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Micro and macroscopic investigation to quantify tillage impact on soil hydrodynamic behaviour

E. Beckers (1), C. Roisin (3), E. Plougonven (2), D. Deraedt (1), A. Léonard (2), and A. Degré (1)

(1) Soil – Water Systems, GxABT, Univ. Liège, Gembloux, Belgium (eleonore.beckers@ulg.ac.be), (2) Laboratory of Chemical Engineering, Department of Applied Chemistry, Univ. Liège, Sart-Tilman, Belgium, (3) Soil Fertility and Water Protection Unit, Department of Agriculture and Natural Environment, Walloon Agricultural Research Centre of Gembloux (CRA-W), Gembloux, Belgium

Nowadays, tillage simplification is an increasing practice. Many advantages are cited in the literature, such as energy saving, soil conservation etc. Agricultural management practices influence soil structure, but consequent changes in soil hydrodynamic behaviour at the field scale are still not well understood. Many studies focus only on macroscopic measurements which do not provide mechanistic explanations. Moreover, research shows divergent conclusions over structure modification. The aim of this work is to fill this gap by quantifying soil structure modification depending on tillage intensity through both macroscopic and microscopic measurements, the latter improving our comprehension of the fundamental mechanisms involved.

Our experiment takes place in Gentinnes (Walloon Brabant, Belgium), on a field organized in a Latin square scheme. Since 2004, plots have been cultivated in conventional tillage (CT) or in reduced tillage (RT). The latter consists in sowing after stubble ploughing of about 10cm. The crop rotation is sugar beet followed by winter wheat. The soil is mainly composed of silt loam and can be classified as a Luvisol.

Macroscopic investigations consist in establishing pF and K(h) curves and 3D soil strength profiles. At the microscale, 3D morphologic parameters are measured using X-ray microtomography. Because of the variation of working depth between management practices (10cm for RT vs. 25cm for CT), two horizons were investigated: H1 between 0-10cm and H2 between 12-25cm. 3D soil strength profiles were established thanks to a fully automated penetrometer (30° angle cone with a base area of 10mm^2) which covered a 160 $\times$ 80cm^2 area with 5cm spacing between neighbouring points. At each node, penetration was performed and soil strength measurements were collected every 1cm from 5 to 55cm depth. K(h) curves were provided by 20cm diameter tension-infiltrometer measurements (Eijkelkamp Agrisearch Equipment). Undisturbed soil samples were removed from H1 and H2 for both management practices: 100cm^3 samples were used to establish pF curves with the Richards procedure, and 35cm^3 samples were used for X-ray microtomography investigation. Samples for microtomography were air-dried at 40°C in order to empty meso- and macroporosity and then scanned using a Skyscan-1172 high-resolution desktop micro-CT system (Skyscan, Kontich, Belgium).

Macroscopic measurements show consistent results: penetrometry profiles confirm the presence of two different horizons for RT, with a permeable superficial horizon between 0 and 10cm and a compacted subjacent horizon. Despite the long-term experiment, the old plough pan is still observed. The superficial horizon is equivalent in terms of pF curves to CT. The second horizon in RT shows significant differences with CT: porosity and especially effective porosity are greater for CT than RT. Infiltration tests confirm these reports with a higher conductivity for CT than RT. In fact, the first permeable horizon for RT is thin and the second horizon impacts vertical infiltration.
These observations will be completed with microtomograms analysis. Pore size distribution, but particularly morphological parameters like eccentricity, orientation, connectivity and anisotropy of the pore network will be quantified and connected with macroscopic measurements.