Soil infrastructure evolution and its effect on water transfer processes under contrasted tillage systems

Parvin N., Bodson B., Vandenbol M., Garré S., Colinet G. and Degré A.
Gembloux Agro-Bio Tech, University de Liège, Unit: Soil - Water Systems, 5030 Gembloux, Belgium

Introduction

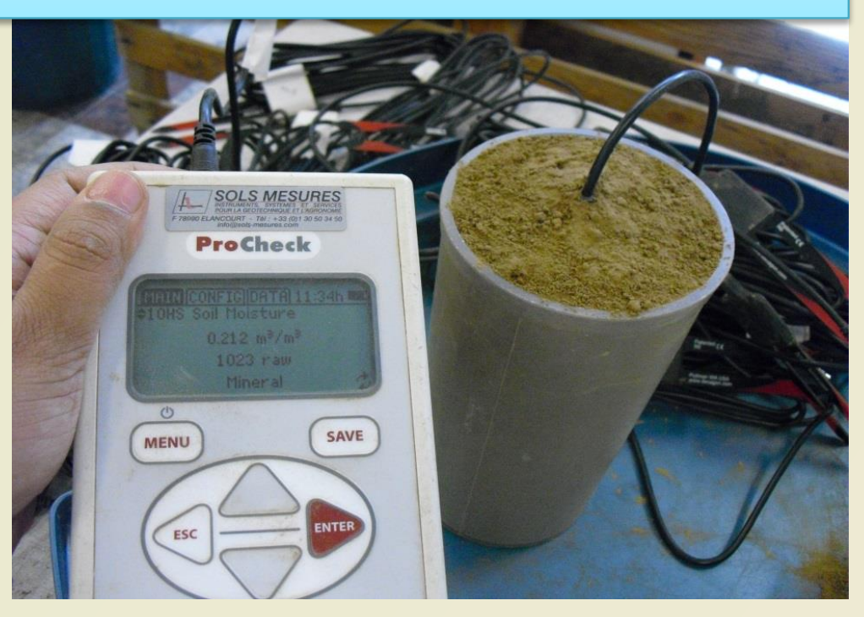
In recent decades, the sustainability of agricultural land in relation with tillage systems has received considerable attention that results into adoption of conservation oriented land management. Several experiments showed that tillage and other land management can influence soil structure (Strudley et al., 2008) and more precisely porosity distribution and these changes in soil can significantly alter other soil physical properties (Bouma, 1992) especially, soil hydrological behavior and consequently nutrient losses, microbial activities and water availability for crop production. Combination of soil water retention capacity and hydraulic permeability measurement with X-ray microtomography and investigation of dynamic of soil water in field scale is a promising approach to characterize the differences in soil porosity , soil water flow pattern and soil infrastructure evolution under different land management.

