LINKING SOIL STRUCTURE PROPERTIES UNDER CONSERVATION AGRICULTURE MANAGEMENT IN VENETO REGION SILTY SOILS

STRUTTURA DEL TERRENO IN SUOLI MEDIO LIMOSI VENETI GESTITI CON PRATICHE DI AGRICOLTURA CONSERVATIVA

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Abstract

Soil structure is one of the most important soil quality indices. Conservation agriculture (CA) has recently been introduced in the Veneto Region as a more sustainable agronomic technique. The aim of this study was to evaluate the effect of CA practices on soil pore network in the silty soils of the Veneto Region in a field experiment where CA practices (no-tillage, cover crop and residues retention) were compared to conventional intensive tillage (IT) system. Almost 100 undisturbed soil samples were collected in 2015 and subjected to porosity characterization coupling mercury intrusion porosimetry and x-ray computed microtomography. Results highlighted no differences between treatments in terms of total porosity while CA was associated with an increase of the pore vertical orientation and ultramicroporosity class. Silty soils of Veneto plain showed a slow reaction to conservation agriculture and more than a 5-yr transition period is probably required to provide a new equilibrium and in turn a better soil structure.

Keywords: conservation agriculture; pore size distribution; pore architecture; pore morphology.
Parole chiave: agricoltura conservativa; distribuzione della dimensione dei pori; architettura dei pori; morfologia dei pori.

Introduction

As in the other European countries, also in Veneto region more sustainable agronomic practices are requested and among these conservation agriculture (CA) (i.e. no-tillage, residues retention and cover-crop usage) has been subsidized during the two last rural development programs of Veneto Government (Regione Veneto, 2016, 2013) to reduce the production costs and to regulate and support several ecosystem services. Soil structure is a key tracer of the changes in soil quality and plays a key role in soil functioning. The aim of this study was to evaluate the effects of CA practices on soil porosity in terms of total porosity, pore size distribution, architecture and morphology in the silty soils of the Veneto region low plain and to compare it with conventional intensive tillage system.

Materials and Methods

A field experiment was set up in 2010 on four farms located in Veneto Region where two treatments, conservation agriculture (CA) and intensive tillage (IT), were compared. IT consisted of 35-cm mouldboard ploughing with crop residues incorporation followed by secondary tillages, while CA included sod seeding, residues retention on soil surface and use of cover crops. In 2015, after 5 years of treatments application, almost 100 undisturbed soil samples were collected from different soil layers (L1: 3-5.5 cm, L2: 12-14.5 cm, L3: 20-22.5 cm and L4: 45-47.5 cm) and analized for pore size distribution (PSD), morphology and architecture coupling mercury intrusion porosimetry ("MIP", in the 0.0074 µm - 100 µm range) (Thermo Finningan, Waltman, USA) and x-ray computed microtomography ("µCT", for pores > 26 µm) (Skyscan 1172, Bruker MicroCT, Kontich, Belgium). MIP-derived pores were then classified as cryptopores (0.0074-0.1 µm), ultramicropores (0.1-5 µm), micropores (5-30 µm), mesopores (30-75 µm) and macropores (75-100 µm) while the µCT-derived ones into five classes: 26-500 (CL1), 500-1000 (CL2), 1000-1500 (CL3), 1500-2000 (CL4) and >2000 µm (CL5). Statistics were based on mixed effect models and principal component analysis on 11 selected variables (Kaiser's measure of sampling adequacy 0.77).

Results and Discussion

No differences between treatments were observed in terms of total porosity which decreased with depth irrespectively of agronomic management (Fig. 1). On the contrary, the PSD in the MIP range (0.0074 µm - 100 µm) highlighted how CA was associated with an increase of ultramicroporosity class (0.1-5 µm) as a result of mesoporosity one (30-75 µm) contraction while no treatment effect was observed in the µCT domain.

