

ANALYSING THE SOIL STRUCTURE UNDER DIFFERENT TILLAGE SYSTEMS USING X-RAY MICROTOMOGRAPHY AND PF CURVES

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Introduction

In addition to the proven method of pF curves, X-ray tomography has found its place in soil science over the past years. Indeed, tomography permits a quantification of the most intimate structure of undisturbed soil samples. More specifically, it gives interesting information concerning the poral distribution, pore elongation, connectivity,...X-ray tomography is thus justified in the case of comparing the effects of different tillages on the soil structure dynamics. Thus, the combination of pF curves and tomography can form a solid basis in order to quantify soil physical fertility.

Materials and Methods



Figure 1: Sowing at the Bordia site, Gembloux, 22-11-10 (Credits: Delphine Dufranne, GxABT)

Site data and sampling: samples were taken from two Belgian loamy fields (Aba(b)) which are subject to both Reduced Tillage (RT) and Conventional Tillage (CT) (table 1): one in Gembloux (Bordia, from 09/08, fig. 1) and one in Gentinnes (Champ du Mont, from 10/05).

Table 1: Cultural practices for the two experimental sites.

Site	Sowing	RT	CT	Crop rotation
Gentinnes	Rotary harrow + seeder	Cultivator + sowing	Plough, 28-30 cm depth + sowing	Winter wheat, mustard, beetroot
Gembloux	Cultivator + rotary harrow + seeder	Sowing	Plough, 23-27 cm depth + sowing	Winter wheat

10 samples were taken from the Ap horizon in Gentinnes (03/10) and 16 in Gembloux (11/10), both on a culture of winter wheat. The samples consisted of plastic cylinders (D = 3cm, H = 5cm) driven into the ground by steel rings. 10 and 14 undisturbed soil samples (100 cm³) were used respectively in Gentinnes and Gembloux for the pF analysis.

Tomography procedure: the samples are dried at 1.5 MPa at first in a Richards pan in order to fill out the water contained in the macro and mesoporosity. The soil cylinders are then scanned in the tomograph (Skyscan-1172 microtomograph, 100kV conical beam, resolution of 17μm, aluminium filter, 16-bits camera with a resolution of 1048×2000 pixels). The 2D images are then thresholded and binarized in Matlab in order to match the modelled and the measured porosity (Beckers et al, 2011). The 2D slices are then analyzed and spatialized with SkyscanTM CT-analyzer (fig. 2).