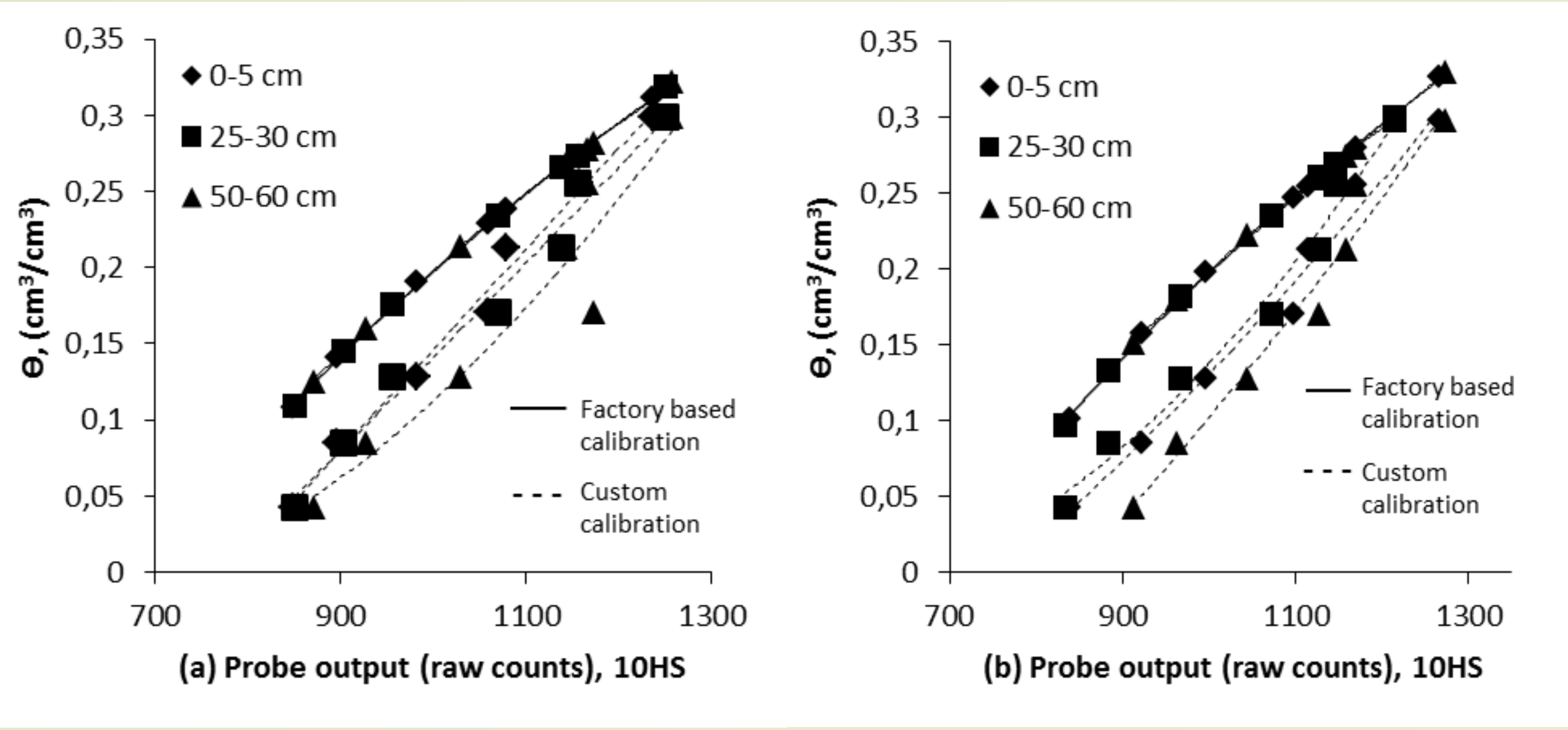
Aim of the project

We aim at investigating the effect of soil tillage along with residue management on soil structure at aggregate scale or more specifically at pedon scale. This investigation will help to emphasize the different water flow pattern especially the preferential flow processes through the soil profile that are influenced by the changes in soil structural distribution.

Findings of site and depth specific calibration of soil moisture sensors (10HS and 5TM) for the experimental field of Solcouvert and Solresidus

