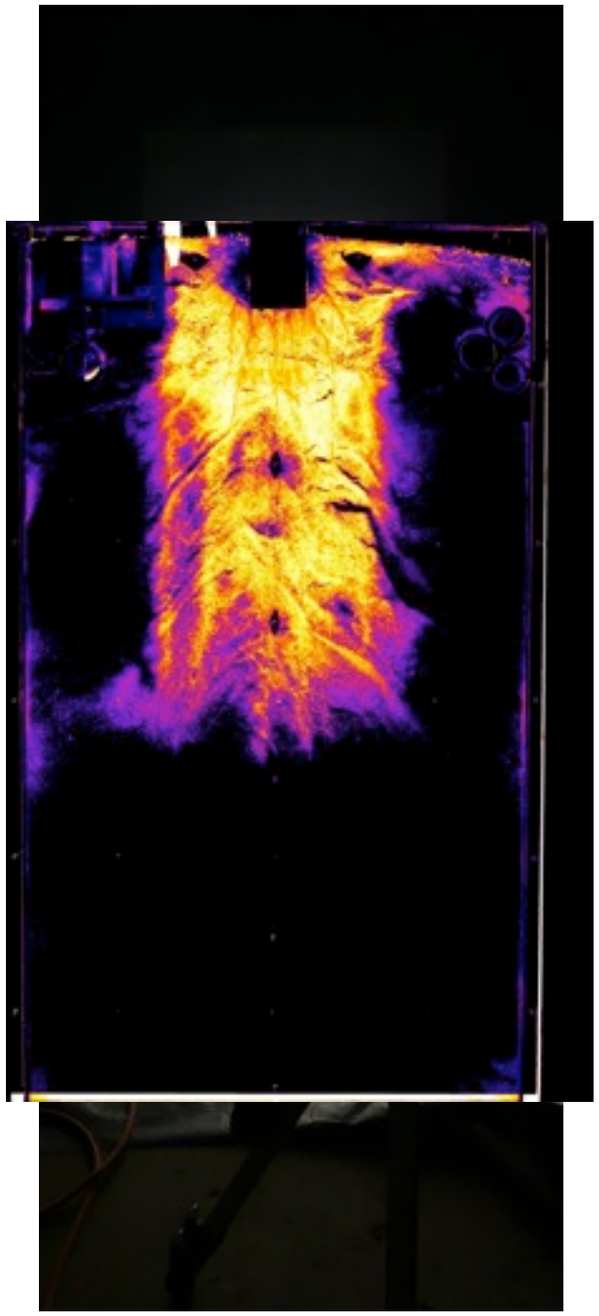
➡ To test the quantitative contribution of *Zm*PIP2:5 at the root system level

Material and methods

Material

- Three tools were used:
  - transgenic plants deficient in *Zm*PIP2:5
  - rhizotrons
  - light transmission imaging

➡ To get picture of the water distribution inside de rhizotrons at a low time scale



Methods

- Six rhizotrons
  - 3 Transgenic + 3 Wild-Type

- When plants are 30 days old:
  - substrate at the field capacity
  - water supply is stopped
  - light transmission imaging every 2 hours during 2 1/2 days.

