Faculté d'ingénieurie biologique, agronomique et environementale

Unité d'écophysiologie et d'amélioration végétale

Water dynamics in the soil-plant environment

Which plant's features regulate the uptake?

Guillaume Lobet, Yangmin Kim and Xavier Draye

Groupe de contact FNRS - 02 April 2009

Outline

- Lab presentation
- Theoretical background
- Methodology and first experiments
- Perspectives

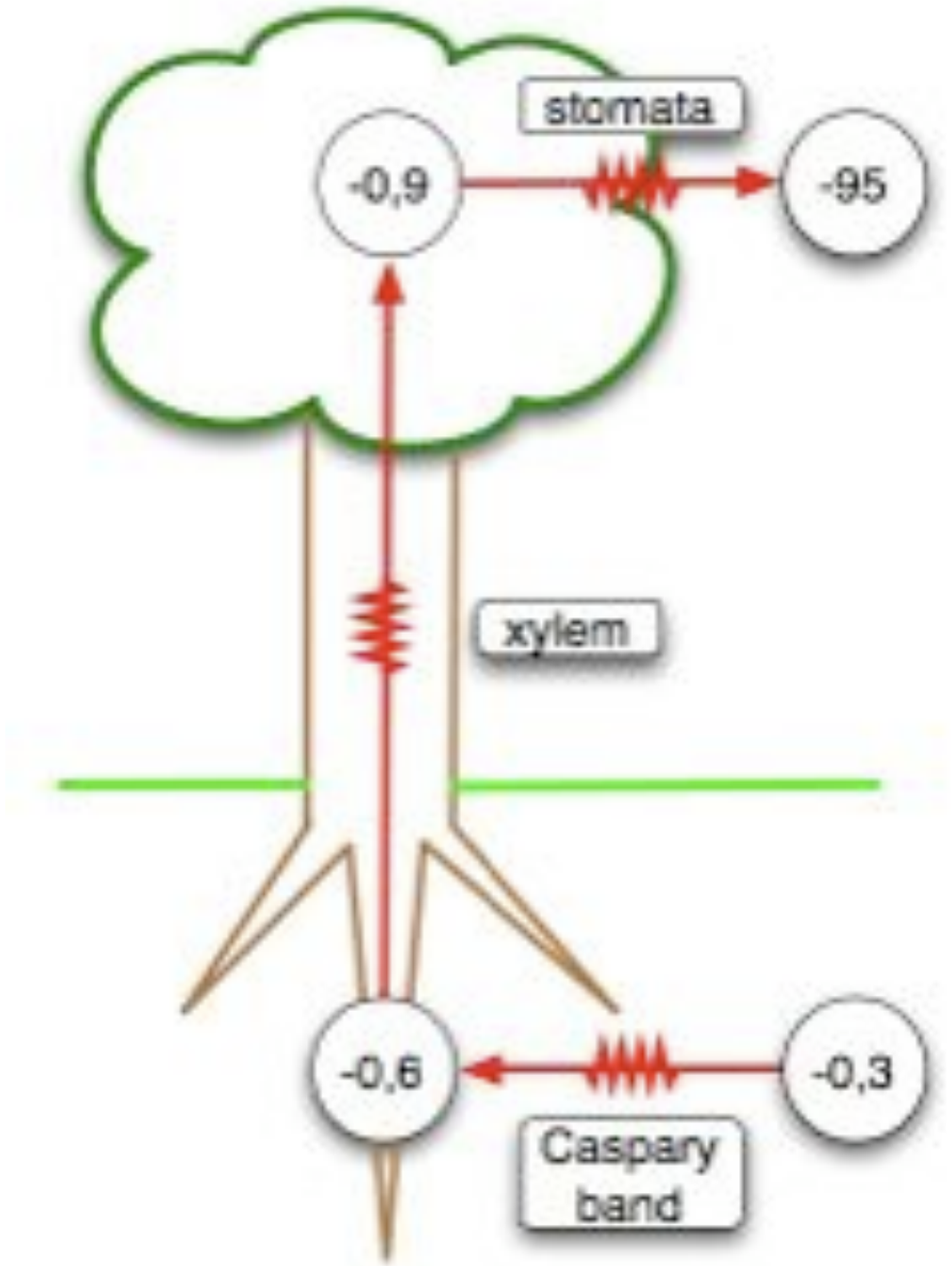
Lab presentation

- Plant genetics and genomics
- Crop physiology
- Biomass valorization
- Structural and functional modeling

Theoretical background

- Water movement
- Resistances
  - Apoplastic barriers
  - Aquaporins
  - Long distance signaling
- Root architecture

Water movement - I



- Water potential gradient
- Soil-Plant-Atmosphere Continuum (SPAC)
- Analogy with electric network
- Some resistances are regulated

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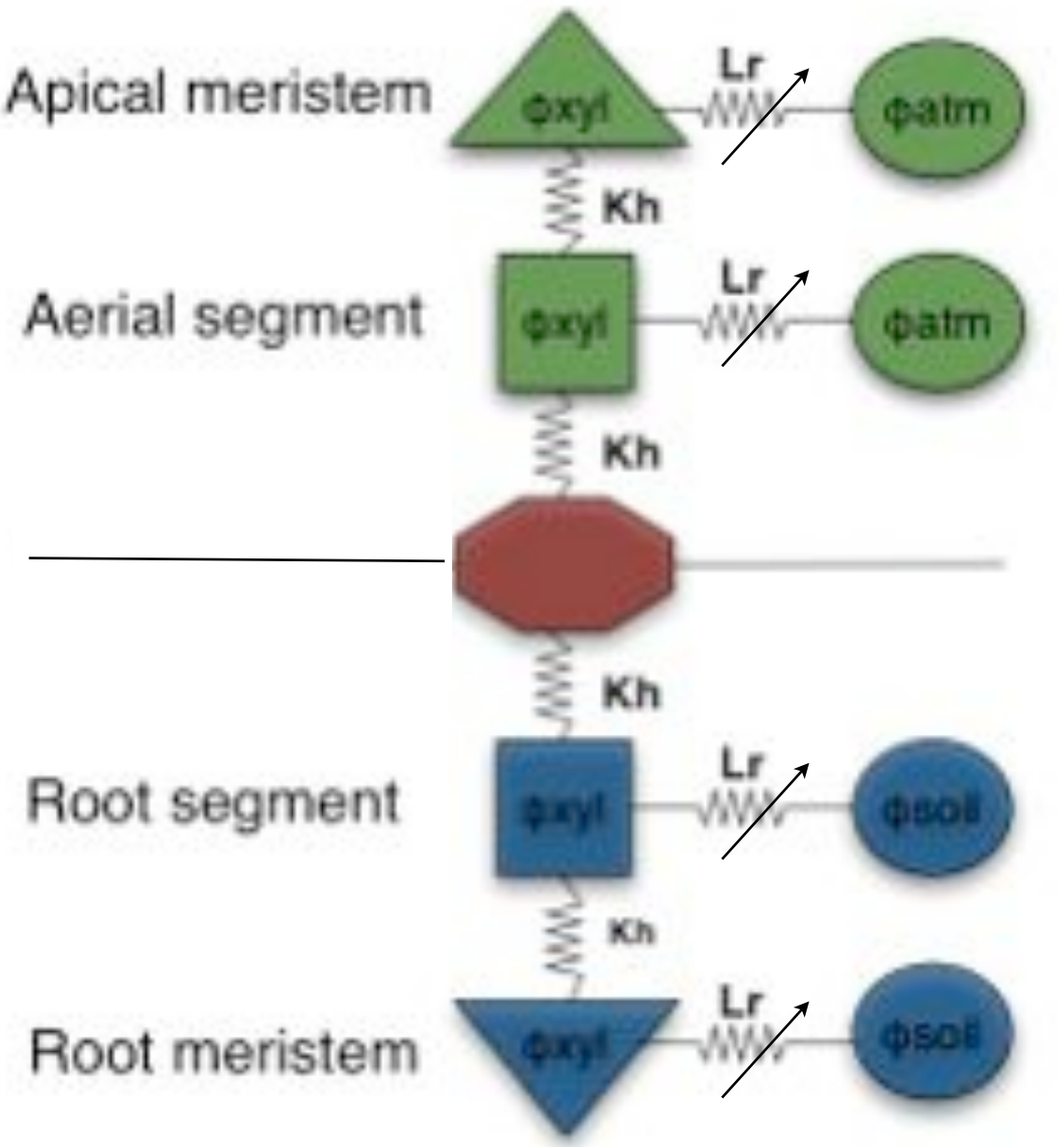