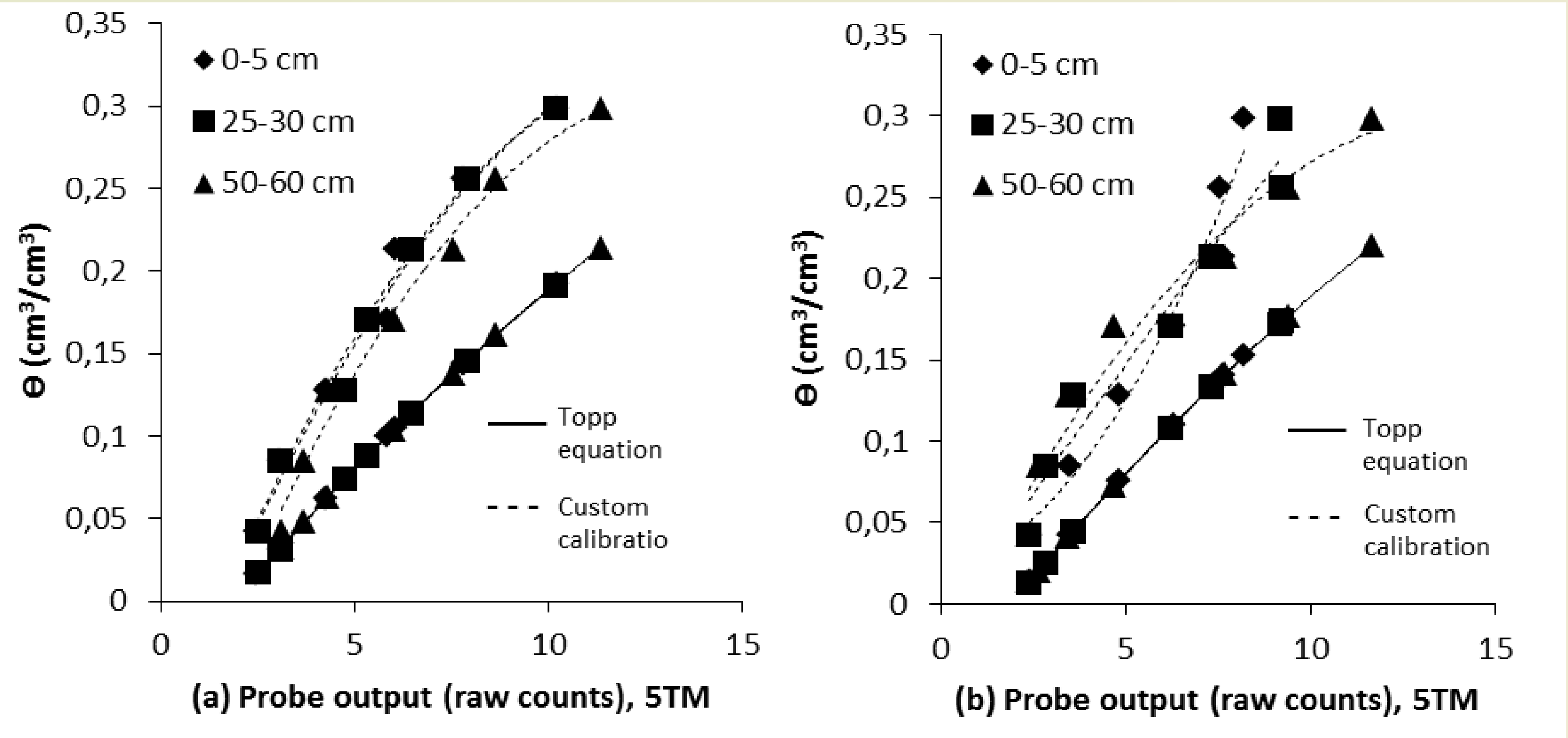
For the sensor calibration, different sites correspond the different location treated with different tillage approaches and the specified depths were 0-5, 25-30 and 50-60 cm; calibration was done by following the standard process of calibration developed by Douglas and Chris, 2010.





Raw output of the 10HS sensors (average value) as a function of volumetric water content (ϴ) for the soils of Solcouvert (a) and Solresidus (b) at three different depths (0-5, 25-30 and 50-60 cm) with the custom calibration and with the factory based calibration

There is significant ($p<0.05$) difference in raw output in relation of different stage of ϴ between the soils of Solcouvert and Solresidus for the depth of 0-5 and 50-60 cm. There were also significant ($p<0.05$) differences among the different depths of same site



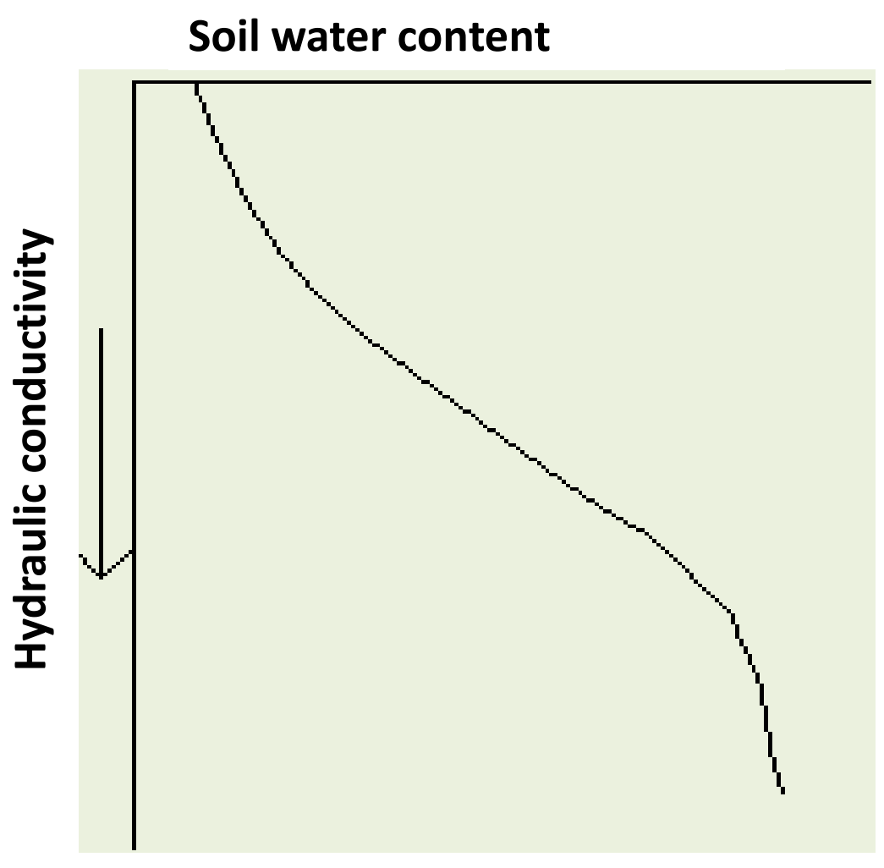
Raw output of the 5TM sensors (average value) as a function of volumetric water content (ϴ) for the soils of Solcouvert (a) and Solresidus (b) at three different depths (0-5, 25-30 and 50-60 cm) with the custom calibration and with the Topp equation (Topp et al., 1980) for the calibration of mineral soils

