



Comparison of three methods to determine C decomposition of organic materials in soils under controlled conditions

Gonzague Alavoine, Jean-Charles Houlbert, Bernard Nicolardot*

INRA, UR 1158, Unité d'agronomie de Laon-Reims-Mons, Centre de Recherche Agronomique, 2 esplanade Roland Garros, BP 224, 51686 Reims Cedex 2, France

Received 13 December 2007; received in revised form 27 February 2008; accepted 4 March 2008

KEYWORDS

Carbon dioxide flux;
Soil respiration;
Organic matter
decomposition;
Static method;
Dynamic method;
Soil incubation

Summary

The carbon decomposition of crop residue and agro-industrial effluent was measured under controlled conditions in a highly calcareous and a loamy soil using three different methods: the dynamic cylinder method (DCM), the static cylinder method (SCM) and the static incubation method (SIM). For the latter two static methods, the CO₂ trapped by NaOH was analyzed with continuous flow colorimetry, while the accumulated CO₂ accumulated in the closed chamber of the dynamic method was measured directly with an infrared gas analyzer. CO₂ emission fluxes obtained from the three methods were in good agreement and significantly correlated for both soils. Nevertheless, for fluxes ranging from 10 to 130 μg C-CO₂m⁻²s⁻¹, SCM overestimated CO₂ emission fluxes by about 15% in comparison to DCM in highly calcareous soil. For fluxes ranging from 0.007 to 1.3 μg C-CO₂ kg⁻¹ s⁻¹, SIM slightly underestimated CO₂ fluxes from the decomposition of organic substrates. The calculated C mineralization rates of organic materials also confirmed that SIM underestimated C degradation of organic materials compared with SCM and DCM. This result was probably due to the poorer efficiency of the alkali trap. Finally, the static method appears to be inadequate for measuring CO₂ emissions in highly calcareous soils since it leads to overestimating C decomposition rates of organic materials due to equilibrium interactions between soil carbonates and bicarbonates. © 2008 Elsevier GmbH. All rights reserved.

Introduction

Inputs of exogenous organic matter in soil (e.g., crop residues, animal wastes, composts, etc.) are essential to renew or increase endogenous

* Corresponding author. Present address: ENESAD UMR 1210 INRA-ENESAD-Université de Bourgogne "Biologie et Gestion des Adventices", 26 Bd Docteur Petitjean, BP 87999, 21079 Dijon Cedex, France. Tel.: +33 3 80 77 23 48; fax: +33 3 80 77 25 51.

E-mail address: b.nicolardot@enesad.fr (B. Nicolardot).

carbon stocks. Their decomposition in soil induces CO₂ emissions, which have been used to evaluate their biodegradability. Most incubation studies have been carried out under controlled conditions using small-scale designs (e.g., glass vials, jars, pots, etc.) to evaluate the biodegradation kinetics and potentials of decomposition (Trinsoutrot et al., 2000; Parnaudeau et al., 2004; Jensen et al., 2005). This approach is often recognized as a reference and has been extensively used to obtain experimental data that are used to parameterize models simulating C and N dynamics under field conditions (Nicolardot et al., 2001; Garnier et al., 2003; Oorts et al., 2007a).

CO₂ emissions from soil can also be measured using larger designs such as open respiration chambers or cylinders that isolate a soil volume or surface. The accumulated CO₂ is measured in the atmosphere above this soil surface when the top end of the chamber is closed (Kucera and Kizkham, 1971; Cropper et al., 1985; Nay et al., 1994; Jensen et al., 1996). Two different techniques are then used to measure CO₂ emissions. The static method consists of measuring CO₂ emissions for variable integration periods using absorption in alkali (Zibilske, 1994) in solid (Edwards, 1982) or liquid form (Minderman and Vulto, 1973; Edwards, 1982). Dissolved carbonates are then determined using potentiometric titration (Edwards, 1982; Cropper et al., 1985; Sakamoto and Yoshida, 1988; Rochette et al., 1992) or segmented micro-flow analysis (Alavoine and Nicolardot, 2002). Accumulated CO₂ in the cylinder can also be determined with gas chromatography (Cleve et al., 1979; Raich et al., 1990). The dynamic method consists of closing the chamber for short periods of time; the accumulated CO₂ in the chamber is generally determined using infrared analysis (Witkamp and Frank, 1969; Kucera and Kizkham, 1971; Rochette et al., 1991; Norman et al., 1992; Nay et al., 1994; Rochette et al., 1997; Savage and Davidson, 2003). Two methods are used in this case: (i) sampled air for analysis is re-injected in the chamber after the initial analysis (Norman et al., 1992; Rochette et al., 1992, 1997) or (ii) sampled air is evacuated and replaced by fresh air with a determined CO₂ content (Kucera and Kizkham, 1971; Kanemasu et al., 1974; Cropper et al., 1985).

CO₂ fluxes are generally estimated with good precision when using the dynamic method (Cropper et al., 1985; Jensen et al., 1996). In addition, the dynamic method disturbs the soil less than the static method (Schwartzkopf, 1978). However, short measurement periods must be integrated or extrapolated to calculate CO₂ emissions over long periods of time. By contrast, the static method is a

time-integrative method that requires less infrastructure and equipment. In addition it allows the study of the decomposition of C-labelled materials and the determination of CO₂ isotopic abundance (Garnier et al., 2003).

The objectives of our study were to compare, under controlled laboratory conditions, optimized static and dynamic cylinder methods for measuring CO₂ emissions after the incorporation of organic substrates in soil and for determining C mineralization rates. These two methods were also compared to a soil incubation method using comparable experimental conditions.

Materials and methods

Soils

Comparisons between the different measurement methods were performed using two different agricultural soils: a highly calcareous rendosol (clay = 8.0%, silt = 15.8%, sand = 11.2%, CaCO₃ = 65.7%, organic C = 1.75%, organic N = 0.20%, pH = 8.4), and a loamy soil (clay = 18%, silt = 76%, sand = 6.0%, CaCO₃ = 0.8%, organic C = 0.89%, organic N = 0.10%, pH = 8.0). Soil samples were taken from the plough layer (0–28 cm), sieved (<4 mm) and kept fresh for 3 days at 4 °C until the beginning of the experiment.

Experimental treatments

In order to obtain a range of CO₂ fluxes emitted by the soils, experimental treatments for both soils included a control soil without organic additions and treatments with additions of organic matter to soil before measurements. Two organic materials were compared: (i) oilseed rape stems (dried at 80 °C and ground to 1 mm; 43.6% C and 0.8% N) incorporated in the soil at 5.18 g dry matter kg⁻¹ dry soil and (ii) liquid effluent from the potato starch industry (4.82 g C L⁻¹ and 0.4 g N L⁻¹) added at 150 mL kg⁻¹ dry soil. In the latter case the soil was air dried at room temperature (residual soil moisture = 20 g kg⁻¹ dry soil) before the addition of the effluent. For each measurement method, the soils were incubated under controlled conditions with the soil temperature at 20 ± 0.5 °C, and soil moisture brought up to and maintained at 200 ± 5 g kg⁻¹ dry soil with the addition of deionised water. Each treatment was replicated three times for the static and dynamic cylinder methods, and four times for the static incubation method.

Download English Version:

<https://daneshyari.com/en/article/2061535>

Download Persian Version:

<https://daneshyari.com/article/2061535>

[Daneshyari.com](https://daneshyari.com)