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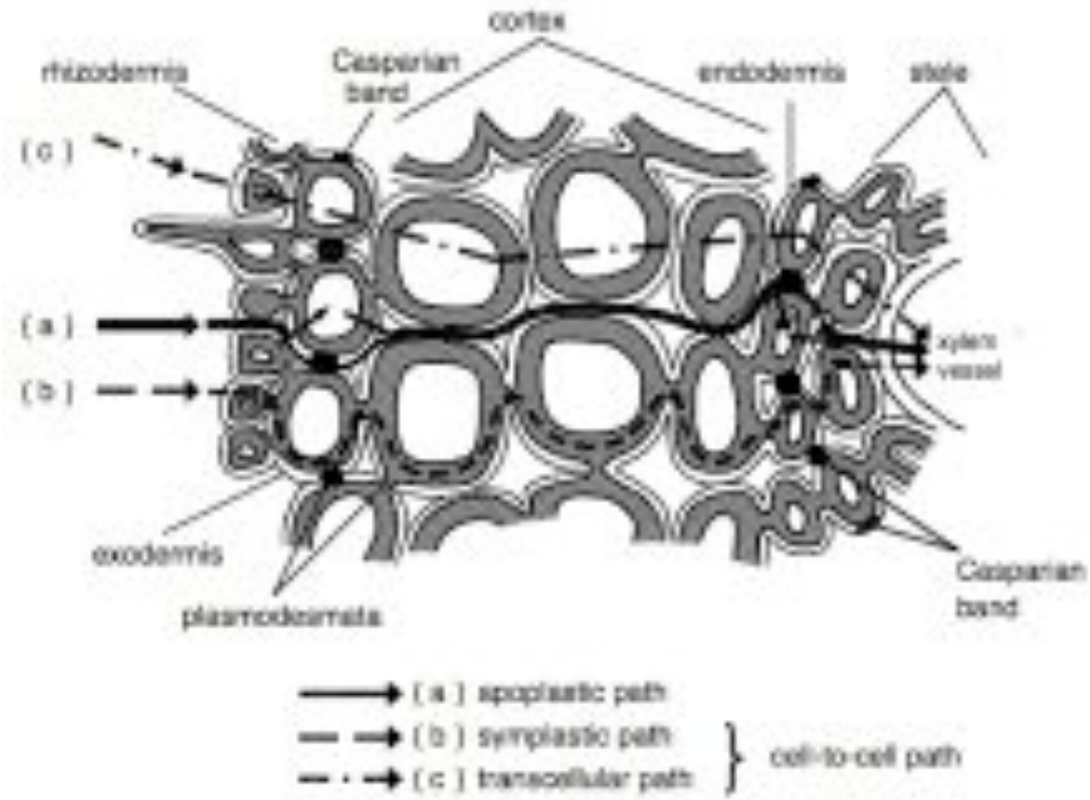
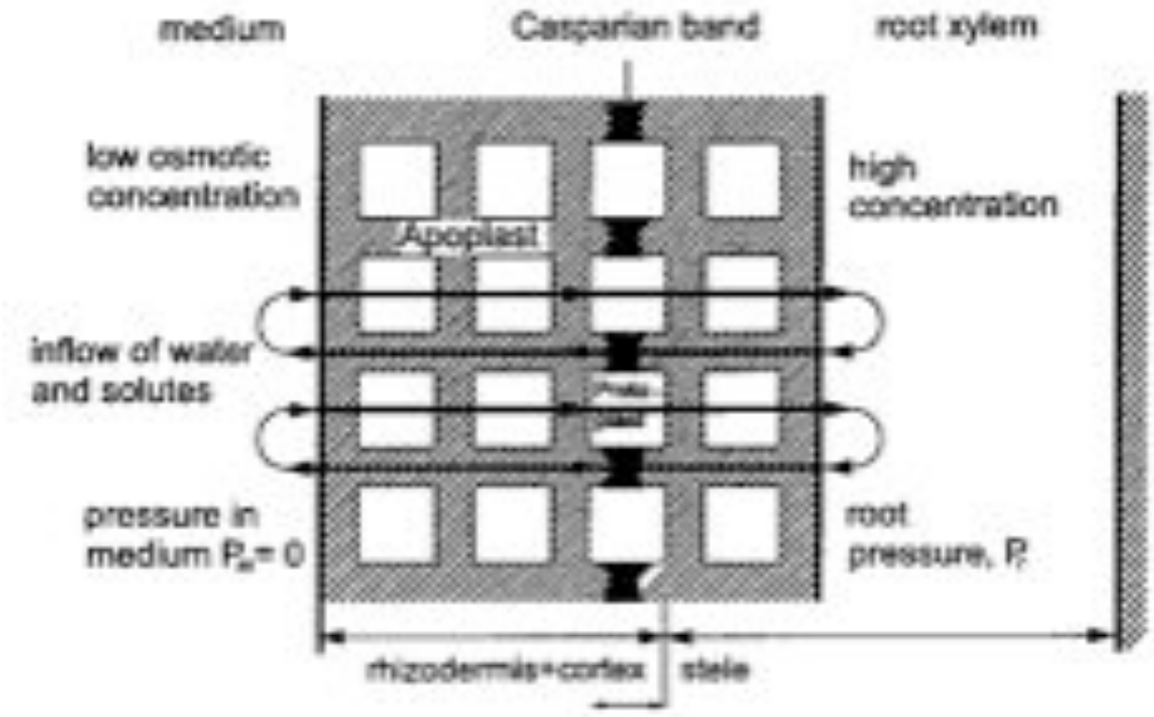
Water movement - 2



from Steudle, 2000

- Different pathways
  - Apoplastic
  - Symplastic
  - Transcellular
- Composite model of root water uptake
  - high evaporation → apoplastic
  - low evaporation → cell-to-cell