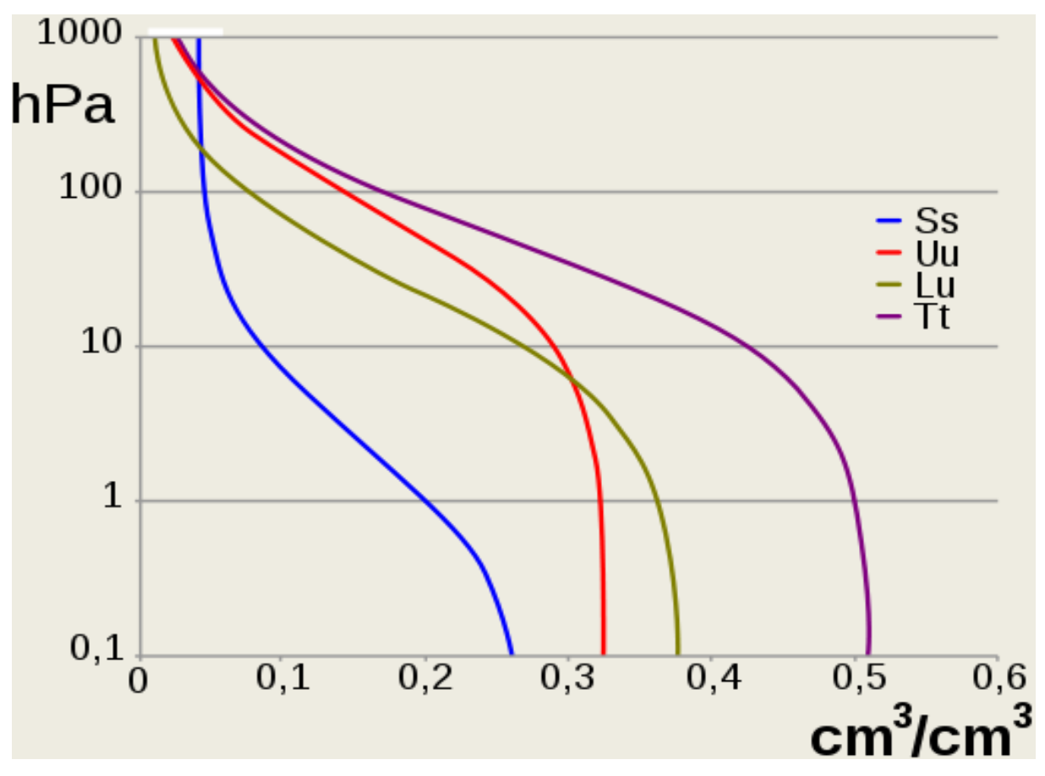
There is significant difference ($p<0.05$) in raw output in relation of different stage of ϴ between the soils of Solcouvert and Solresidus for all three depths. There were also significant ($p<0.05$) differences among the different depths of same site

Materials and methods

The project will take place on the already established ‘Solresidus’ and ‘Solcouvert’ experimentations in Gembloux, Belgium. The research will focus on four different practices; **‘conservation tillage with organic matter restitution’** versus **‘conservation tillage without organic matter restitution’** in the plots of ‘Solresidus’ and **‘strip-till’** versus **‘winter ploughing’** in the plots of ‘Solcouvert’. There are four replications of four different practices and the investigation will be done in each replication in each year. The experimentation has been started from June 2013; all the experiment will be repeated twice a year.

