Assessing structure potential in soil and water conservation : Monitoring top soil hydrology from micro to field scale.

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Introduction

Soil structure is a key parameter which influences erosion and water transfer phenomenon. Those last decades, farmers and scientists have been working on different techniques of soil preparation. New experiences and studies tried to assess the impact of different tillage systems on soil structure. The most important ways in Belgian agriculture are conventional and conservational tillage. Conventional tillage concerns all the methods that include ploughing in the soil's preparation, generally before the seeding of the main crop. With a conservational tillage, seeds are directly put into the soil. Different properties of the soil and more precisely the topsoil can be modified by the tillage. The macro-, meso- and microporosity, the aggregates stability, the organic matter content are as many properties that are impacted by the tillage system. On the soil conservation point of view, reduced-tillage systems have the advantage to let residues on the soil's surface which protect the soil from splash effect. Conventional tillage mixes them into the topsoil and cracks on the surface can be observed (Wahl et al., 2004).

The porosity has been studied in many cases in relation with infiltration. The main studies (Wahl et al., 2004) have found that infiltration and porosity is better under no-tillage systems. Sasal et al. (2005) explained it by the vertical pores created by roots and worms which help higher infiltration rates. In conservational tillage these pores aren't destroyed by the plow's action. Reduced tillage can also diminish the engines driving through the fields, which avoid compaction and conserve the soil's infiltration capacity. However, some studies have found out that infiltration may be decreased when no tillage is applied (Sasal et al., 2005). These authors have found higher organic matter and better aggregates stability which is in contrast with lower infiltration rates. It seems therefore necessary to go further in the fine soil structure description to enhance the comprehension of its hydrological behavior under different tillage systems.

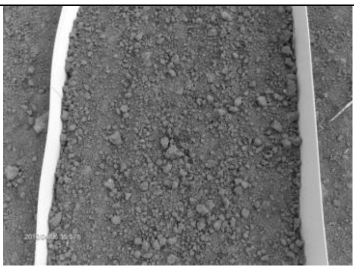
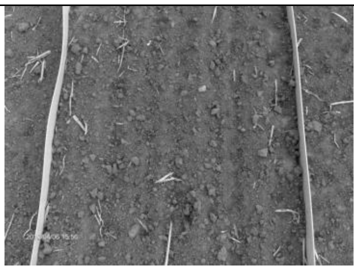
This paper describes an experiment that covers different aspects of soil structure in relation with soil and water conservation. Different scales are used to describe and understand the soil structure's potential in soil and water conservation. It also gives the first results we obtained about tillage systems in term of runoff and sediments production and in term of porosity description.

Materials and methods

A first site was devoted to the micro and meso scale study. Two tillage systems have been applied in the field since 2004: the conventional tillage and the conservational tillage. The soil is mainly composed of silt loam. Under each experimental plot a pit was installed where special gutter were put. These gutters collect lateral flows at three depths. In the same field, soils samples, with a 3 cm diameter and a 5 cm height, were removed from the upper layer for both management practices. These samples were scanned by X-ray microtomography (Beckers et al, 2010). The resolution used in this device allowed us to visualize meso- and macro-porosity. Scanning results consist in 2D images. The 2D images are recombined to form 3D structures. Then the pore network can be analyzed through useful factors like size distribution, shape, connectivity, orientation, tortuosity in relation with the sample's retention curve.

A second site was devoted to the field scale. On this site, different tillage systems were tested for sugarbeet. The field had a 5% mean slope and a loamy soil. Three preparation systems were tested: the winter ploughing after a mustard intercrop, the fall ploughing followed by a mustard intercrop, and a fall decompaction followed by a mustard intercrop. The Figure 1 shows views of the three preparations for sugar beet.

Figure 1. Views of the soil after application of the three preparation systems.

Winter ploughing	Fall ploughing	Decompaction
		

Each system was repeated three times. For each one, simulated rainfalls were applied. Downward sediment and water were collected during the simulations. The simulated rainfall was applied three times during the crop's development. It was designed to be an erosive rainfall corresponding to a 100 years return period and 30 minutes duration including a global change scenario.

