An evaluation of techniques for root observations

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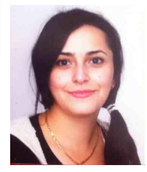

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Introduction

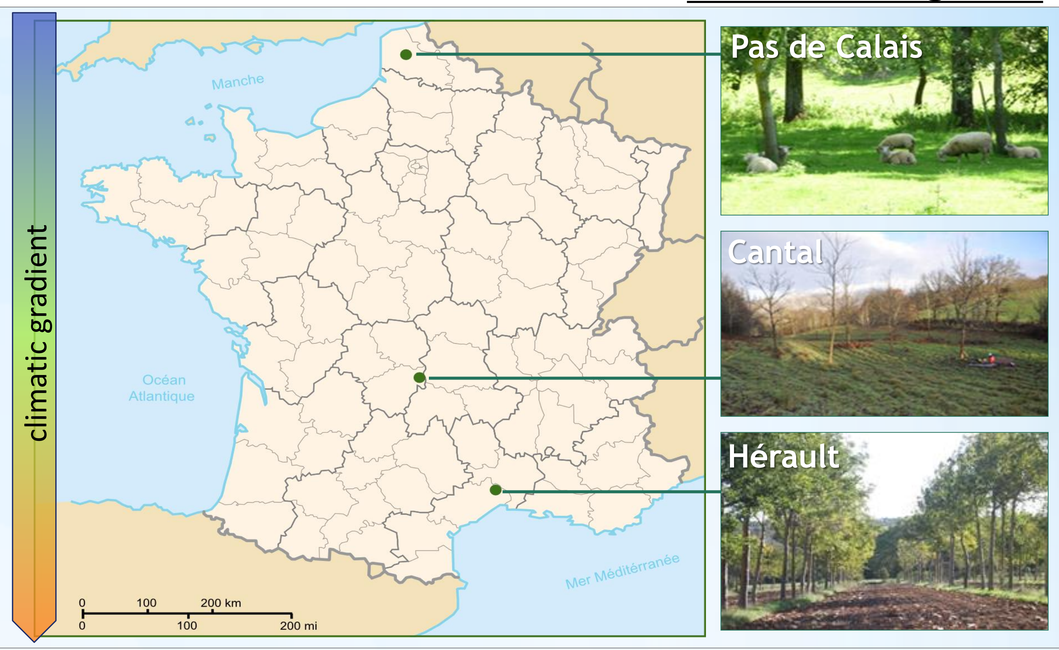
Belowground processes play an essential role in ecosystem nutrient cycling and the global carbon budget (C) cycle. Quantifying root dynamics (production, longevity, mortality and decomposition), is crucial to the understanding of ecosystem structure and function, and in predicting how ecosystems respond to climate variability. However, we have a relatively poor understanding of the best method of root observation, especially in a heterogeneous soil in the field.

Objectives

We installed rhizotrons, or 'root windows' in the field. We compared five techniques to observe and measure roots: time-lapse camera, portable handheld scanner, smartphone scanner, flatbed scanner and tracing on sheets.

Study sites

Three agroforestry systems comprising hybrid walnut (*Juglans nigra* × *Juglans regia*) cultivars and pasture/crops along a climatic gradient in France.

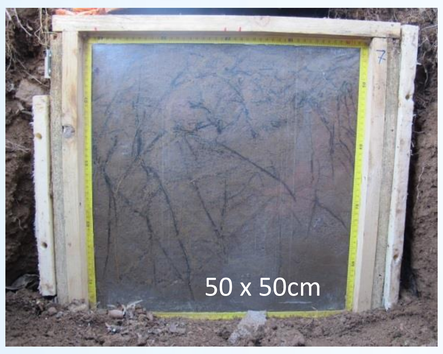


Methods

I. Transparent sheet

Rhizotron profile :

A transparent plastic sheet is placed in front of the rhizotron.



II. Camera

Time lapse cameras (CUDDEBACK ATTACK) installed in front of rhizotrons / 1 color image/day & /night (with flash).

III. Portable handheld scanner

Scanner color portable A4 - Format JPEG. Scan Resolution: 300 -600 dpi. scan the rhizotron by moving the scanner on the surface of rhizotron glass.

Two A4 images size are needed for one 50x50cm surface

IV. Flatbed scanner

Epson Perfection V370.high optical resolution of 4,800dpi and CCD (charged-coupled device) technology

Four A4 images are needed for one 50x50cm surface

V. Smartphone scanner

Scanning application on smartphone works by taking photographs and then determines the border of the rhizotron to calibrate the scan.

Drawing of roots

Root elongation is manually traced onto a transparent sheet every month. Colors indicate different observation times.