Results

Growth parameters

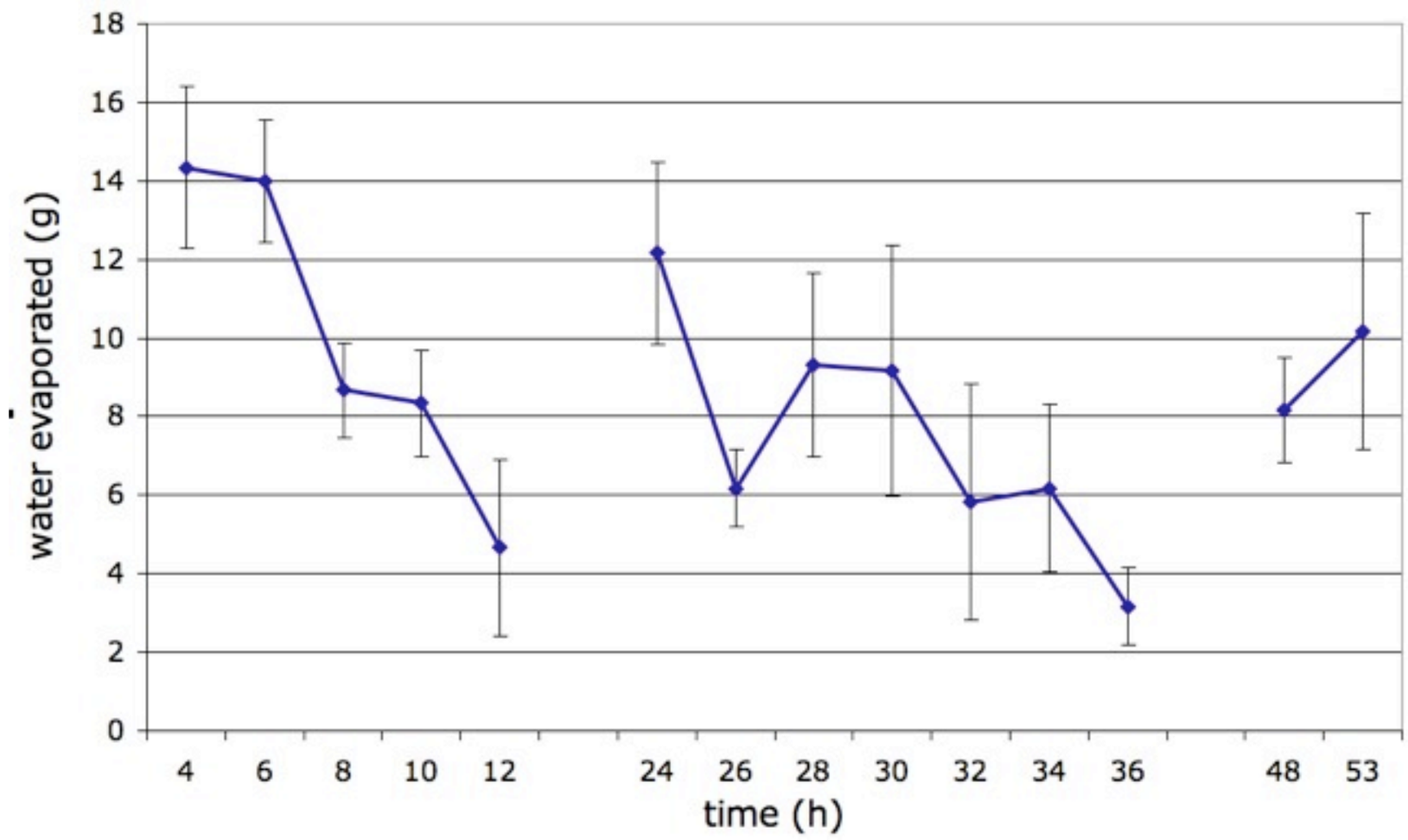
- Shoots:
  - similar growth rate for all the plants
- Roots:
  - two groups:

	Trangenics	**Wild-types**	**p-value**
Depth (cm)	61.7 ± 16.1	60.0 ± 17.3	0.909
Growth rate (cm/day)	16.7 ± 6.8	11.6 ± 4.9	0.352

	Deep	**Superficial**	**p-value**
Depth (cm)	75.0 + 8.66	48.3 + 7.64	0.016 *
Growth rate (mm/day)	19.21 + 7.65	11.53 + 4.15	0.008 **

intrinsic variability of the growth rate

Transpiration



- During the day
  - effect of stomatal regulation
- Across days
  - water less available
  - roots less efficient

Aquaporins

- Western Blot at the end of the experiment:
  - no differences between Transgenics and Wild-Type

