APPLICATION OF ORGANIC CARBON STATUS INDICATORS ON VINEYARD SOILS: THE CASE STUDY OF DOC PIAVE (VENETO REGION, ITALY)

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ABSTRACT

According to the Kyoto Protocol objectives, it's necessary to identify alternative carbon dioxide sinks, and vineyard soils could be a significant opportunity.

A set of soil organic carbon status indicators, proposed by JRC (Stolbovoy, 2006), was tested on vineyard soils of DOC Piave area (Veneto region) to validate it.

Information available in the regional soil database for the study area (Soil Maps of Treviso and Venice provinces at 1:50,000 scale with 614 soil profiles on about 150,000 ha, 5% of which with vineyards) was analysed to point out significant relationships between soil organic carbon content, soil type and land uses. An approach for functional soil groups was adopted: the soil typological units were grouped on the basis of texture, coarse fragments, drainage and physiography (Manni, 2007). The highest value, which differs statistically from the others, was observed in fine texture and poorly drained soils. Furthermore, vineyard soils showed higher content than crop soils, especially on the first 30 cm. But no significant differences were observed. Then, for each functional group and separately for vineyard and crop topsoil and subsoil, a set of soil organic carbon status indicators were defined. The results showed higher capacity to sequestrate carbon on vineyard topsoil.

The present study allows an overview of the DOC Piave area carbon pool and highlights priorities areas where policy interventions should be concentrated.

KEYWORD

Soil organic carbon – sequestration – vineyard – indicator – functional group.

INTRODUCTION

According to the Kyoto Protocol objectives to reduce greenhouse gases emissions, in the last years the joined countries are been elaborating footprint wine carbon calculators. In 2007, the Australian law imposed to the main wineries and winemakers to count emissions; they are asked to communicate greenhouse gases emissions, productions and energy uses. Also Italy is working on the first wine carbon calculator called Ita.Ca® and, in the next program versions, vineyard soils's role of CO_2 sequestering into organic matter will be introduced (Battaglene *et al.*, 2010). So viticulture represents a carbon sink.

In a previous study, conducted on the alluvial Veneto plain of Brenta and Piave rivers, soil organic carbon (SOC) of different land uses was considered (Manni, 2007). The OC trend of the topsoil (0-30 cm) was compared between orchard, meadow, vineyard, vegetable and corn. Vineyard soils showed a significantly higher OC content (49 t/ha).

To study vineyards' capacity to sequestrate OC, the DOC Piave area has been investigated (Fig. 1). The study area is located in Treviso and Venice provinces and is near 150,000 ha extended. The main land uses are crop and, for about 5% of the area, vineyard.

Fig. 1. DOC Piave area.

In the present study a set of Soil Organic Carbon Status Indicators (SOCSI), developed by the JRC-Ispra to support the EU policies related to SOC, are been considered to investigate OC trends in different soil types and land uses. The SOCSI are knowledge-based and can be derived from available soil data at regional scale. SOC content results from combination of Soil Typological Unit (STU) and land use/management. Each combination has specific SOC margins so SOC content change is limited. Moreover, potential for the change depends on the actual OC content.

The present study aims to test the SOCSI in the DOC Piave area and validate them against empirical observations. There is an urgency to make the SOCSI instrumental for supporting authorities to setup policy decisions regarding carbon management (Stolbovoy, 2008).

MATERIALS AND METHODS

To describe the different soil types of DOC Piave area, soil maps of Treviso and Venice provinces at 1:50,000 scale were considered (Soil Service-ARPAV Treviso, 2008); also, to distinguish between the different land uses, the covered soil map of Veneto Region at 1:10,000 scale (Regione Veneto, 2009) was used.

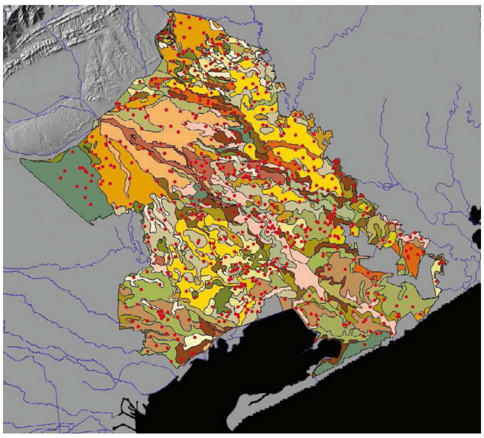

Fig. 2. Soil profiles on DOC Piave area.