Water movement - 2



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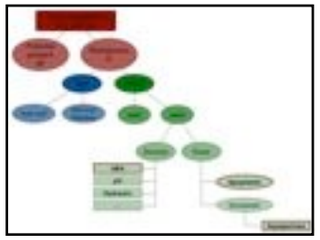
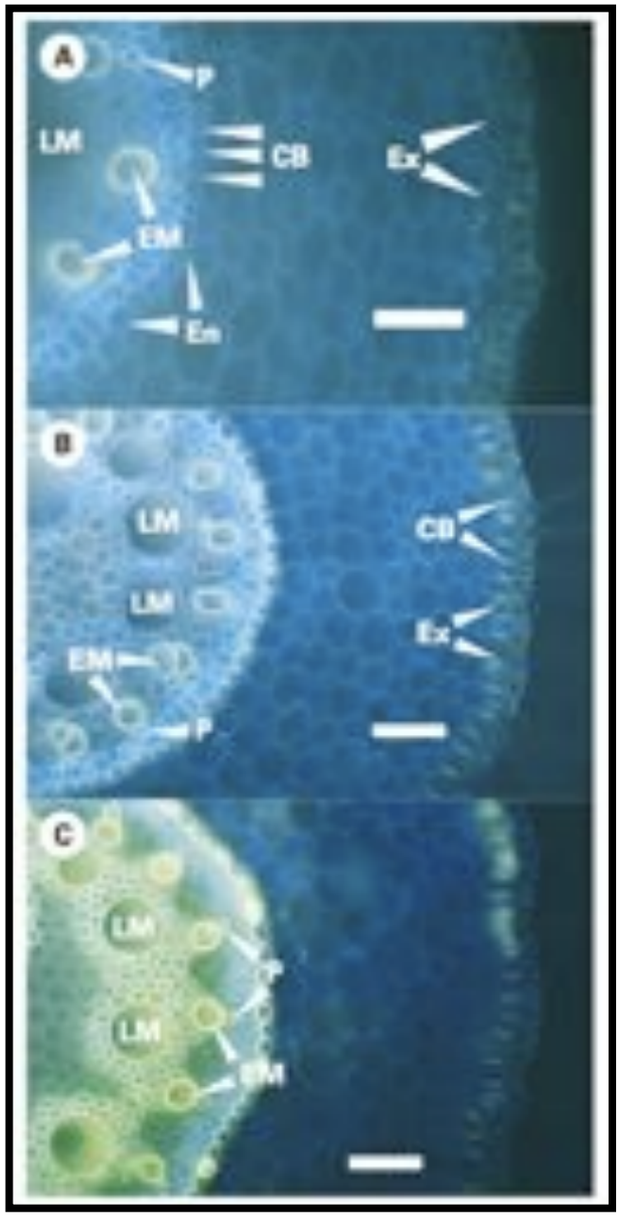
Resistances