Figure.1. Classical methods to measure soil water retention and hydraulic conductivity





Soil Water retention curve

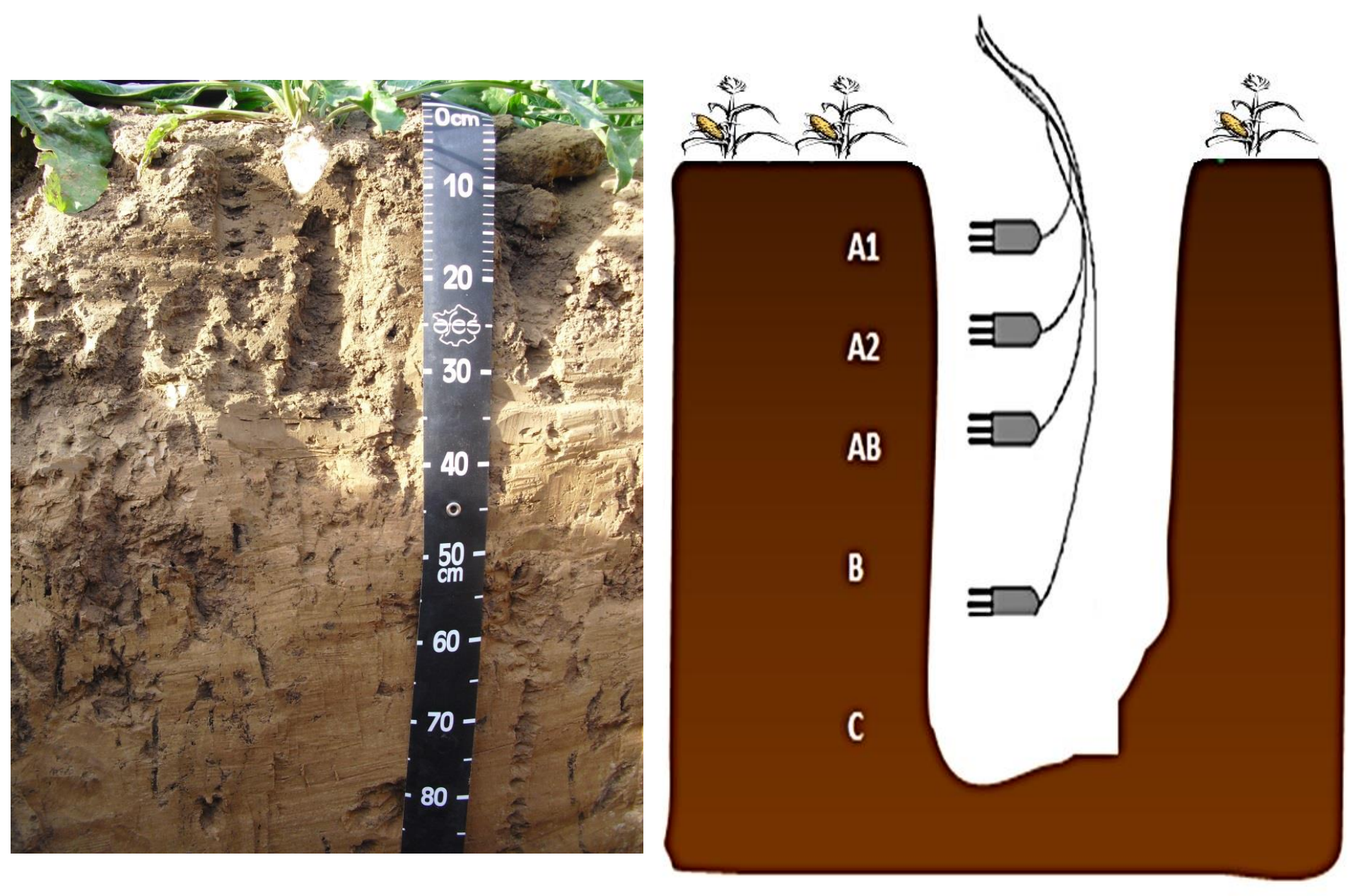


Figure 2. Soil pits observation in four different tillage systems and set up Soil moisture sensors setup at different depths to capture total moisture network during the crop growing season