The study area includes 614 soil profiles, 153 of which on vineyard (Fig. 2); each of them is geographically referred with a GIS system (ArcView 3.3®) and is been reconnected to the STUs defined for the soil maps. Soil data are been collected in a regional database managed with Access® 2003. It includes soil profiles and STUs description, soil chemical and physical analysis for each horizon. In particular, the OC value considered is been analyzed according to 14,235 ISO method. Bulk density, necessary to convert OC % into t/ha, is been measured by a soil sample ring of known dimension (100 cc) (ISO 11,272-core method) or is been estimated by pedotransfer specific for plain soils.

Through a set of query, topsoil (0-30 cm) and subsoil (0-100 cm) OC values, are been calculated by weighting each horizon's OC content. The OC trend, between different soil types and land uses, has been represented by bar charts, then significant differences are been investigated by STATISTICA 8® program (LSD test, p=0.05).

Since data for each of 70 STUs were sometimes too little to work out statistical analysis, the functional soil groups defined for the alluvial plain of Brenta and Piave rivers (Manni, 2007) were adopted. STUs were grouped into functional groups (Tab.1) on the basis of texture, coarse fragments content, drainage and physiography. But not all the groups differed significantly.

Tab. 1. Functional groups description.

FUNCTIONAL GROUP	LANDSCAPE	COARSE FRAGMENTS	DRAINAGE	TEXTURE
A1	High plain	1-15%		
A2		>15%		
B2	Low plain	<1%	excessively drained, somewhat excessively drained, well drained	Corse loamy, coarse silty
B3		<1%	excessively drained, somewhat excessively drained, well drained	Fine loamy, fine silty, clayey
B4		<1%	moderately well drained	Sandy, coarse loamy, coarse silty
B5		<1%	moderately well drained	Fine loamy, fine silty, clayey
B6		<1%	somewhat poorly drained, poorly drained, very poorly drained	Fine loamy, fine silty, clayey
O2	Soils with mollic horizon	<1%	somewhat poorly drained, poorly drained, very poorly drained	All textures

A set of SOCSI, proposed by JRC (Stolbovoy, 2006), has been applied for each functional group. The set includes:

- data-derived parameters (mean, minimum and maximum values);
- knowledge-derived parameters (CSP-Carbon Sequestration Potential, PCL-Potential Carbon Loss, CSR-Carbon Sequestration Rate, CLR-Carbon Loss Rate and capability classes for OC change).

The minimum and maximum values represent the margins of the OC range of change. Potential for the change depends on the actual OC content (Fig. 3).

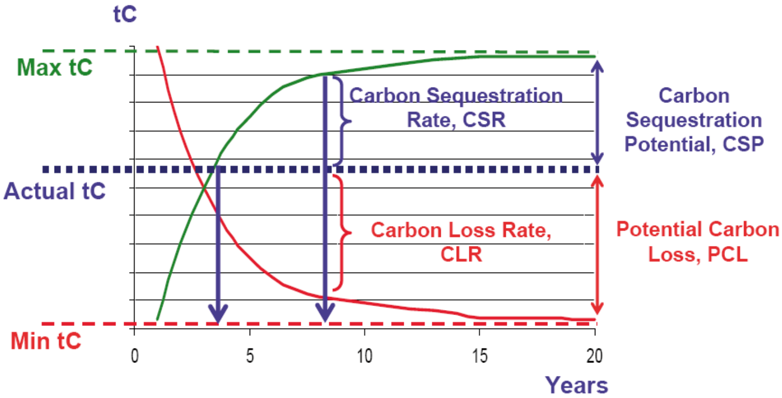

Fig. 3. OC range of change (Stolbovoy, 2006).

Following the JRC procedure, the low/medium/high capability classes of CSP and PCL were defined for each functional group:

- Low (L): < [Min + (Max – Min)/3]
- Medium (M): between [Min + (Max – Min)/3] and [Min + 2(Max – Min)/3]
- High (H): > [Min + 2(Max – Min)/3

These SOCSI could be drawn on maps (one for CSP and one for PCL) to show areas in low, medium or high PCL/CSP classes.