Apoplastic barriers - I



- Influence the radial resistance of roots

- At the endodermis and exodermis



From Enstone et al., 2003

Apoplastic barriers - I

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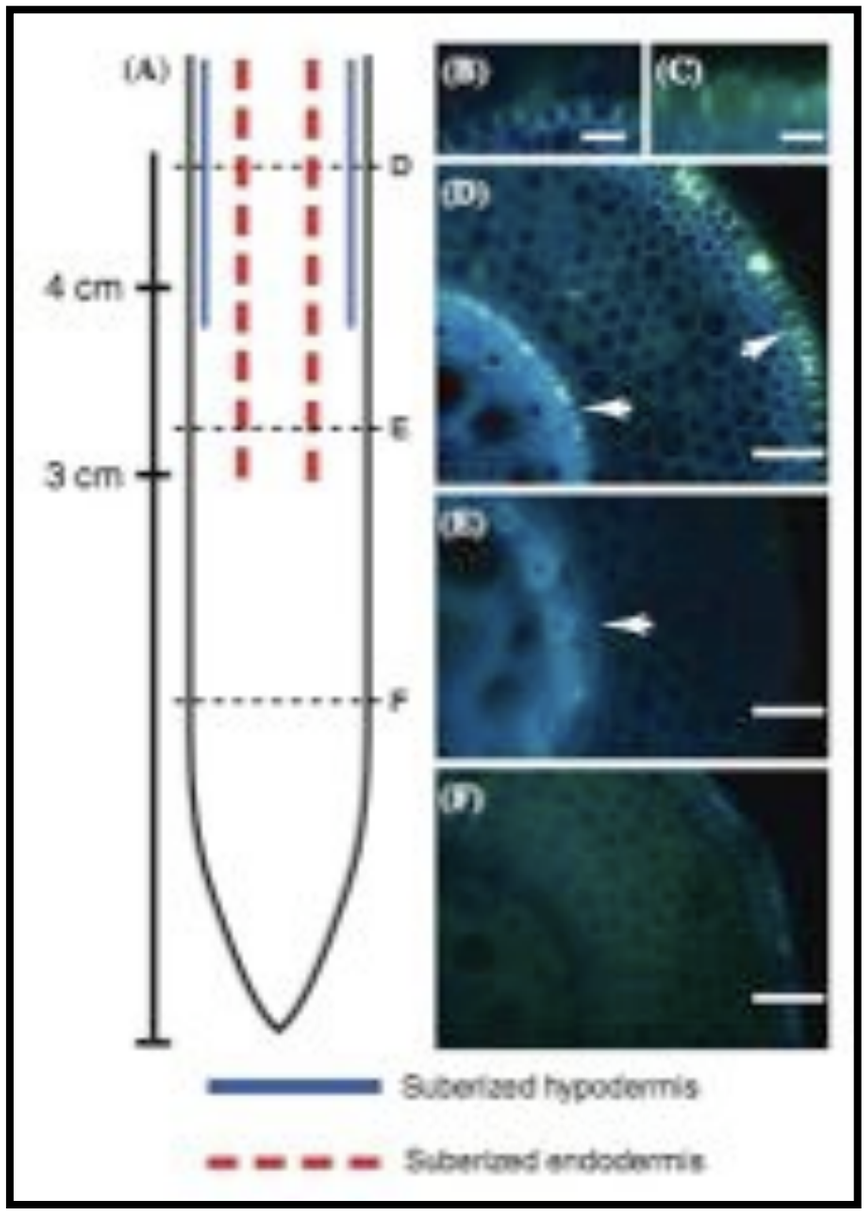
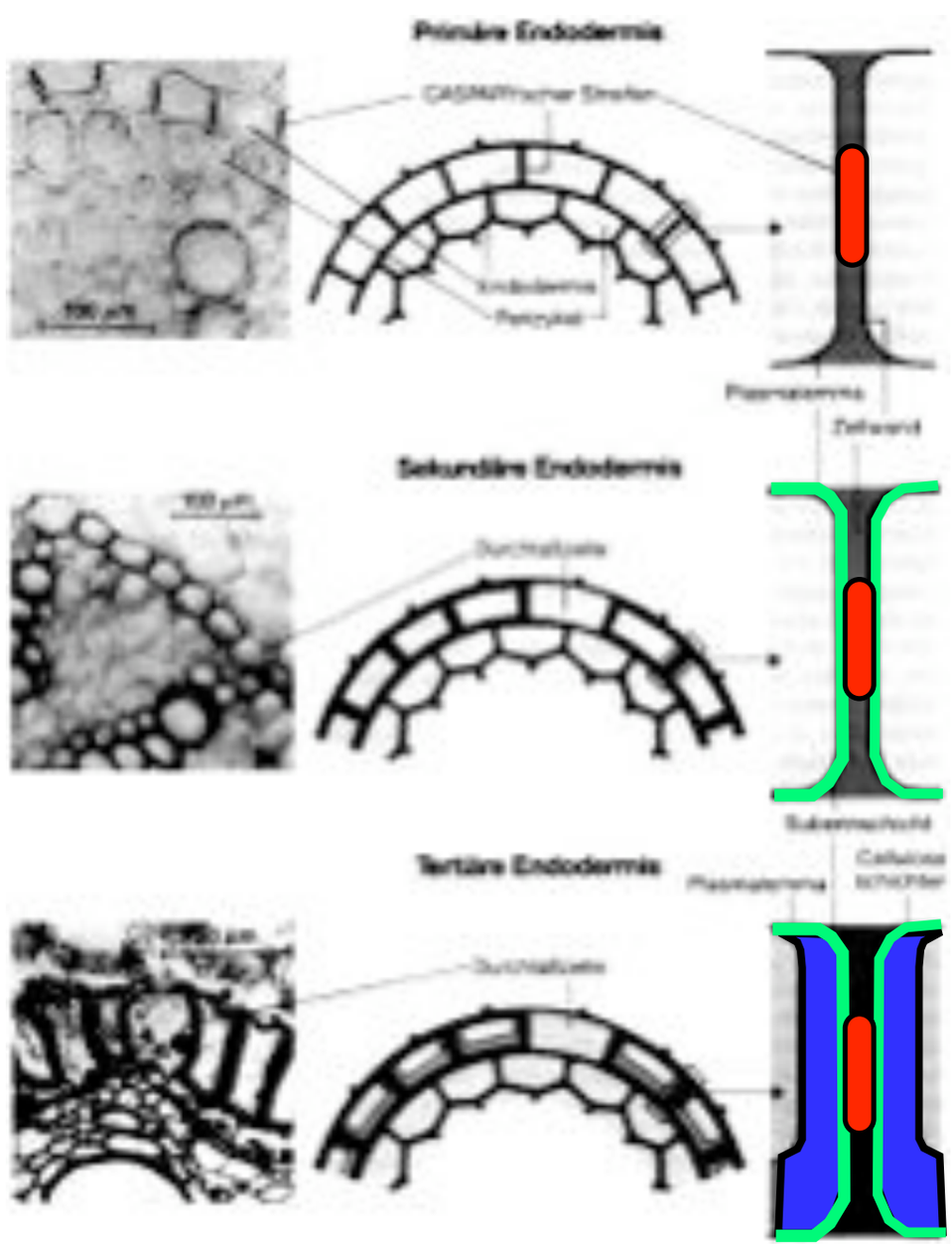


From Hachez et al., 2006

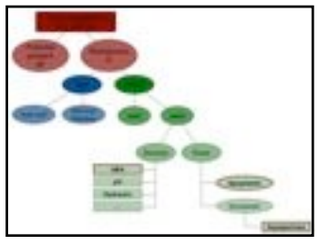
Apoplastic barriers - 2



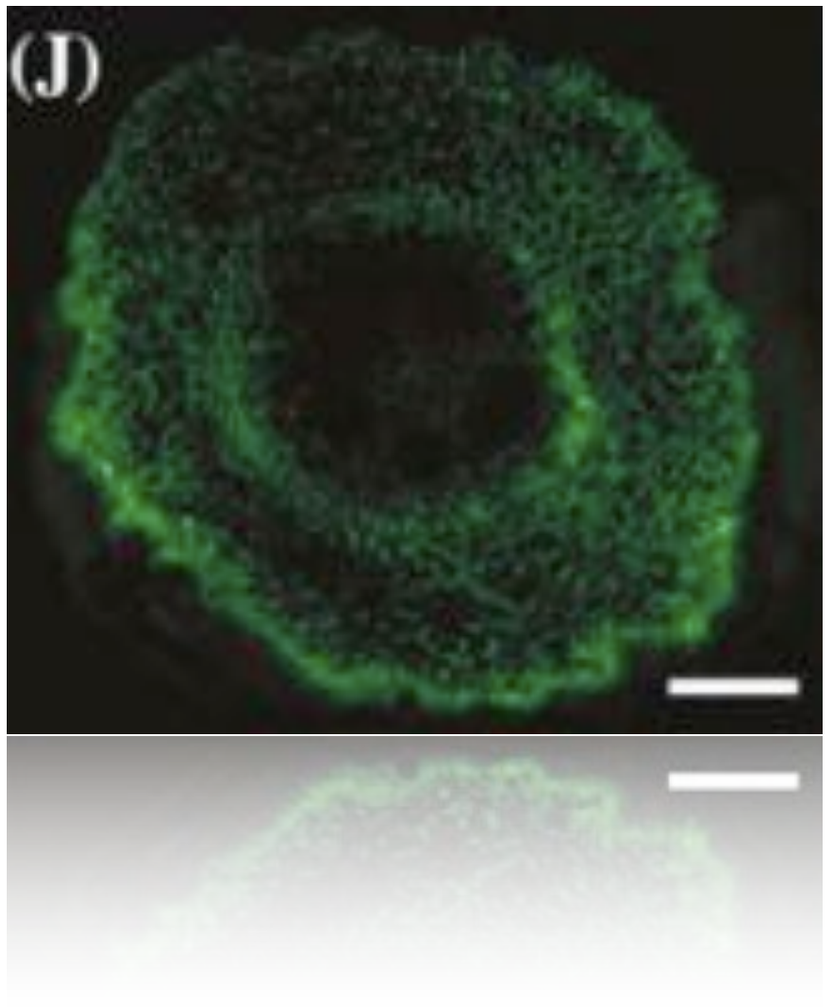
- Primary wall
  - Casparian band
  - lignin
  - block ions
- Secondary wall
  - Suberin lamellae
  - suberin
  - block water
- Tertiary wall
  - cellulose
  - mechanical role

