Using Geophysical Techniques to Characterize Tillage Effect on Soil Properties

F. Jonard[*,1], M. R. Mahmoudzadeh[2], C. Roisin[3], L. Weihermüller[1], F. André[2], H. Vereecken[1], and S. Lambot[1,2]

[1] Agrosphere (IBG-3), Institute of Bio- and Geosciences, Research Centre Jülich, Germany
[2] Earth and Life Institute, Université catholique de Louvain, Belgium
[3] Walloon Agricultural Research Centre, Belgium
* Corresponding author: f.jonard@fz-juelich.de

1 Objective

Tillage practices influence physical, chemical, and biological soil properties, which also affect soil quality and consequently plant growth. In this study, the main objective was to evaluate the effect of different tillage systems on soil physical properties by using geophysical methods, namely, ground-penetrating radar, capacitance probes, electromagnetic induction (EMI), soil sampling, and by penetrometer.

2 Experimental Setup

The experiment was conducted on a bare agricultural field in Gentinnes, in the loess belt of central Belgium. Since 2005, three contrasting tillage systems were applied on different plots: i) conventional tillage (CT) with mouldboard ploughing to 27 cm depth, ii) deep loosening tillage (DL) with a heavy tine cultivator to 30 cm depth, and iii) reduced tillage (RT) with a spring tine cultivator to 10 cm depth. The geophysical and soil strength measurements were performed in April 2010.

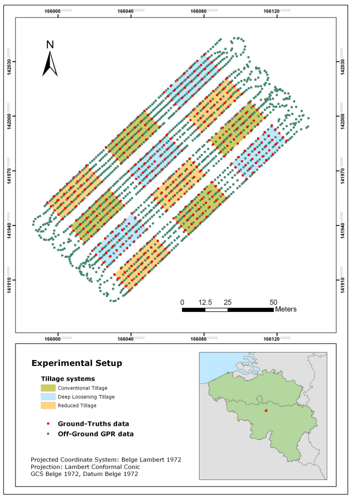

Figure 1. Study site of Gentinnes, Belgium. Sampling points for the ground-truth measurements and the GPR data acquisition are shown.

3 Geophysical Measurements

We used two capacitance moisture sensors (ThetaProbe ML2x and 5TE) and two different GPR systems: a far-field radar for soil moisture retrieval [1] and a near-field radar for soil stratigraphy imaging. We also used two EMI sensors (Profiler and EM38) to map the bulk soil electrical conductivity in order to provide insights with respect to the spatial variability of the soil properties.

Figure 2. Far-field GPR (horn antenna linked to a VNA, D-GPS device, and a PC), near-field GPR (on the back), and EMI sensor (on the front) mounted on a quad to measure soil dielectric permittivity and apparent electrical conductivity.

4 Soil Strength Measurements

A penetrometer was used to distinguish the different tillage practices and their effects on soil density.

Figure 3. Fully automated penetrometer used for the soil strength measurements [2].

5 Results

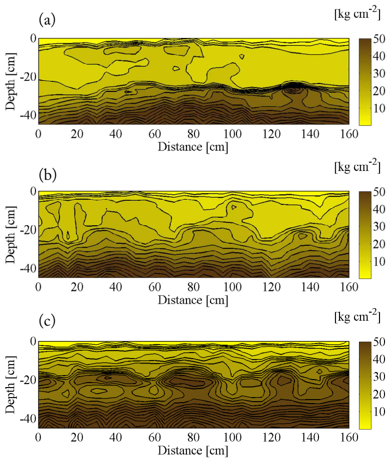

Figure 4. 2D soil strength maps obtained by penetrometer after (a) CT, (b) DL, and (c) RT.

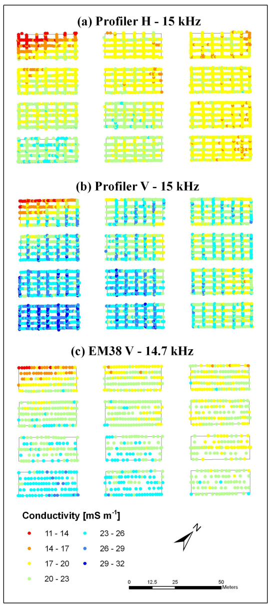

Figure 5. Map of the apparent soil electrical conductivity retrieved by Profiler with horizontal and vertical dipoles and by EM38 with vertical dipoles.

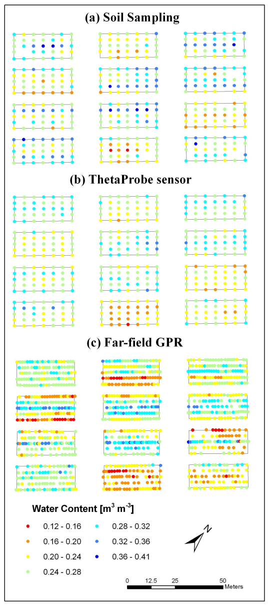

Figure 6. Volumetric soil water content maps obtained by soil sampling, capacitance sensor, and far-field GPR.

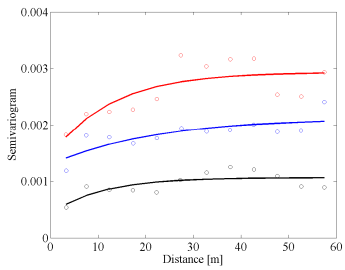

Figure 7. Semivariograms for far-field GPR-derived soil moisture computed for the plots prepared with CT (red), DL (blue), and RT (black).

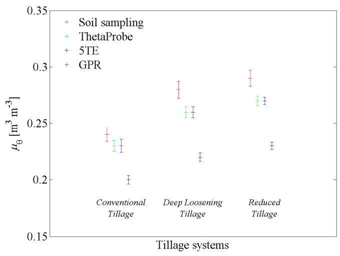

Figure 8. Mean soil water content per plot and per tillage. Error bars represent confidence interval between the four plots for each tillage.

6 Conclusion

We observed that the mean surface water content was significantly lower for CT than for DL and RT, which was partly explained by lower macropore connectivity between the topsoil and the deeper layers after CT. This study confirms the potential of GPR and EMI sensors for soil physical properties determination at the field scale.

References

[1] Jonard, F., Weihermüller, L., Jadoon, K. Z., Schwank, M., Vereecken, H. and Lambot, S. (2011). *Mapping Field-Scale Soil Moisture With L-Band Radiometer and Ground-Penetrating Radar Over Bare Soil.* IEEE Trans. on Geosci. Remote Sensing 49, 2863-2875.

[2] Roisin, C. (2007). *A Multifractal Approach for Assessing the Structural State of Tilled Soils.* Soil Science Society of America Journal 71, 15-25.