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Experimental design to monitor the influence of agricultural treatments on the dynamics of soil water content

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CONTEXT

Electrical resistivity tomography (ERT) is appropriate to perform high-resolution monitoring of dynamics of soil water soil water content (SWC). The main advantages of this technique are that (i) it is quasi non-invasive and (ii) the measurement volume is larger than traditional methods. Based on our experience, we discuss several points which can be important for using geophysical methods in an agricultural context. In particular, we focus on the scale and resolution, the constraints influencing the experimental design and the data validation.

GENERAL APPROACH (1)

The experimental field consists of 4 replications of 4 agricultural treatments (40m x 15 m). Our approach can be divided into several points:

1°) Spatial variability of apparent electrical resistivity σ_a at the field scale (in collaboration with S. Lambot and G.A. Rodriguez (UCL & FNRS))

- after sowing (April) and after harvesting (November)
- electromagnetic induction and ground penetrating radar to map the entire field with a distance of 0.75m between the measurement lines
- ERT transect with 1m electrode distance for calibration purposes

2°) Variability of σ_a , scale ~1x2 m, depth:1.20m

- after sowing and after harvesting
- surface electrodes on a grid (figure 1c)
- 1 measurement per plot(in figure 1a)

3°) σ_a dynamics over the growing season,, scale ~1x2m

- from sowing until harvesting; 1 time a week
- 4 plots, including 3 modalities + 1 bare soil (in figure 1a)
- surface electrodes on a grid + sunk electrode sticks

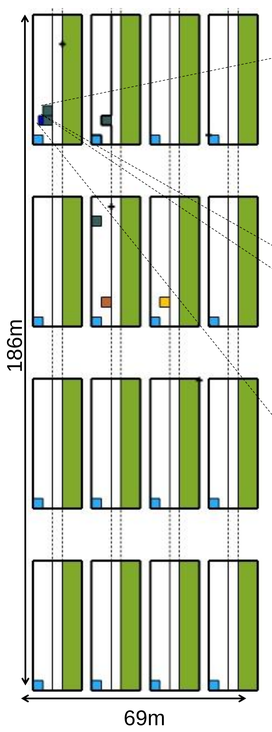
(figure 1b , 1c and 1d)

- Wenner-Schlumberger and Dipole-Dipole arrays

Remark: during prolonged drying cycles, exceptional infiltration events, etc., the temporal resolution will be increased to catch daily soil moisture patterns and stress periods for the crop.

EXPERIMENTAL SETUP

Figure 1a: experimental field (top view)



σ_a monitoring (figure 1b)
$\sigma_a(\theta)$ calibration (figure 1e)
field variability of σ_a
ϕ, pF-curves(θ_{sat})
X-ray images, pF-curves
crop production monitoring

in collaboration with : N. Parvin, M.-P. Hiel, D.Eylenbosch (same university)

Figure 1b: zone for ERT monitoring (top view)

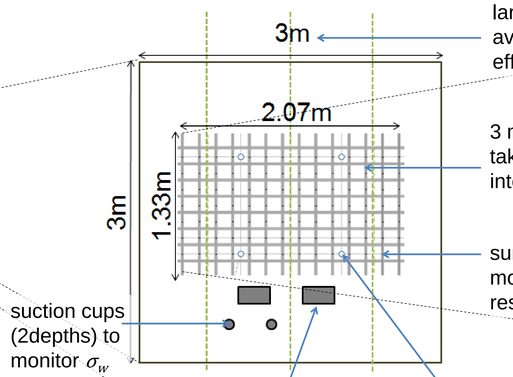


Figure 1c: ERT monitoring - grid and sticks (top view)

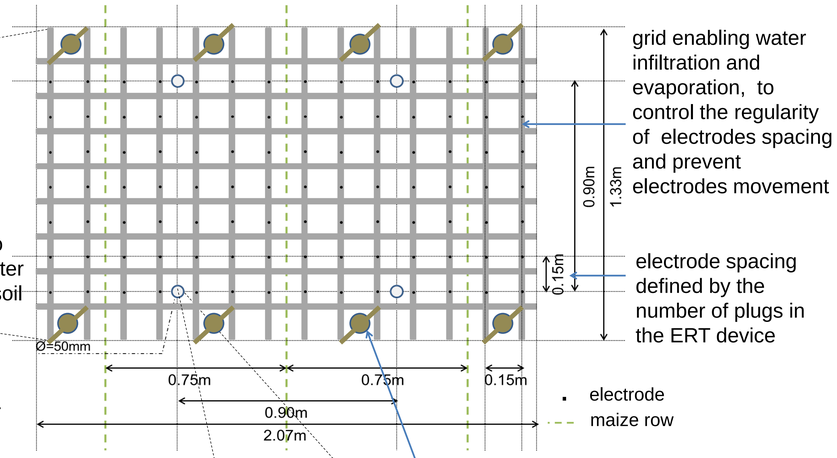


Figure 1e: calibration pit (cross sectional view)

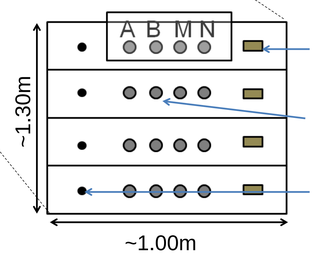
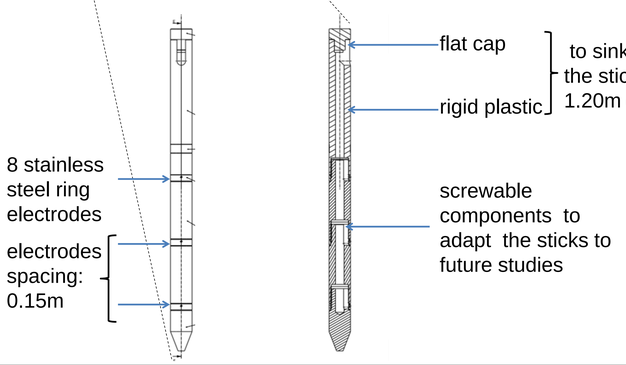


Figure 1d: ERT monitoring: stick



PARAMETERS : Φ: total porosity θ_{sat}: soil water content at saturation θ: soil water content σ_a: soil apparent conductivity σ_w: electrical conductivity of soil solution

GENERAL APPROACH (2)

4°) $\sigma_a(\theta)$ relationship: Archie's law under unsaturated conditions

$$\frac{\sigma_a}{\sigma_w} = \phi^m \left(\frac{\theta}{\theta_{sat}}\right)^n$$

- σ_a and θ :calibration pit (in figure 1a and 1e);σ_w :close to the grid (figure 1c); ϕ : bulk density (1 time a month) over the growing season; θ_{sat} :pF-curves (in figure 1a)

5°) Validation and valorization of data

- measurement of θ via time domain reflectometry (TDR) (figure 1b)
- interactions between, soil structure, θ and plant development (in figure 1a)

OPEN QUESTION

The insertion of the sticks into the soil requires:

- a minimal disturbance of the soil surface
- a sufficient strength to insert them at 1.2m depth
- a minimal compaction around the boreholes for good soil-electrode contact

WHICH SOLUTION?