From Lüttge et al, 1994

Aquaporins

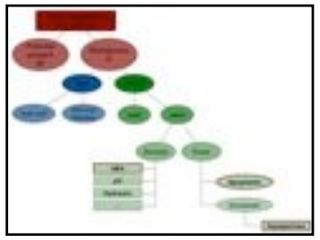


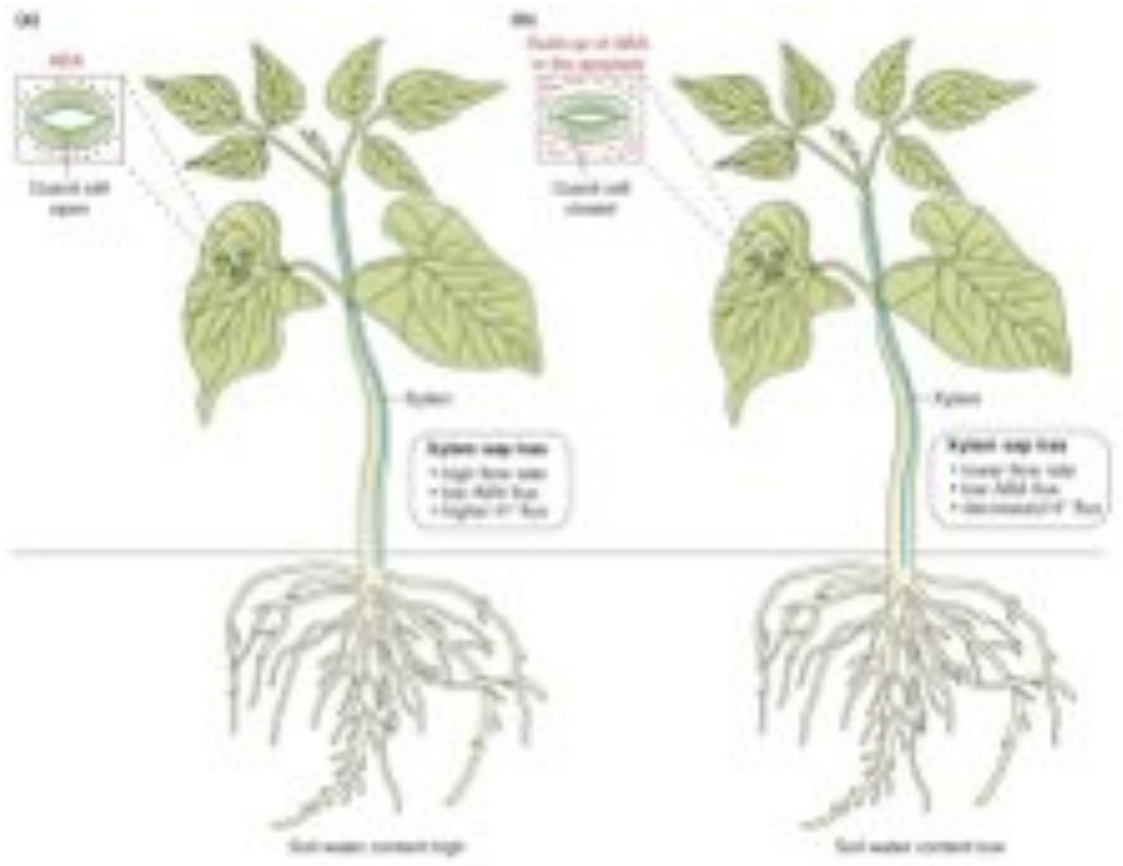
- Water channel
- Increase the membrane water permeability
- Can be regulated actively
- Present in key tissues



From Hachez et al., 2002

Long distance signaling





- Signal from the root to the shoot in case of water stress
- Trigger the closure of the stomata
- Actors:
  - ABA
  - pH
  - Hydraulic signal

Architecture

- Importance of the architecture during the uptake
- Needs matching between root and water localization
- Importance of the root type and age