- Morphological differences

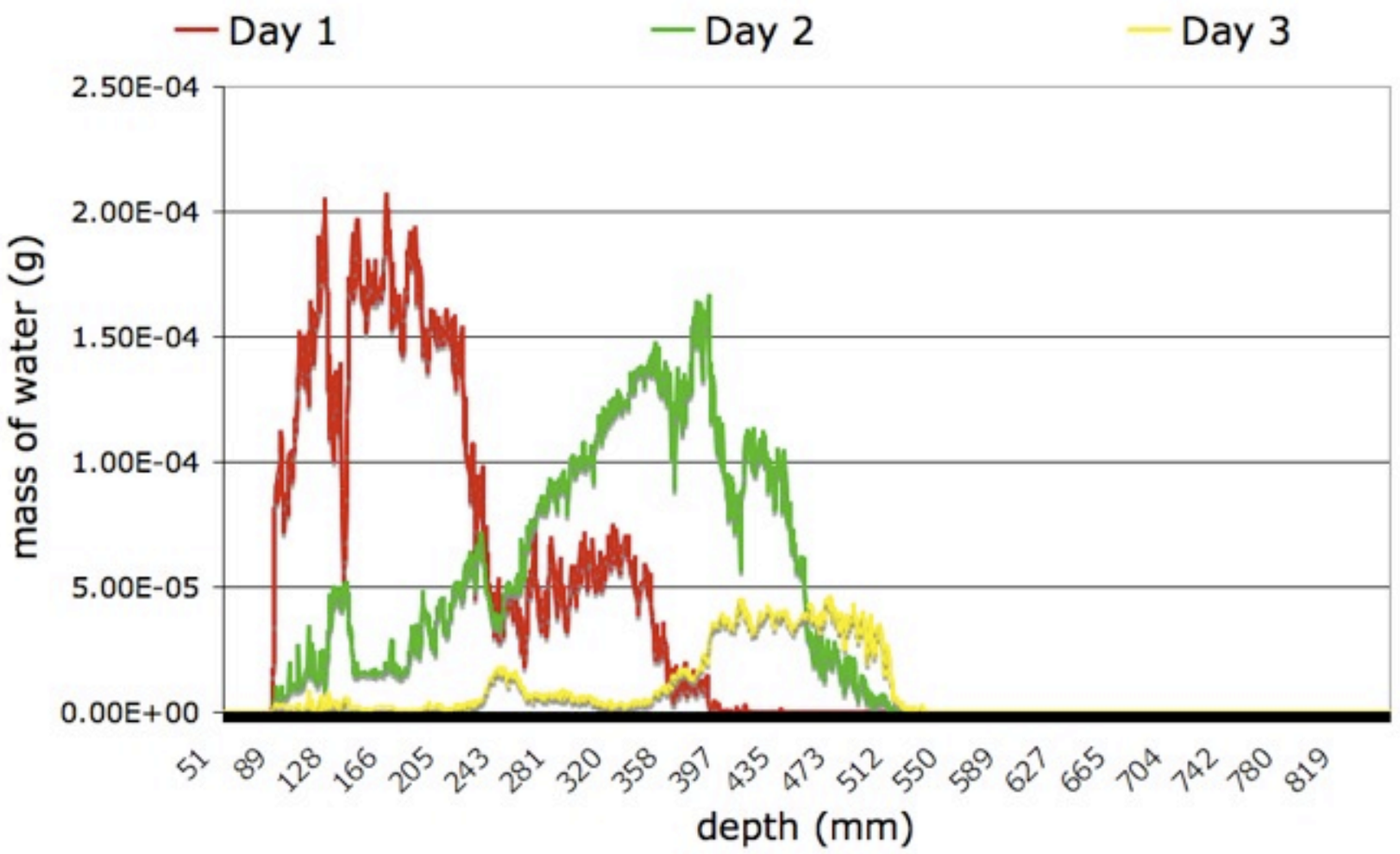
	Trangenics	Wild-types	p-value
root:shoot	0.99 + 0.035	0.86 + 0.062	0.032 *
% primary roots	21.59 + 1.90	14.18 + 2.95	0.022 *

Transgenics produce:
- more roots
- more primary roots

➡ Variation of the expression of the *silencing*?
- Influence of the temperature

Uptake

- Localised
- Rapid apparition of a dry zone
- The uptake region moves down quickly
  - effect of the substrate and root density (?)



Uptake pictures

Superficial Deep

- Identical behaviours for the different type of root systems

Discussions

Hypotheses on the influence of the lack of aquaporins

- On the development
  - roots less efficient if lacking AQP
  - increase of the root surface in order to balance the decrease in efficiency:
    - creation of new roots
    - increase in the growing rate of the existing roots (?)
    - ~~increase of branching~~

➡ Functional equilibria (Brouwer 1963)

➡ Equilibrium between supply and demand

Hypotheses on transpiration and water uptake

- In case of water stress
  - roots in the dry zone produce ABA
  - stomatal closure and decrease of transpiration

- If uptake localised
  - faster response of the roots

➡ Negative feed-back
➡ Prevent a drying of the rhizosphere

➡ Same dynamics observed in Partial Root Zone Drying experiments (PRZD)

Conclusions

Conclusions

- The **lack of aquaporins** may have an influence on the developmental processes (to be confirmed)

- The **localised dynamics of the water uptake** induces a tight regulation of the global uptake behaviour

- **Light transmission imaging** allows the observation of the water uptake *in situ* and without heavy equipment

- **Functional-structural plant modelling** could be a useful tool for the understanding of the water dynamics in plant

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