Le Corps professoral de

Gembloux Agro-Bio Tech - Université de Liège vous prie

de lui faire l'honneur d'assister à la défense publique de la dissertation originale que

**MADAME GAO Lili,**

**Titulaire d'un *master of soil science***

présentera en vue de l'obtention du grade et du diplôme de

**DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,**

le 26 juin 2017, à 10 heures précises (personne ne sera admis après cette heure),

en l'auditorium TOPO1 (Topographie, bât. 3),

Passage des Déportés, 2 à 5030 GEMBLOUX.

Cette dissertation originale a pour titre :

« Effects of long-term conservation tillage on soil structure and soil organic carbon dynamics in Loess Plateau of China ».

**Le jury est composé comme suit :**

Président : Prof. P. LEJEUNE, Président du Département BIOSE,
Membres : Prof. A. DEGRE (Promoteur), Prof. D. CAI (Copromoteur – CAAS, Chine), Prof. B. BODSON, Prof. J.-T. CORNELIS, Prof. A. LEONARD, Prof. X. WU (CAAS, Chine).

**Abstract**

Loess Plateau accounts for one-third of the arable land in China, which plays a vital role in agricultural production for China. However, the Loess Plateau suffered severe soil and water loss. On the basis of the degradation of soil resources in the Loess Plateau, improving the farmland management and preventing the degradation of soil resources are the urgent problems in sustainable development of the ecological environment of the Loess Plateau. The overall objective of this dissertation was to evaluate the long-term impact of conservation tillage on soil physical characteristics and soil organic carbon (SOC) characteristic as compared with conventional tillage. Two experiment stations were set up. One of the experiment stations was in China and performed four tillage systems: conventional tillage (C-CT), no tillage (C-NT), sub-soiling (C-SS) and reduced tillage (C-RT). Another station was established in Belgium and performed two tillage systems: conventional tillage (G-CT), shallow tillage (G-ST). Soil pore size distributions were measured by pressure plate extractor in bulk soil scale and by non-invasively X-ray Micro Tomography in macro-aggregates scale. SOC characteristics were evaluated using nuclear magnetic resonance ($^{13}C$ NMR).

The results showed that in the 0-10 cm and 10-20 cm depth soil layers, C-NT and C-SS treatments showed a significantly higher proportion of wet aggregates >250 µm (macroaggregates) compared to C-CT. In these two layers the proportion of wet aggregates <53 µm (microaggregates) was significantly higher in C-CT respect to C-NT and C-SS. SOC content increased as the aggregate fraction size increased, and was higher within wet aggregates >250 µm than within the 250-53 µm and <53 µm (silt + clay) fractions at both the depths. In addition, the conservation tillage (C-NT and C-SS) significantly decreased the soil bulk density and enhanced the total porosity compared with C-CT in the surface layer. Pore size distribution in C-CT soil was unimodal, with the maximum in the 10-30 µm matrix pores of the surface layer. However, in the surface layer the pore size distributions from C-NT and C-SS showed a dual porosity curve, with two peaks in the matrix and structural pores areas. The 10-20 cm layer showed similar pore size distributions in each treatment.

The results showed that aggregates in conservation tillage (G-ST and C-NT) had numerous connected pores compared with conventional tillage (G-CT and C-CT). The Euler number (Ev) was significantly lower and visible total porosity and surface area (SA) were significantly higher in conservation tillage (G-ST and C-NT) than in conventional tillage (G-CT and C-CT) in both studied locations. The predominant size of pores was significantly higher in conservation tillage (G-ST and C-NT) than in conventional tillage (G-CT and C-CT) (> 150 µm vs 90-120 µm). Pore location within the aggregates also showed differences, with porosity being evenly distributed in the aggregates under conventional tillage (G-CT and C-CT). Under conservation tillage (G-ST and C-NT), the aggregates were heterogeneous, showing higher porosity at the center of the aggregates. There was a higher SOC content in the external layer than in the internal layer in conservation tillage in Belgium (G-ST). In no tillage in China (C-NT), the SOC in the external and internal layers, however, showed similar results. Overall, convention tillage (G-CT and C-CT) reduced the proportion of the largest pores within soil aggregates, whereas there was no significant relationship between pore morphologies and SOC content.

Soil samples were physically fractionated into five fractions: free light fraction (FLF), occluded light fraction (OLF), coarse sand (c-POM), fine sand (f-POM), and mineral associated organic matter +silt +clay (m-SOM). The SOC stocks in the 0-30 cm layer were influenced by the tillage systems. Although there were no significantly differences in SOC among these four treatments in the 0-10 and 10-20 cm layers in first 10 years, after 16 years, the SOC stocks were highest in the C-SS and C-NT treatment in the 0-10 cm layer. From 2009 to 2015, with increase in time of experiment, the fractions of m-SOM-C in C-RT and C-CT were increasing. In addition, the m-SOM-C of RT and CT showed relatively higher C content in comparison with other two treatments. As determined by $^{13}C$ NMR, in light fractions, including FLF to OLF, the abundance of aromatic C increased when the abundance of O/N-alkyl C declined. A gradual increasing in the abundance of alkyl C in fine particles of heavy fractions accompanied with a decreasing in aromatic C. The FLF had a higher abundance of O-alkyl C with a lower abundance of aromatic C in C-SS and C-NT compared to C-CT and C-RT. The OLF had higher abundance of aromatic C in the C-RT and C-CT than C-NT and C-SS soils in sampling times, however, these changes were not evident in heavy fractions.

Taken all together, the results from both long-term field experiments showed that conservation tillage can help improve soil structure compared with conventional tillage. The conservation tillage resulted in improve soil physical properties and SOC content. Those results indicated that conservation tillage can contribute to sustainable agriculture in Loess Plateau.