From Ge et al., 2000

Methodology

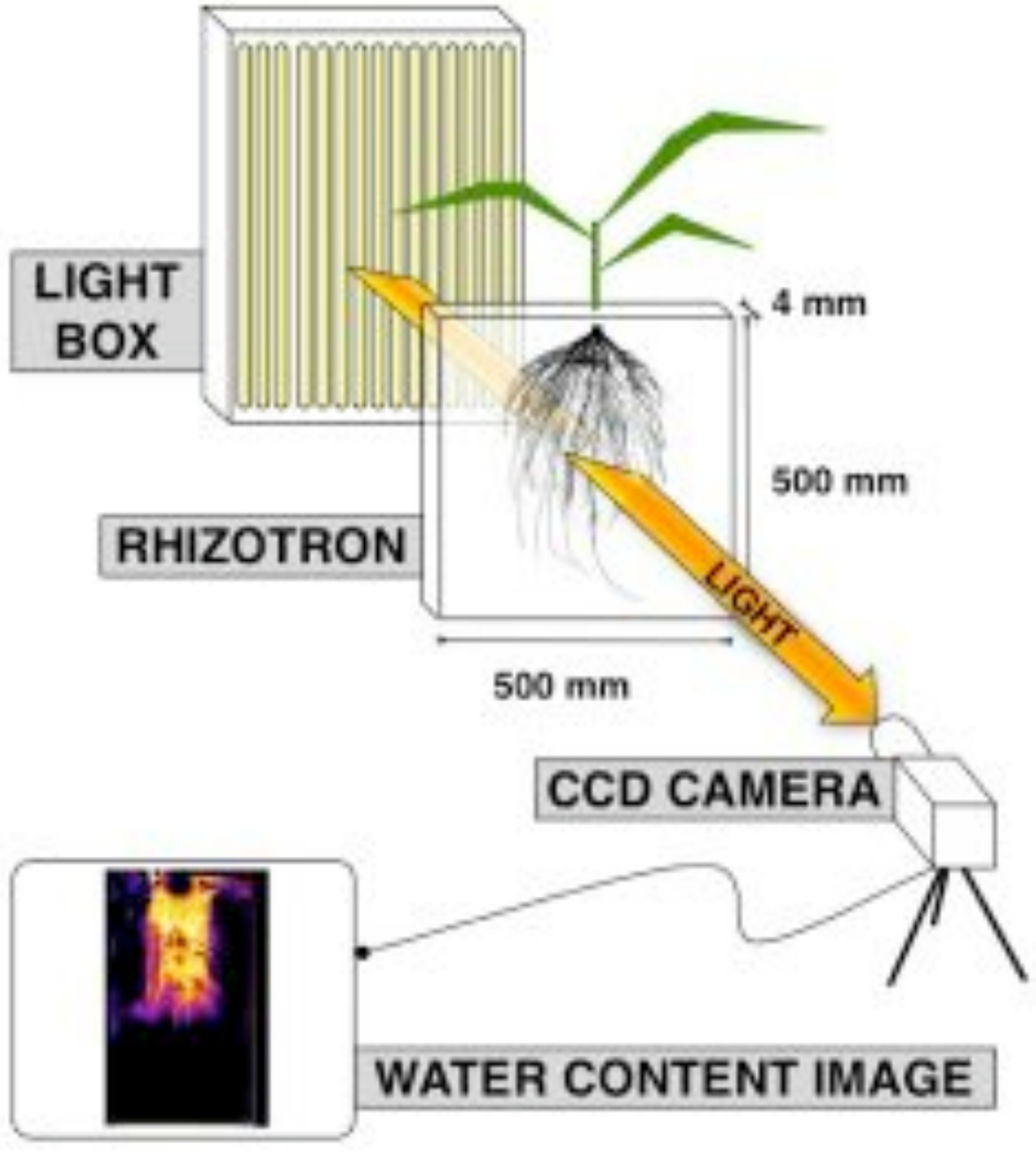
- Aims
- Experimental platform
- Models
- First experiments

Aims

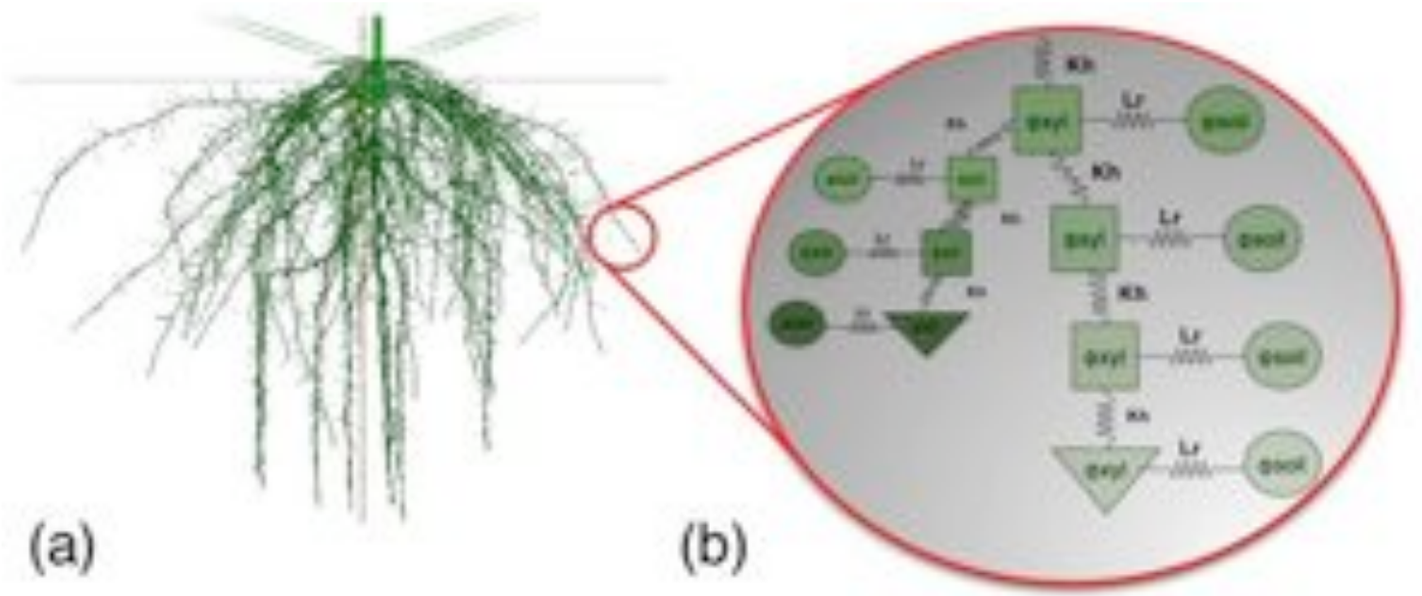
- Analyze the water uptake dynamics in an explicit 3D soil-plant continuum
- Analyze the quantitative contribution of various features which influence the water uptake:
  - Architecture
  - Apoplastic barriers
  - Aquaporins
  - Long distance signaling

Experimental platform

- Maize grown in rhizotrons
- Light transmission imaging
- Observation of the water uptake dynamics