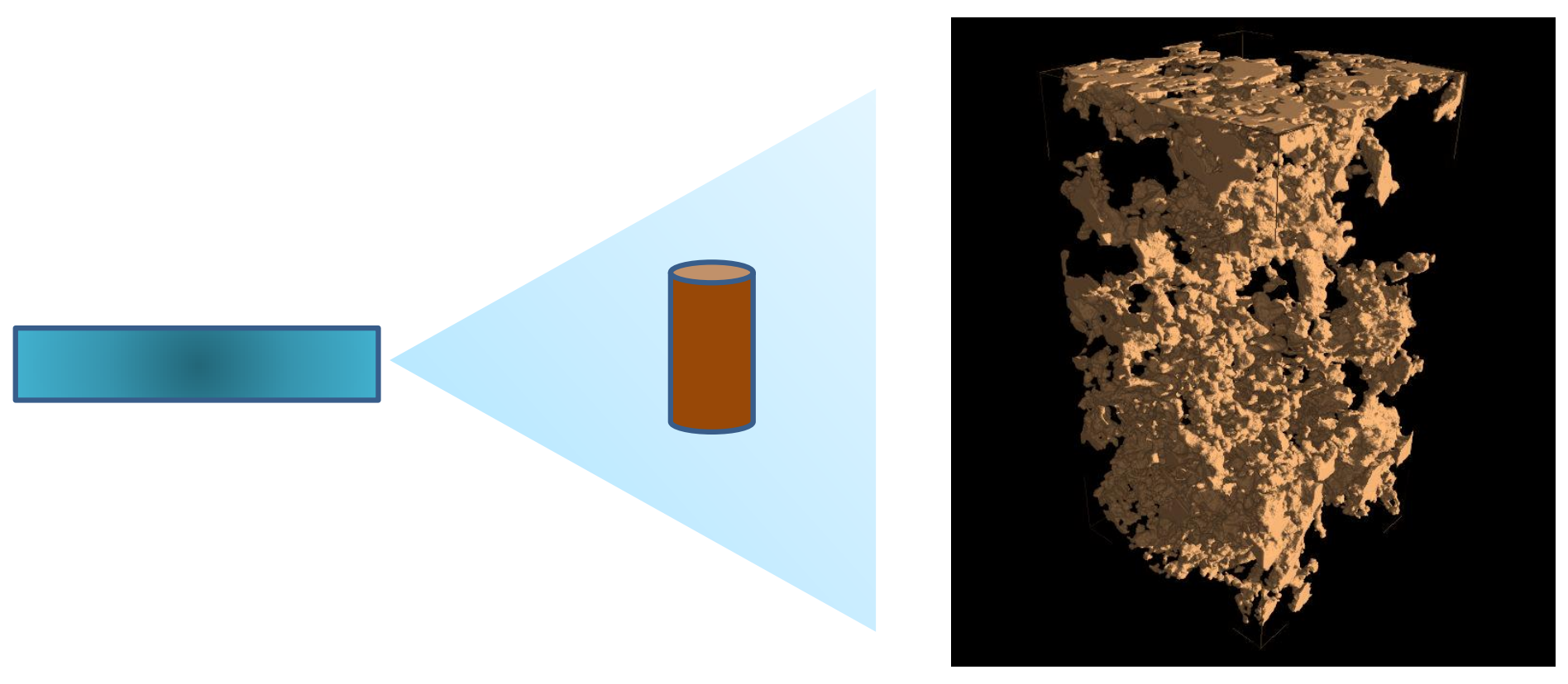
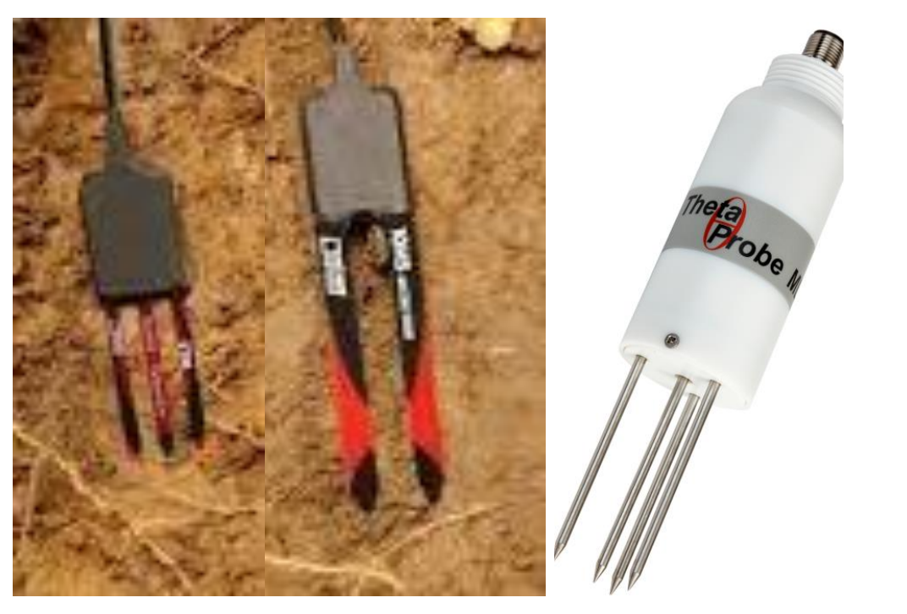