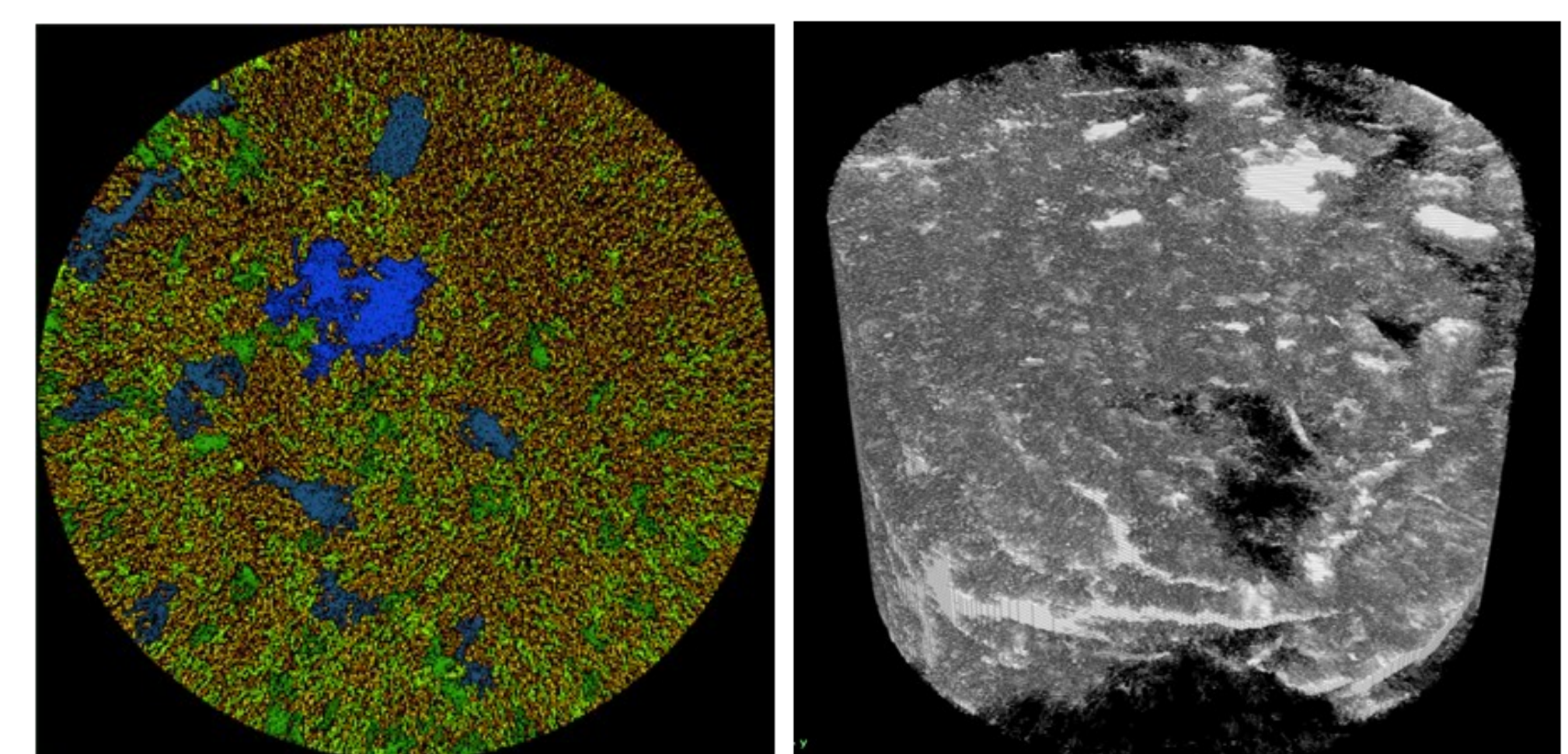


Figure 2: 2D and 3D soil imaging under CTanTM. (Diameter = 2.765 cm. Height = 1.693 cm.)

Results

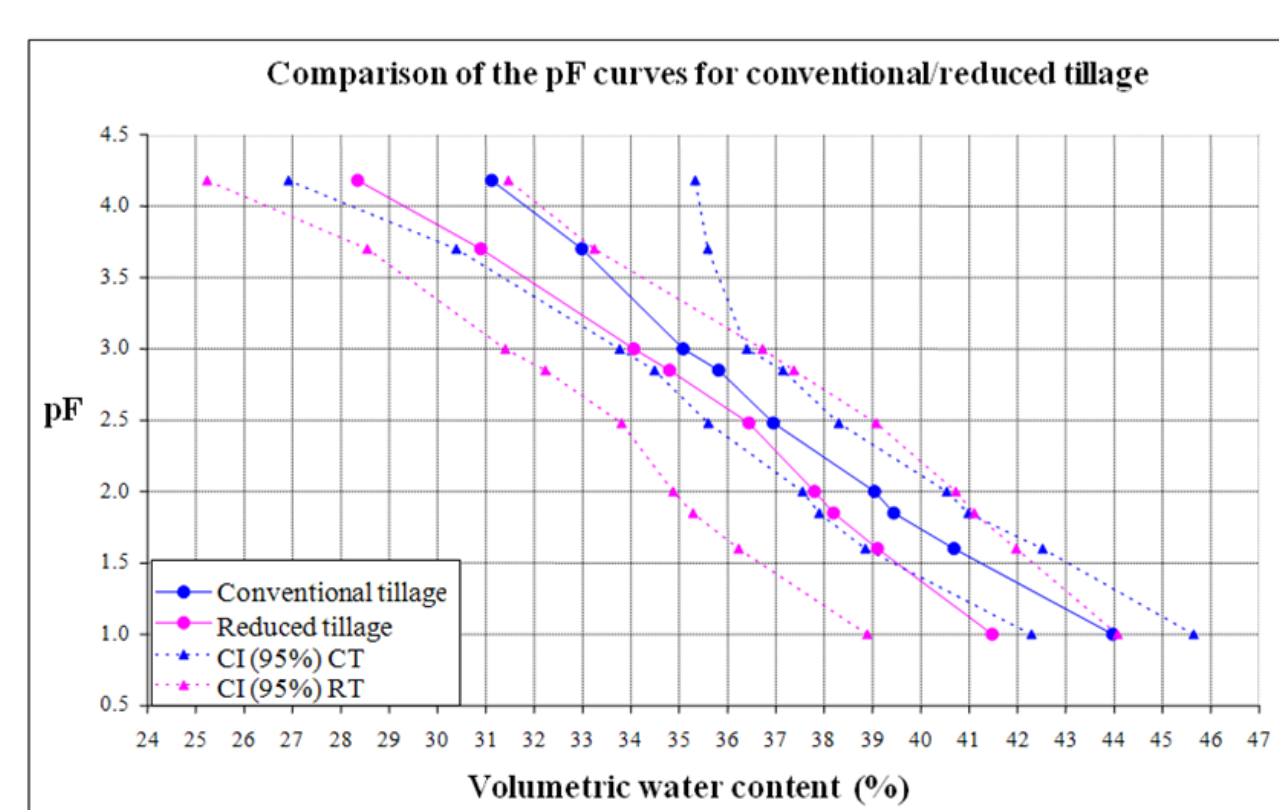


Figure 3: Comparison of the pF curves of CT and RT on the Gentinnes Site (03/2010)

On the site of Gentinnes, pF analysis showed a greater available water content (between pF 2.5 and 4.2) for RT, and a greater efficient porosity (between saturation and pF 2.5) for CT (fig.3). The differences in available water content, although not significant, were confirmed by site observation. The differences in efficient porosity were significant. Tomography analysis yielded the following: under RT, the pores are smaller and the anisotropy less developed. The poral connectivity was found greater in CT.