Models



- PlaNet-Maize
  - Plant architecture
  - Plant growth
  - Transports

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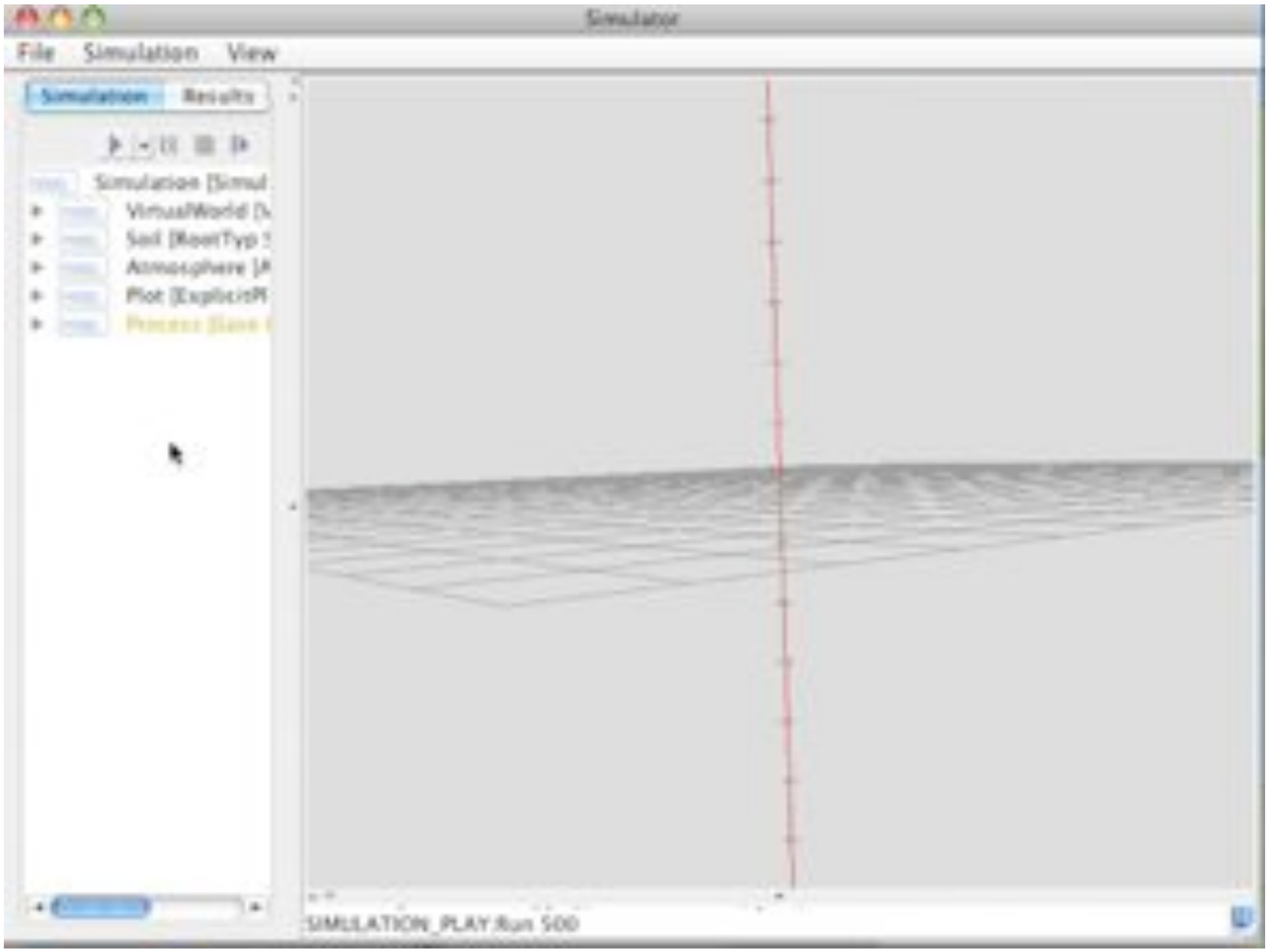

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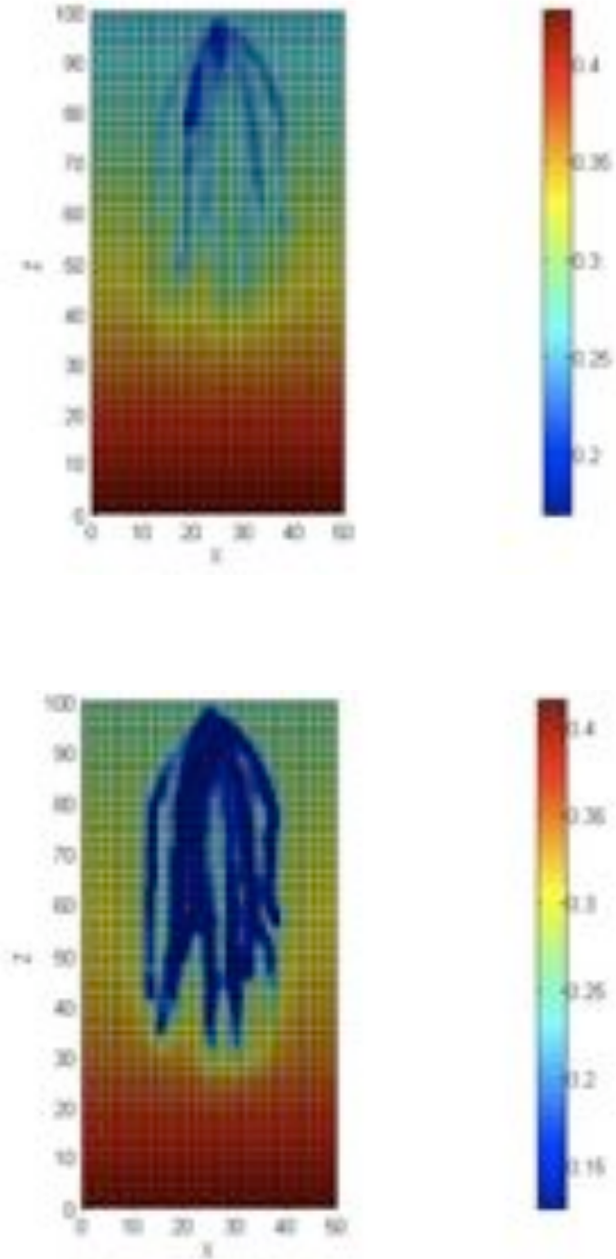
Models

- R-SWMS
  - Water transfers
  - Root hydraulic architecture
  - Soil hydrodynamics



First experiments

shoot growth
root growth rate

water uptake dynamics
root scan
leaf surface

- Localized uptake
- Downward movement
- Quick drying of substrate

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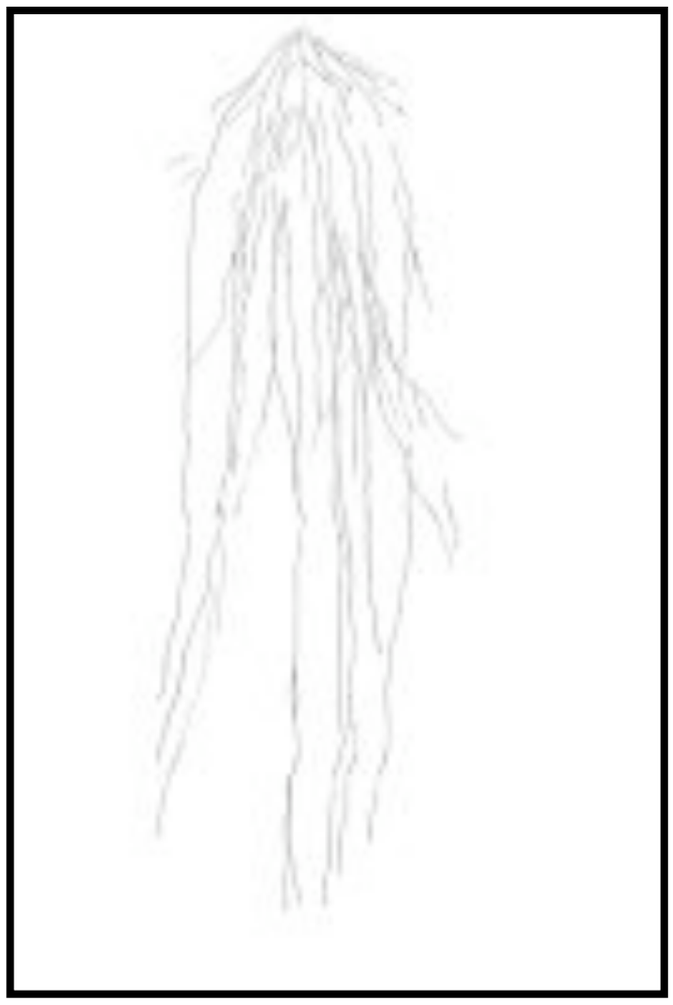