Figure.3. Porosity distribution of a soil samples by scanning with X-ray microtomography

All the measurements will help to characterize Macro and microscopic distribution of soil pores and hydrodynamic behavior of soil under different tillage and land management

Soil Moisture sensors:
(Decagon 10HS, 5TM and ML3 Thetaprobe)



Soil moisture sensors are calibrated with the soils of four different objects and for different depths to get highest accuracy of the measurement of volumetric water content as soil specific calibration can increase the accuracy from ±3-4 % to ±1-2% (Douglas and Chris, 2010).

Collaborations

This project is a part of multidisciplinary projects focusing on ‘Use of residues in agricultural systems’. Valorization of crop residues play an important role for soil fertility, soil productivity, biological activity and soil structural stability. So, the side questions of the role of soil macro fauna, structural evolution by the effect of roots and microbial activities in soil and quantitative distribution of organic matter could be addressed through by the close collaboration with other PhD students ((Chélin M. (Garré S.), Degrune F. (Vandenbol M.), Barbieux S. (Colinet G.), Hiel M.-P. (Bodson B.)); who will also work in the same four trials of ‘Solresidus’ and ‘Solcouvert’.

References

Bouma, J., 1992. Effect of soil structure, tillage, and aggregation upon soil hydraulic properties. In: Wagenet, R. J., Baveye, P., Stewart, B. A. (Eds.), Interacting Processes in Soil Science. Lewis Publishers, Boca Raton, pp. 1-36.
Douglas R. C., and Chris C. 2010. Calibrating ECH2O Soil Moisture Sensors; Revised 11/17/10; Decagon Devices-Application note.
Strudley, M. W., Green, T. R., and Ascough, J. C. 2008. Tillage effects on soil hydraulic properties in space and time: state of the science, *Soil Tillage Res.*, 99, 4–48.
Topp, G. C., Davis, J. L., and Annan, A. P. 1980. Electromagnetic determination of soil water content: measurements in coaxial transmission lines, *Water Resources Research*, 16(3): 574-582.

Conclusion

All the experimental setup will help us to characterize the hydrodynamic properties patterns through the soil and to understand the effect of tillage, pedofauna, root development and crop residues on the distribution of soil structure and porosity. In the same time, to capture the total soil moisture networks, the moisture sensors will be in the field during the crop season. For the specific spatio-temporal comparison, the monitoring results from electrical resistance tomography will be available from one of the collaborated projects. Soil structural stability could be analyzed based on the further need of illumination of dynamic changes in soil structure in solid phase.

Regarding the calibration of soil moisture sensor, we can conclude that it could be the overestimation of moisture content if the manufacturer based equation is used for the calculation. So, site and depth specific calibration of low cost sensors is very essential for the interpretation of results. Soil bulk density and textural differences could be the main reason for the differences of moisture content of different sites and depths measured by the moisture probes.