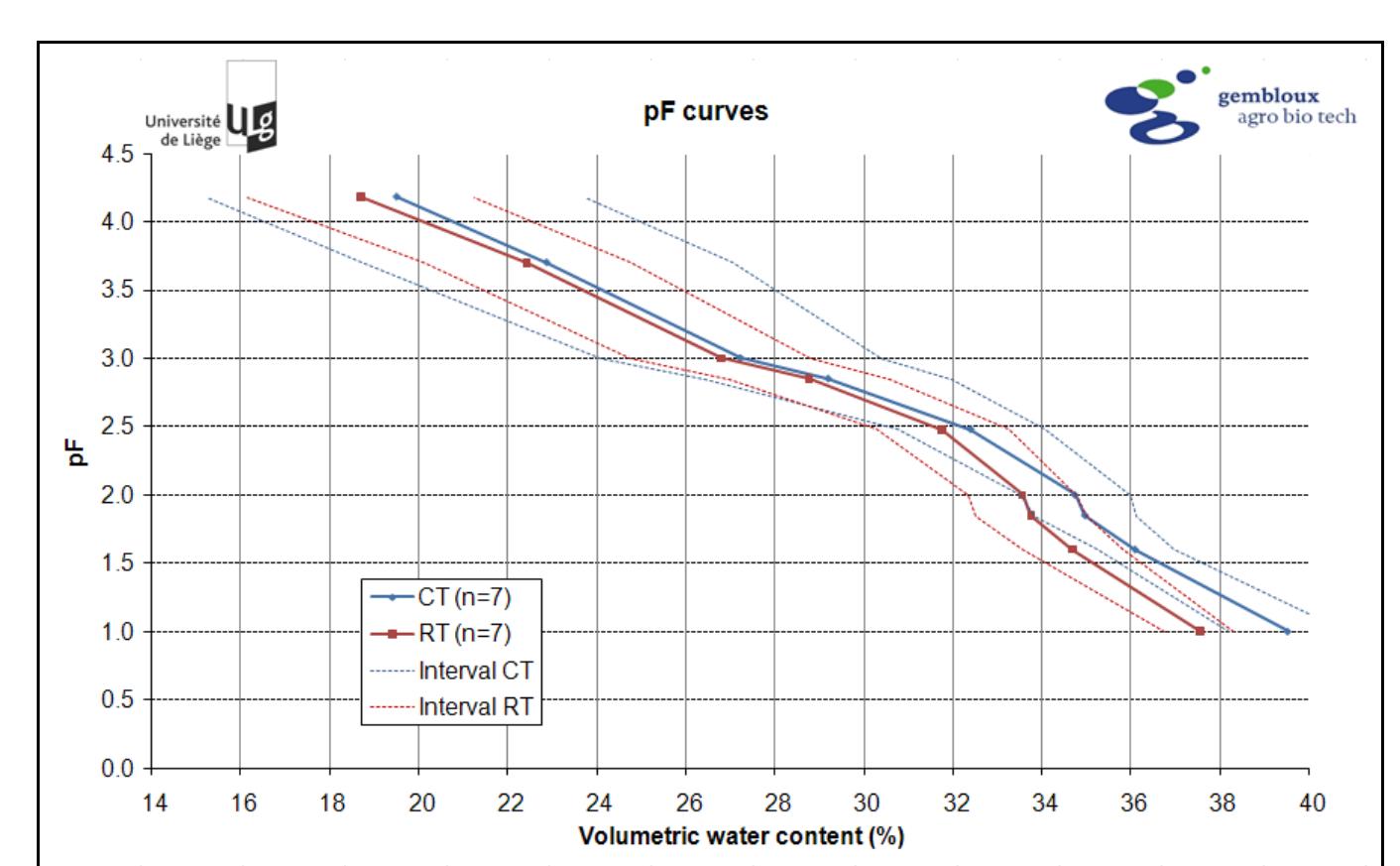


Figure 4: Comparison of the pF curves of CT and RT on the Bordia Site (11/2010)

On the site of Gembloux, however, no significant differences were found between the tillage systems concerning the pF curves (fig. 4). Tomography showed smaller pores for RT, but the differences deduced by the analysis of the Gentinnes samples concerning connectivity and anisotropy were not found in this case.

Conclusions

To conclude, from the results, the soil structure is found to differ between RT and CT. The pores tend to be smaller and less oriented in RT, whilst in CT pores are more connected. Soils undergoing a CT show a greater efficient porosity, whilst soils under RT display a greater available water content. However, these differences were mostly spotted on the Gentinnes site: in Gembloux, the differences between the samples were less marked. This could be due to the fact that the soil did not have time to undergo significant modifications (less than 3 years of tillage differentiation). More sampling is needed in any case before inferring general conclusions from these observations. A further analysis of the soil images, especially concerning pore orientation, will be done in order to fully exploit the tomography results.