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

Lobet, Guillaume ; Pagès, L. ; Chaumont, François ; Javaux, Mathieu ; Draye, Xavier

Document type : Communication à un colloque (Conference Paper)
Integrating soil and plant knowledge at different scales to better understand the dynamics of water in SPAC

G. LOBET, L. PAGES, F. CHAUMONT, M. JAVAUX & X. DRAYE

Nottingham, 11 September 2008
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
  - ZmPIP2:5 mainly present in endoderm and exoderm of maize roots

To test the quantitative contribution of ZmPIP2:5 at the root system level

From: Hachez et al., 2006
Material and methods
Material

- Three tools were used:
  - transgenic plants deficient in ZmPIP2:5
  - 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:

<table>
<thead>
<tr>
<th></th>
<th>Trangenics</th>
<th>Wild-types</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>61.7 ± 16.1</td>
<td>60.0 ± 17.3</td>
<td>0.909</td>
</tr>
<tr>
<td>Growth rate (cm/day)</td>
<td>16.7 ± 6.8</td>
<td>11.6 ± 4.9</td>
<td>0.352</td>
</tr>
</tbody>
</table>

- intrinsic variability of the growth rate

<table>
<thead>
<tr>
<th></th>
<th>Deep</th>
<th>Superficial</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>75.0 + 8.66</td>
<td>48.3 + 7.64</td>
<td>0.016 *</td>
</tr>
<tr>
<td>Growth rate (mm/day)</td>
<td>19.21 + 7.65</td>
<td>11.53 + 4.15</td>
<td>0.008 **</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>Trangenics</th>
<th>Wild-types</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>root:shoot</td>
<td>0.99 + 0.035</td>
<td>0.86 + 0.062</td>
<td>0.032 *</td>
</tr>
<tr>
<td>% primary roots</td>
<td>21.59 + 1.90</td>
<td>14.18 + 2.95</td>
<td>0.022 *</td>
</tr>
</tbody>
</table>

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 (?)
• 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
Acknowledgements

UCL:
Xavier Draye
Mathieu Javaux
François Chaumont

INRA, Avignon:
Loïc Pagès
Claude Doussan
Thanks for your attention