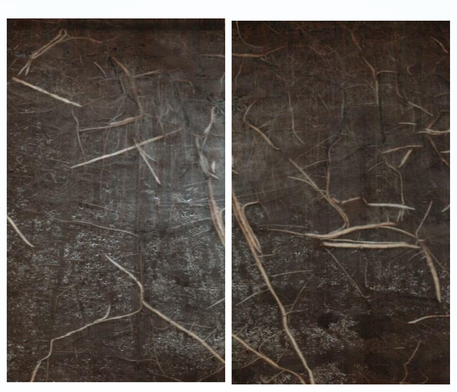
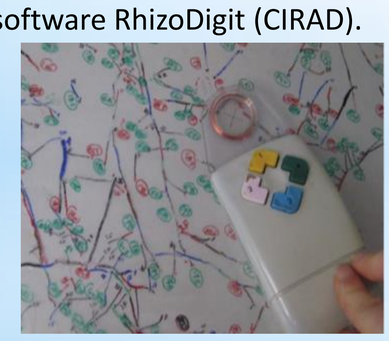
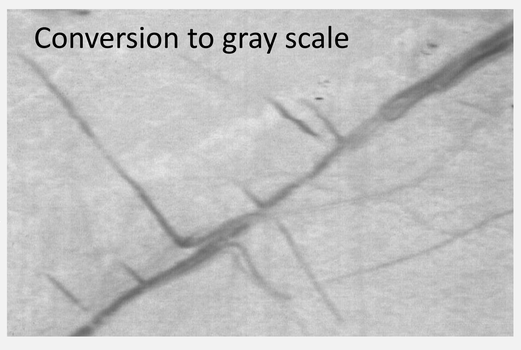


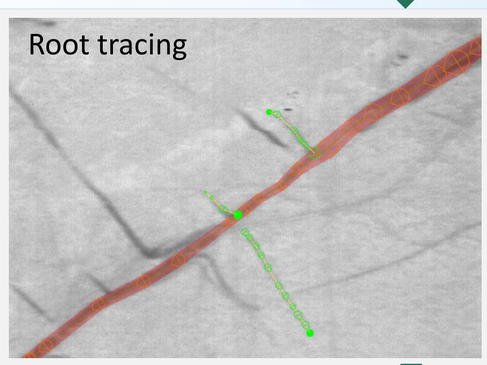
Image stitching software

Digitizing

Sheets are digitized using the software RhizoDigit (CIRAD).

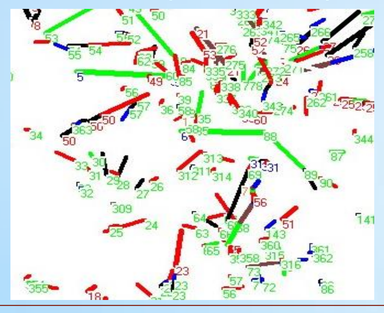


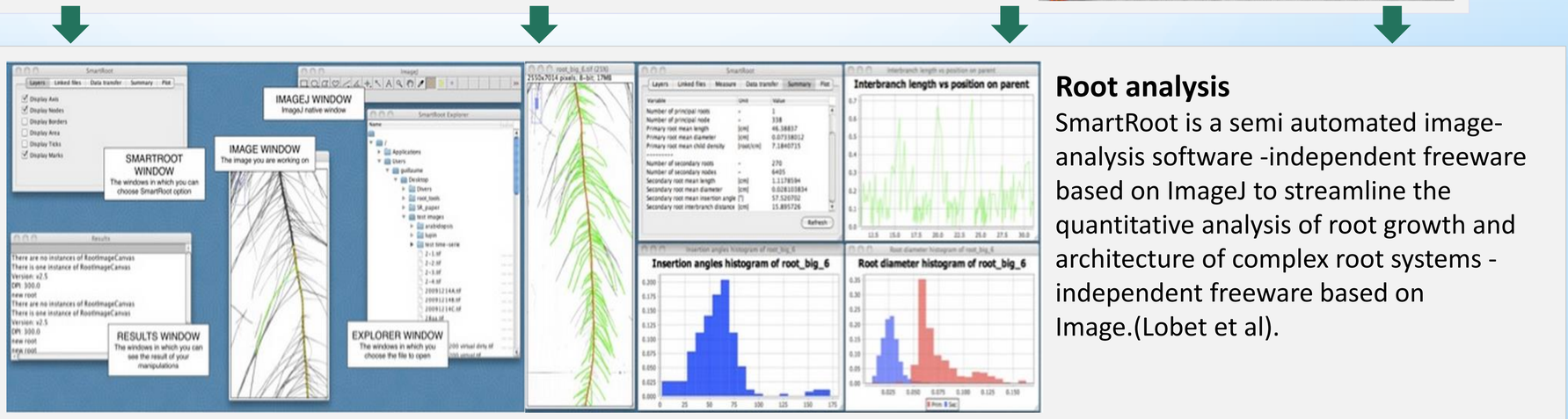




Analysis

Root initiation density is calculated using Bohm's root wall method (Bohm 1979).





Root analysis

SmartRoot is a semi automated image-analysis software -independent freeware based on ImageJ to streamline the quantitative analysis of root growth and architecture of complex root systems - independent freeware based on Image.(Lobet et al).

Preliminary results

- The number of roots (especially fine roots) recorded by **sheet transparent** for same rhizotron was less than those taken by other techniques on the image.
- Visual observation showed a deformation on images taken by a **handheld scanner** which could deform the length of roots and their diameters .
- The main advantage of the **Time-lapse camera** is that it can be left in place for several months without any manual intervention, but some reflection occurs due to the flash.
- **Flatbed scanner** is expected to be the best technique considering image quality (deformation, resolution, contrast and time) , but there are some constraints :not automatic(manual) data acquisition in field and the scanner has many accessories so is not easily transportable.

References

- BÖHM, W.; 1979: Methods of Studying Root Systems. Ecological Studies 33. Springer, Berlin, Heidelberg, New York.
- Guillaume Lobet, Loïc Pagès and Xavier Draye. A Novel Image Analysis Toolbox Enabling Quantitative Analysis of Root System Architecture. 2011 Plant Physiology, Vol. 157, pp 29-39 doi: 10.1104/pp.111.179895.