Water uptake patterns and root system architecture of *Zea mays* in a natural soil under influence of drought stress monitored by MRI

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Introduction: Root water uptake is determinded by many factors such as water availability, soil properties and the transpiration demand. The uptake also considerably effects water flow and solute transport within the soil. Roots are the "hidden half" of plants what limits the observing of these processes under natural conditions. Magnetic resonance imaging (MRI) provides access to the content of this "black box" by visualizing spatially high-resolved water contents. This has been successfully proved by Pohlmeier et al. (VZJ. 7, pp. 1010-1017, 2008) for *Ricinus communis* grown in a model medium. Continuing these studies, the new aspect is the determination of water uptake patterns and root system architecture in a natural soil, which is characterized by very short transverse relaxation times T_2.

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1. Method

- 14 days old *Zea mays* grown in natural soil
- Initially saturated θ_S = 0.37 cm³/cm³
- Soil covered → evaporation restrained
  → **only** transpiration
- Measured each 2nd day gravimetrically and by means of MRI
- 4.7 T (200 MHz for ¹H) vertical ultra wide bore magnet (Magnex Scientific, UK)

Water content determined by:

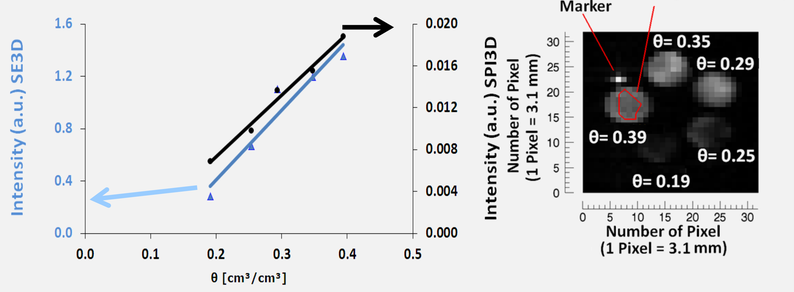
- Single point imaging 3D (SPI3D)
  Resolution (mm): 3.1x3.1x3.1
  t_P= 0.05 ms
  t_R= 10 ms
- Spin echo 3D (SE3D)
  Resolution (mm): 3.1x3.1x3.1
  t_E= 0.84 ms
  t_R= 300 ms

Root system architecture:

- Spin echo multi slice (SEMS)
  Resolution (mm): 0.4x0.4x2
  t_E= 6 ms
  t_R= 10.000 ms
  51 slices a 2mm

2. Calibration

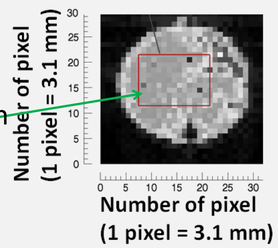
- 5 columns with same bulk density and different water content
- Different intensities (grey value) for each theta
- Integration over ROI (mean intensity value)

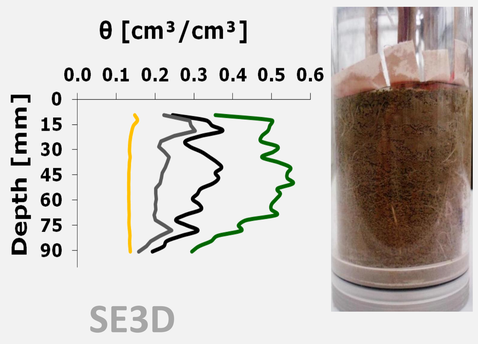


3. Soil water content

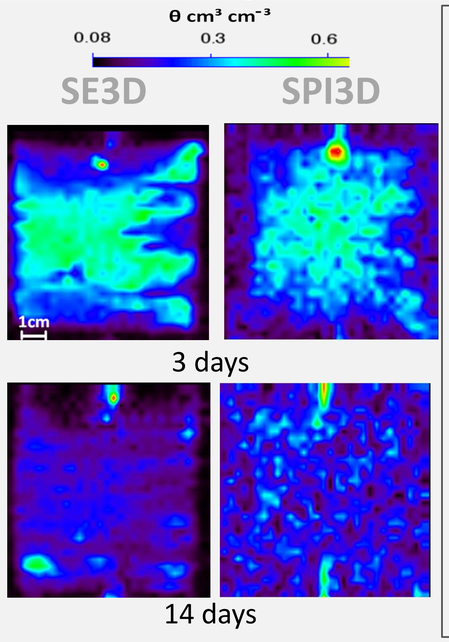
Moisture profiles determined by:

- Mean intensity values for an axial section by integration over a ROI
- Normalized to calibration



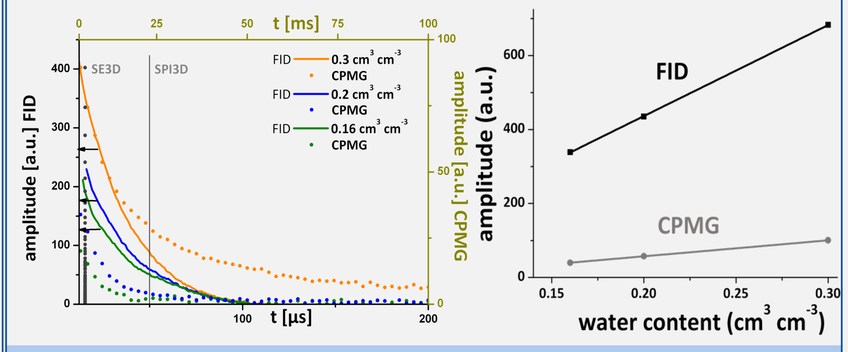


Water content maps of one slice

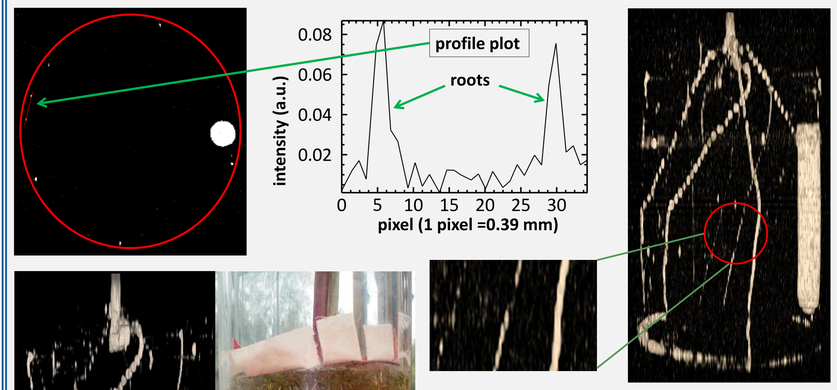


- SPI3D and SE3D are both feasible for determination of water content in natural soil
- Detection limit=0.15 cm³/cm³
- Quite uniform water uptake patterns during drying
- Indication of an always sufficiently high hydraulic conductivity of the soil to sustain water supply for the plant
- Partial volume effects due to low resolution

4. T_2* & T_2 relaxation in natural soil



5. Root system architecture



roots with diameter > 0.4 mm (1 pixel) can be visualized

Use your smartphone on this!

Conclusion: We showed that root water uptake is quite uniform during drying. Due to the very short relaxation times of the natural soil SE3D with very short t_E is feasible to achieve moisture profiles down to a detection limit of θ=0.15 cm³/cm³. Root system architecture can be measured down to the limit of one pixel where only seminal roots are detectable for sample size used here.