RESULTS AND DISCUSSION

Bar charts of functional groups' topsoil (0-30 cm) and subsoil (0-100 cm) OC content (t/ha and %) on vineyard and crop were drawn. The most significant results are on vineyard's OC (t/ha) graphics. Both the topsoil and the subsoil bar charts (Fig. 4 and 5) show a close relationship between soil properties and SOC content:

- in the high plain, soils with lower coarse fragments content (A1 than A2) have higher fine earth volume and so higher OC content;
- in the low plain (from B2 to B6), OC trend increases according to clay content and in opposition to the soil drainage (except for B2 group on topsoil): sandy soils result in more ready oxidation of organic matter compared with heavier soils because have lower moisture content and are more aerated;
- the O2 group has obviously the highest OC content, in fact soils are characterized by mollic horizon and are very poorly drained.

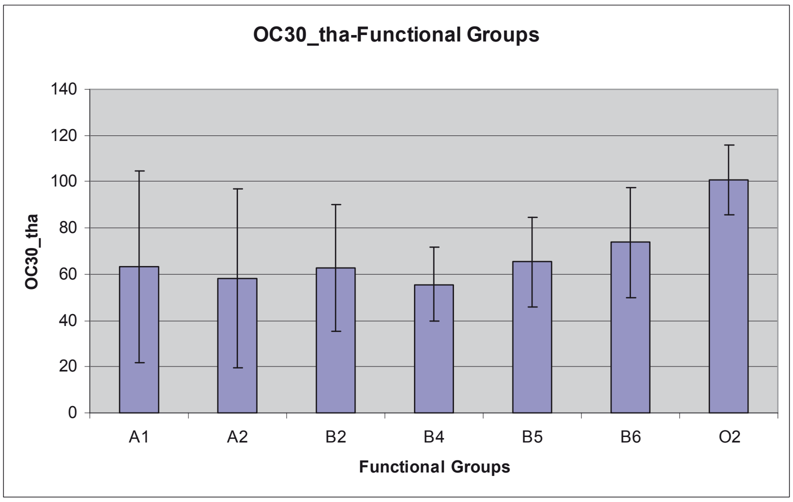

Fig. 4. Vineyard's topsoil OC content (t/ha) of the functional groups.

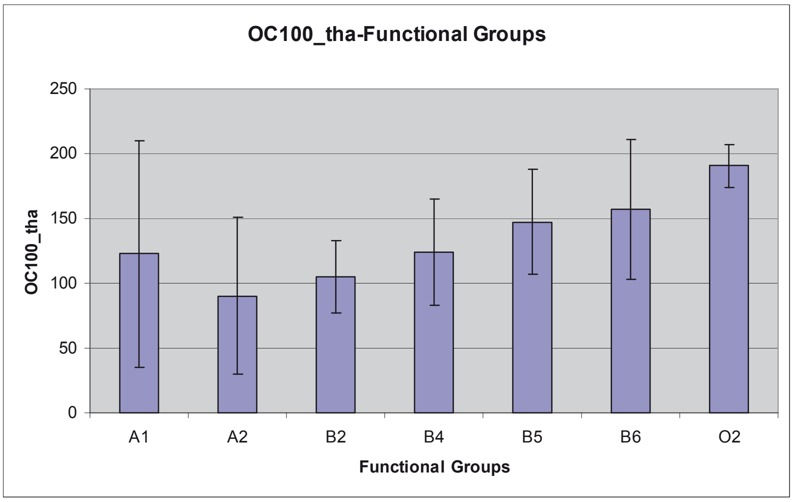

Fig. 5. Vineyard's subsoil OC content (t/ha) of the functional groups.

The only significant differences are between B4-B6 and between O2-all the other groups; if subsoil OC is considered, also A2-B5 and A2-B6 differ significantly.

Then, vineyard and crop land uses were compared. Vineyard shows higher values than crop on topsoil for all the functional groups (there are no observations for B3 group on vineyard), except for O2 group (Fig. 6). But no significant differences are observed.