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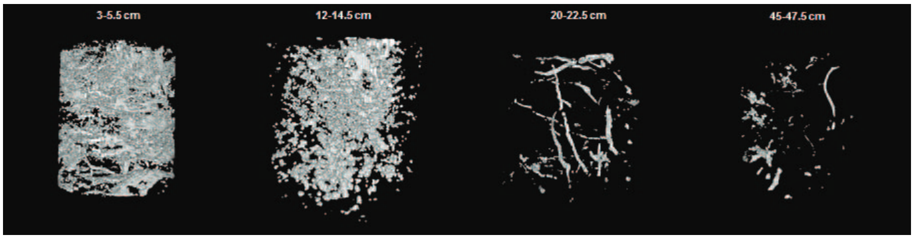

Fig. 1:Total porosity (µCT-derived) distribution in different soil layers.
Fig. 1:Distribuzione della porosità totale (da µCT) lungo il profilo del suolo.

Pore architecture and morphology were positively affected by CA treatment only in terms of pore orientation (76° vs 72°). Indeed, independently of agronomic management, the soil pore network of Veneto region silty soils was less complex and more connected with soil depth increasing (Fig. 1) as revealed by fractal dimension and connectivity density indices decreasing.

The PCA analysis extracted two principal components. The first one (PC1) was representative of the macroscale domain as related to texture- and MIP-derived parameters while the second one (PC2) was related to the macroscale domain as linked to the µCT-derived parameters. In the plain described by PC1 and PC2, PC1 divided farm 3 from the other farms because it was less related with microscale properties (Fig. 2). Inside farm 3, PC2 discriminated the two treatments with CA being less correlated with macroscale properties (Fig. 2). Finally PC1 divided the top layer from the others as more representative of macroscale soil pore characteristics (Fig. 2).

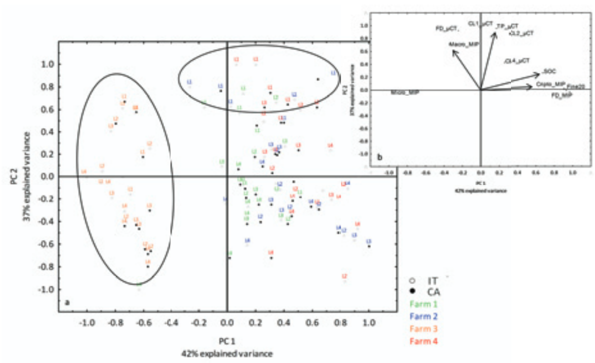

Fig. 2 Principal component analysis. 2-a represents case scores where different colour highlights different experimental farms and different labels correspond to the studied soil layers. 2-b represents factor loadings: Macro_MIP: 75-100 µm, Micro_MIP: 5-30 µm, Crypto_MIP: 0.0074-0.1 µm, FD_MIP: fractal dimension (MIP-derived), Fine20: particles < 20 µm, SOC: soil organic carbon, CL1_µCT: 26-500 µm, CL2_µCT: 500-1000 µm, CL4_µCT: 1500-2000 µm and FD_µCT: fractal dimension (µCT-derived).
Fig. 2 Analisi delle componenti principali. In 2-a vengono rappresentati i casi dove i colori sono associati a diverse aziende e le etichette agli strati studiati. In 2-b vengono riportati i fattori estratti: Macro_MIP: 75-100 µm, Micro_MIP: 5-30 µm, Crypto_MIP: 0.0074-0.1 µm, FD_MIP: dimensione frattale (da MIP), Fine20: particelle < 20 µm, SOC: carbonio organico, CL1_µCT: 26-500 µm, CL2_µCT: 500-1000 µm, CL4_µCT: 1500-2000 µm and FD_µCT: dimensione frattale (da µCT).

Conclusions

In the short term, the implementation of conservation agriculture practices was not able to easily improve soil structure but despite no remarkable differences were observed in terms of total porosity or pore size distribution, CA allowed at least the formation of a more vertical soil pore network which could be seen as the result of a higher biological activity. More than 5-yr transition period is probably required to provide a new equilibrium and in turn a better soil structure.

Acknowledgment

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