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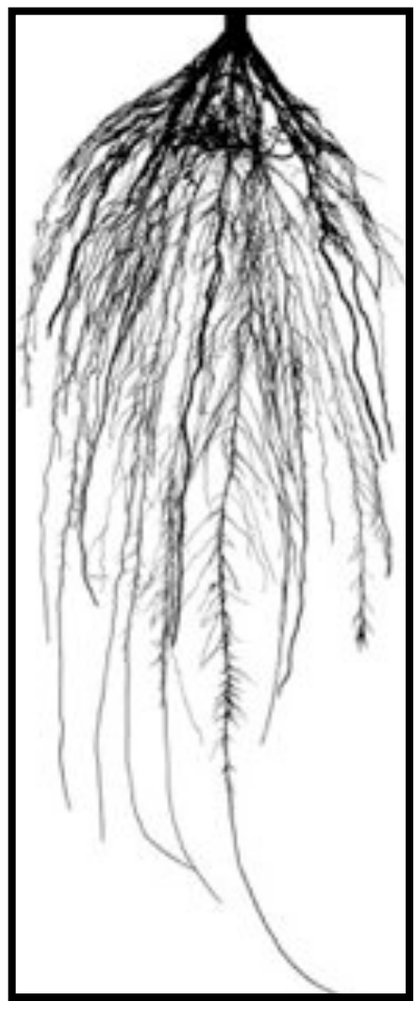

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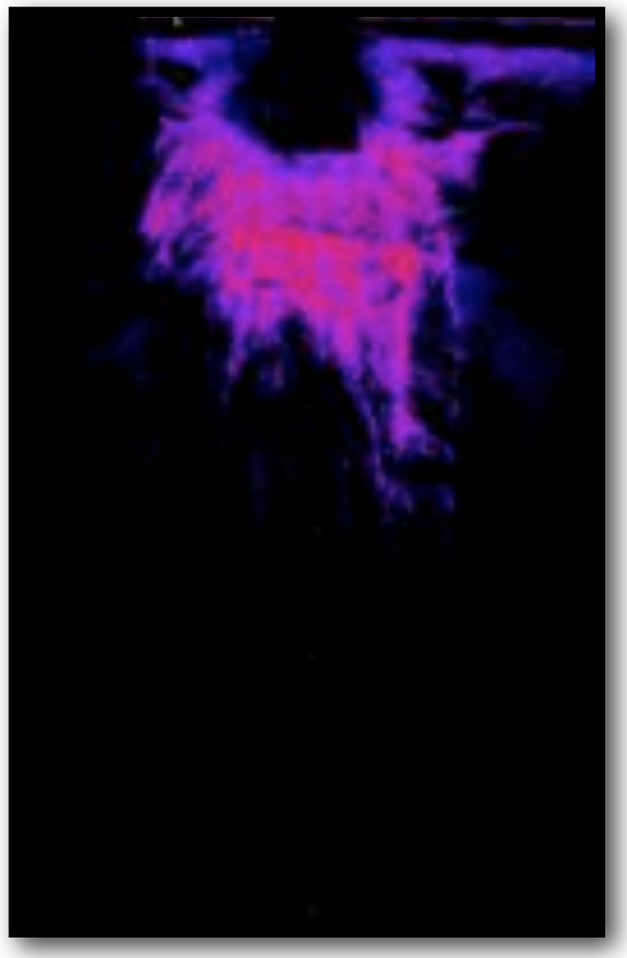

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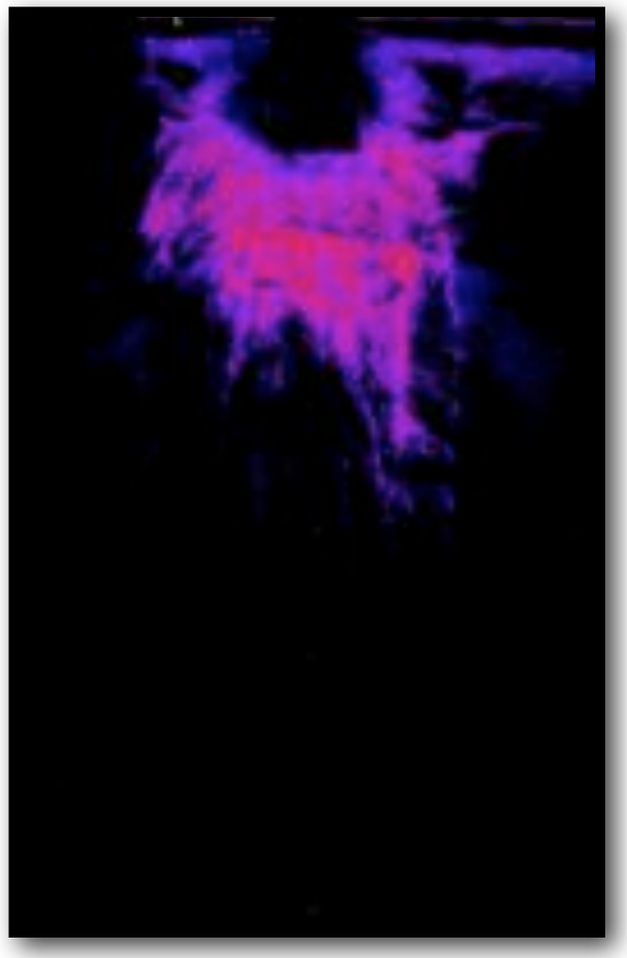

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Perspectives

Perspectives

- Aquaporins
  - ZmPIP2:5
- Architecture
  - *lrt1*
  - Excisions
- Long distance signaling
  - Partial Root Zone Drying
  - ABA deficient mutants
- Improvements
  - Infrared light
  - Ground penetrating radar
  - Plastination

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Acknowledgments

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Thank you for you attention.