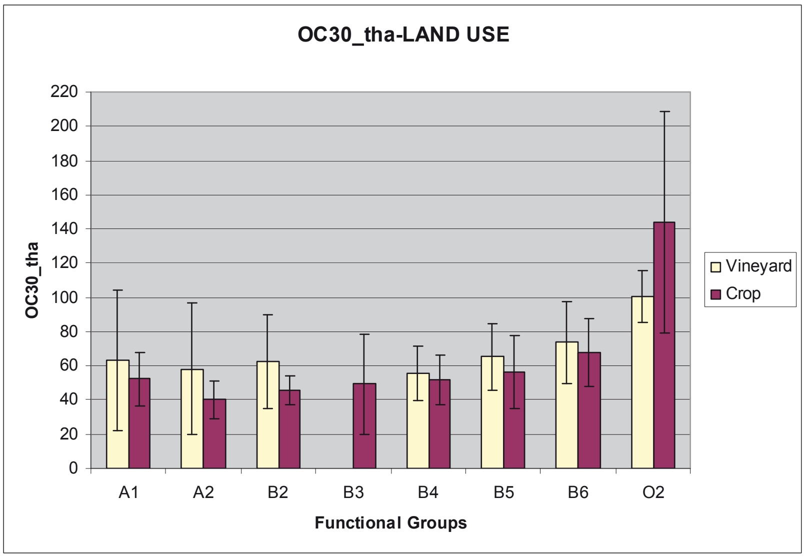

Fig. 6. Topsoil OC content (t/ha) of vineyard and crop land uses.

Topsoil OC content on vineyard is higher because of the conservative tillage adopted by the wineries included in the DOC Piave zoning. Information about vineyard's management are been collected by interviews to the about 90 wineries involved in the present study. In particular, they were asked to give information about soil manure (chemical or organic), irrigation, soil tillage, presence of grass covered soil. Almost all the wineries apply also organic manure on soil, have a reduced tillage and, at least, an inter-row grass covered soil. These agricultural practices maintain or increase soil organic matter content, especially on the first 30 cm.

The typical topsoil OC trend is, instead, lost in the subsoil OC content: only A1, A2 and B5 groups have higher content on vineyard**.**

Following a procedure proposed by the JRC (Stolbovoy, 2006), the minimum, mean and maximum OC functional groups values were found (for topsoil and subsoil, in t/ha and %), separately for vineyard and crop land uses. Then, the capability classes of PCL and CSP were calculated. The most significant results are shown by OC (%) on vineyard topsoil, where some functional groups have low potential to loss and high potential to gain carbon (L/H); subsoil, instead, has medium potentials (M/M) for all the groups. No H/L classes were found.

The groups showing major potentials of changing (with L/H classes) are A1, B2, B5 and B6 if OC(%) is considered. So, applying an appropriate vineyard's management, it's possible to increase topsoil organic matter for these functional groups.

The crop capability classes show, in opposition to vineyard classes, more possibilities to change in the subsoil than in the topsoil, so interventions to increase SOC on crops is more complicated. A conversion from crop to vineyard, instead, could allow to increase SOC pool acting on topsoil.

The capability classes founded could be drawn on maps to better highlight the priority areas where interventions on soil protection should be concentrated.

CONCLUSIONS

Since topsoil OC (t/ha) was significantly higher on vineyard than on the other main land uses of the Veneto plain (Manni, 2007), the DOC Piave area is been investigated.

Information available in the regional soil database was analysed to point out significant relationships between SOC content on different soil types and land uses (vineyard-crop).

Functional soil groups were created and bar charts of topsoil (0-30 cm) and subsoil (0-100 cm) OC content (% and t/ha) of the different functional groups were obtained, separately for vineyard and crop land uses. In the high plain, vineyard's soils with lower coarse fragments content (A1 than A2) have higher OC (t/ha) values; in the low plain (from B2 to B6), OC trend increases according to clay content and in opposition to the soil drainage (except for B2 group on topsoil); the mollic and very poorly drained soils (O2) have obviously the highest OC content. Furthermore, vineyard shows higher values than crop on topsoil for all the functional groups, except for O2 group. Topsoil OC content on vineyard is higher because of the conservative tillage adopted by the wineries involved in the present study. However, the functional groups will be created again on the basis of other factors to better highlight differences between different soil types on different land uses.

Following a procedure proposed by the JRC (Stolbovoy, 2006), a set of SOCSI were calculated. Some functional groups, on topsoil vineyard, showed low potential to loss and high potential to gain OC. So, applying an appropriate vineyard's management, it's possible to increase topsoil organic matter for these soil groups. The capability classes founded could be drawn on maps to highlight the regional areas where policy measures and interventions should be concentrated to guarantee soil protection.

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