Available online at www.sciencedirect.com
ScienceDirect
Soil & Tillage Research 92 (2007) 10–17
Soil & Tillage Research
www.elsevier.com/locate/still

Humification-mineralization pyrolytic indices and carbon fractions of soil under organic and conventional management in central Italy

S. Marinari [a,*], K. Liburdi [a], G. Masciandaro [b], B. Ceccanti [b], S. Grego [a]

[a] Dipartimento di Agrobiologia e Agrochimica, Università degli Studi della Tuscia, via S. Camillo de Lellis, 01100 Viterbo, Italy
[b] Istituto per lo Studio degli Ecosistemi-Sezione di Chimica del Suolo, CNR, 56125 Pisa, Italy

Received 18 January 2005; received in revised form 29 November 2005; accepted 23 December 2005

Abstract

The aim of this study was to evaluate chemical changes in soil organic matter (SOM) in organically and conventionally managed fields, using pyrolytic indices and the extraction of different carbon fractions. Pyrolysis-gas chromatography (Py-GC) was used to study structural changes in SOM, whereas the different soil extractions gave a fractionation of C forms. Organic management increased both humic and labile C forms (microbial biomass C and water soluble organic C). A significant positive relationship was found between the living SOM fraction, expressed as microbial biomass/total organic C ratio (MBC/TOC) and humification rate. A negative relationship was found between the pyrrole to phenol ratio (O/Y) and total extractable C (TEC).

An opposite trend has been observed for the second pyrolytic index (N/O), which represents the mineralization of fresh organic matter. Mineralization was higher in organically managed soil, probably because of consistent input of fresh material to the organic field. Carbon fraction pools and pyrolytic indices provided complementary indications of SOM quality under organic and conventional management.

Keywords: Agricultural management; Pyrolysis; Carbon fractions; Soil organic matter; Humification; Mineralization

1. Introduction

Organic farms do not use synthetic fertilisers and pesticides, striving to protect environmental quality and to enhance beneficial biological interactions and processes (Vandermer, 1995). The regular use of manure on an organic farm maintains high levels of soil organic matter (SOM) (Wu et al., 2004; Watson et al., 2002; Gerardht, 1997). Increased levels of SOM, and hence increased organic reserves of nutrients, are widely reported for organic systems (Stockdale et al., 2001; Derrick and Dumaresq, 1999). However, Shepherd et al. (2002) found small differences in SOM between organically and conventionally managed soils in UK, which were attributed to the relatively small differences between the organic matter inputs in the system studied compared with the large background pool of SOM. Mineralization is an important process that can provide mineral nutrients for plants and micro-organisms by means of biochemical oxidation of SOM. Mineralization and immobilization are soil microbial processes governed by C availability and are closely linked to active fractions of SOM (Hassink, 1994). Therefore, an active soil microflora and a considerable pool of accessible nutrients are two important priorities in organic farming (Wander et al., 1994).

Soil organic matter can be divided into two major pools based on relative susceptibility to biological

* Corresponding author. Fax: +39 0761 357242.
E-mail address: marinari@unitus.it (S. Marinari).

0167-1987/$ – see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.still.2005.12.009

decomposition: an easily metabolised pool and a more resistant pool (humic substances) (Tate, 1987). The "light fraction" of SOM, which consists of partially decomposed (i.e. non-humified) materials comprised mainly of dead materials from roots and unharvested shoots, is often found to be very labile, as described by Berry et al. (2002).

Humic substances are widely recognized as an important fraction of SOM because they have several fundamental functions: regulation of nutrient availability, linkage with mineral particles and immobilization of toxic compounds (Ceccanti and Garcia, 1994). It is also known that humic substances are complex polymeric organic compounds comprising polyphenols, proteins, active enzymes, lipids, and polysaccharides (Ceccanti et al., 1986; Tate, 1987).

Difference in composition of SOM between organically and conventionally managed soils has been demonstrated (Elmholt, 1996; Wander and Traina, 1996). Fractionation of SOM by size density separation, chemical extraction of humic substances and microbial C can be linked to organic management-induced shifts of SOM characteristics.

In addition to C fractions, which have been reported as quantitative markers of SOM (Ceccanti et al., 1994), pyrolysis-gas chromatography (Py-GC) has been proposed as a reproducible and relatively rapid technique for studying qualitative changes in the structure of SOM under different agronomic uses (Nierop et al., 2001; Masciandaro et al., 1997, 1998).

The aim of this work was to study how organic management affects SOM quality in terms of chemical structural changes and C fractions using extraction and pyrolytic techniques.

2. Materials and methods

2.1. Experimental setup and sampling

Side-by-side comparison of conventional and organic based production systems was established on "Colle Valle Agrinatura" farm, located approximately 20 km north-east of Viterbo city, in Central Italy (latitude 42°29′N and longitude 12°16′E). In 1993, the conventional farm (300 ha) was split into 230 ha of organic and 70 ha of conventional management. The selected areas for soil analyses were two adjacent fields, organically (3.5 ha) and conventionally (3.0 ha) managed, to ensure the same pedological conditions except management. Soil was a sandy clay loam (USDA) with a pH of 7.0 and 7.6 in H_2O and KCl, respectively. Cation exchange capacity (CEC) was 42 mol kg^{-1}. Beginning in 1993, and until 1999, the organic field was utilised to grow cereal and sunflower (*Helianthus annuus* L.), except for 1995 crop of clover (*Trifolium pratense* L.). The cropping system with conventional management was similar until 1997, when continuous tobacco (*Nicotiana tabacco* L.) was planted. From 2000 to 2001 both fields were under fallow. In October 2001, soil was sampled at each of six sites in both organic and conventional fields, with sampling points on a 70 m × 70 m grid. Large pieces of raw organic material were removed from the soil surface before collecting samples. Samples were collected at two different depths (5–20 and 20–35 cm). Cultural management was representative of methods employed in conventional and organic systems for this region of Italy (Table 1).

2.2. Soil analyses

Total organic carbon (TOC) was determined by dichromate oxidation (Springer and Klee, 1954). Total organic nitrogen (TON) was determined by sulphuric acid digestion using Se, $CuSO_4$ and K_2SO_4 as catalyst and regular Kjeldahl distillation method (Bremner and Mulvaney, 1982). Total extractable carbon (TEC) was extracted by shaking samples with 0.1 M NaOH + 0.1 M $Na_4P_2O_7$ (1:10, g soil:ml solution) for 48 h at 60 °C. After centrifugation (5000 rpm for 15 min), supernatant was filtered and raw fulvic (FA) and humic acids (HA) were separated by acidifying to pH 2 with H_2SO_4. Isolation, separation and purification

Table 1
Management practices employed on the conventional and organic fields

	Specific inputs and practices used	
	Conventional farming	Organic farming
Organic input	None	Animal manure (8 t ha^{-1})
Chemical input	N–P (100–80 kg ha^{-1}) Pesticide (3–6 kg ha^{-1})	None
Tillage methods	Ploughing 0.3–0.4 m deep (every year) Two disking 0.15 m deep	Ploughing 0.3–0.4 m deep (each 3 years) One disking 0.15 m deep Two hoeing