Results and discussion

Site 1

The first results of the microscale investigation of soil samples show a significantly higher effective porosity in the conventional tillage system. There is a tendency showing smaller pores in conservational tillage and consequently a higher useful water reserve for crops (Figure 1). These first results were comforted by our field observations during the 2010 summer where the drought was better supported by crops in the conservational plot. The pore's shapes also shows a tendency of higher anisotropy in the conservational plot, with a more horizontally-oriented porosity (Beckers et al, 2010). Interflows collection in the gutters showed a tendency of higher horizontal flows under conservational tillage. These results are consistent but need to be confirmed by further investigation.

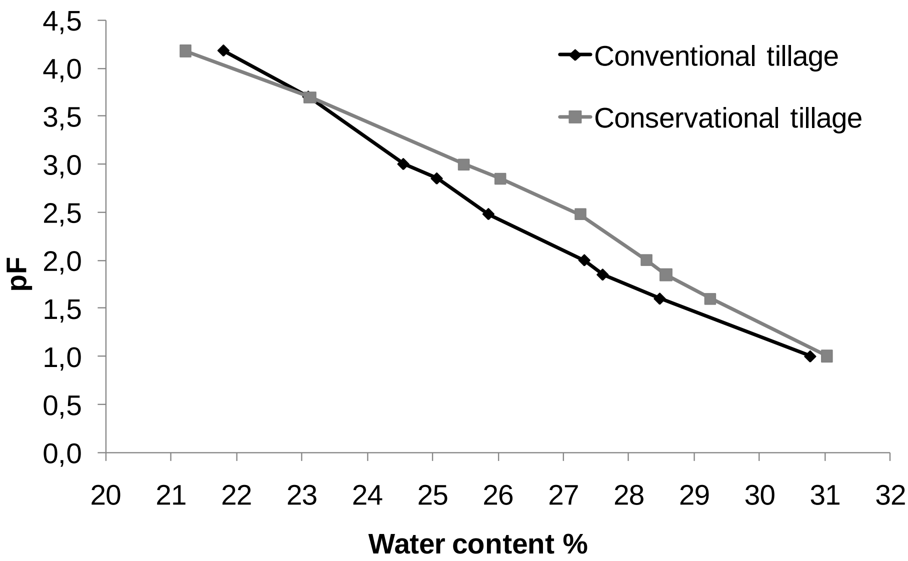


Figure 1: Soils' retention curves under conventional tillage and conservational tillage (6th year of tillage differentiation).

Site 2

In the second site, three simulations of erosive rainfall have been carried out, on June the 14th, July the 19th and August the 25th. At those dates, the crops had respectively 50-75%, 75-90% and 90-100% of cover. The results are shown in the Table 1. We can see that a lower volume of runoff is observed for the "winter ploughing" but the lowest erosion rate is achieved by the "decompaction". We can also notice a well known phenomenon: the runoff and the sediment production decrease when the crops develop a better ground cover.

Some values measured under natural rainfall for Belgium give a total amount of soil losses of about 4.5 t/ha in one season under conventional ploughing. For conservational tillage they give 1.3 t/ha of soil losses in one season of sugar beet.

Table 1. Results in term of mean erosion rate and mean runoff volume for sugar beet for the three tillage systems and the 3 dates of rainfall simulation (site 2).

Date	Erosion rate - mean [t/ha]	Runoff volume - mean [l]
14 june	0.579	41.00
19 july	0.173	21.75
25 august	0.003	1.40
Tillage system	**Erosion rate - mean [t/ha]**	**Runoff volume - mean [l]**
Winter tillage	0.277	16.13
Fall tillage	0.359	28.92
Decompaction	0.117	19.11

Conclusions

Tillage system impacts pores' size, shape and distribution. Consequently, topsoil's hydrology may be significantly modified. Both water and soil conservation deserve deeper investigations in order to enhance soils' structure potential in these matters. The oral presentation will show the last results of the field monitoring.

References

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