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Relationships between C respiration and fine particulate organic matter (250-50 µm) weight

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ABSTRACT

Soil organic matter (SOM) status was evaluated using the relationships between two independent soil variables, i.e., C respiration and the weight of particulate organic matter POM (4000-50 µm) under different vegetation covers and ecosystems of central Belgium. A positive relationship was found between the weight of the finest POM fraction, i.e., fine POM fraction (250-50 urn) and C respiration after 1 week (R^2 = 0.34, n = 120, p< 0.0001) and 2 weeks (R^2 = 0.28, n = 120, p < 0.0001) of incubation. Therefore, we assumed that the C respiration and the weight of fine POM might be used to evaluate the SOM status under different vegetation covers and ecosystems.

Keywords: C respiration ; Fine particulate organic matter (250-50 µm) ; Texture ; Vegetation cover

1. INTRODUCTION

Organic matter affects soil fertility, crop productivity, and terrestrial cycling of C, N and P. Particulate organic matter (POM), one of active soil organic matter (SOM) forms has been evaluated by Cambardella and Elliot [2] and Vanlauwe et al. [12] to characterize SOM status in different agricultural systems. POM might be used as early indicator of SOM status after the change of plant community composition and agricultural systems. POM fractions are significant in SOM turnover, because they may serve as a readily decomposable substrate for micro-organisms, and as a short-term nutrient reservoir for plants. POM is an increasingly popular measure of labile SOM, because it responds readily to soil management, often identifying statistically significant trends when measures of total SOM would not [13]. To specify its effects, POM might be split into fractions [12,8]. In acidic soils of Southern Cameroon, the effectiveness of leguminous fallow has been shown by an increase in N content of medium (2000-250 |xm) and fine POM (250-53 µm) [9].

Soil C respiration has been used to evaluate C biodegrad-ability, and is an appropriate method to evaluate SOM status in the natural or managed ecosystems. Koutika et al. [7] used mineralised C of whole soils and its fractions to characterize SOM under pasture soils and forest counterparts in state of Para, eastern Brazilian Amazon Basin. By studying POM status and C mineralization, Koutika et al. [10] showed that SOM dynamics change after invasion by exotic plants: Solidago *gigantea* and Prunus serotina invasions induced an enhancement of SOM dynamics (high C contents of POM fractions and high soil C mineralization). While Heracleum mantegazzia-*num* and Fallopia japonica invasions, slowed SOM dynamics (lower POM weight and C and N contents and lower C mineralization). Therefore, the aim of the present paper is to combine the two variables, i.e., C respiration and POM status to evaluate SOM status under different vegetation covers and ecosystems.

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Table 1 *- Soil texture, pH and vegetation cover of Kraainem, Gulledelle and St Ghislain (Solidago gigantea)*

Sites and index	Vegetation cover	Sand (%)	Silt (%)	Clay (%)	pH_{H_2O}	pH_{KCl}	$\Delta pH(pH_{H_2O} - pH_{KCl})$
Kraainem and Kra-silt sandy	Grassland	45.2 ± 1.71	52.3 ± 1.41	2.5 ± 0.45	6.76 ± 0.16	6.07 ± 0.21	0.69 ± 0.22
Kraainem and Kra-silt sandy	Solidago *gigantea*	43.0 ± 2.23	54.6 ± 2.11	2.4 ± 1.24	6.25 ± 0.21	5.30 ± 0.27	0.95 ± 0.11
Gulledelle and Gul-sand silty	Grassland	47.4 ± 24.5	39.7 ± 22.1	12.9 ± 3.16	6.52 ± 1.09	5.79 ± 1.30	0.73 ± 0.30
Gulledelle and Gul-sand silty	Solidago gigantea	28.4 ± 14.48	57.9 ± 12.83	13.7 ± 2.48	7.49 ± 0.39	7.10 ± 0.35	0.38 ± 0.23
St Ghislain and StG-Silty sandy	Grassland	44.0 ± 14.90	38.9 ± 10.70	17.0 ± 7.78	7.61 ± 0.22	7.20 ± 0.17	0.41 ± 0.12
St Ghislain and StG-silty sandy	Solidago gigantea	46.2 ± 7.67	39.7 ±10.70	14.1 ± 4.91	7.57 ± 0.14	7.14 ± 0.12	0.43 ± 0.07

2. MATERIALS AND METHODS

Eight sites were selected based on following criteria under different vegetation covers (grassland or forest): (i) a well established (i.e., at least 10-year-old) and still increasing population of S. *gigantea,* P. serotina, H. *mantegazzianum* and F. *Ja-ponica,* and clearly distinct from the surrounding vegetation; (ii) adjacent (i.e., few meters apart) zones of uninvaded vegetation consisting of herbaceous native species, such as Epi-*lobium* hirsutum, Holcus lanatus, *Betula pendula* and Fagus syluatica, more details on vegetation cover are given in Ref. [10]; and (iii) a soil auger investigation that suggested a relatively homogenous soil cover in the whole area (i.e., no apparent topsoil difference between invaded stands and uninvaded zones). The different sites are Kraainem, Gulledelle, Saint Ghislain, Kauwberg, Louvain-la-Neuve, Massart garden, Ganshoren and Enfants Noyés. Kraainem is located at 5 km from Brussels. Gulledelle, Kauwberg, Ganshoren, Enfants Noyés and Massart garden are located in the Brussels-Capital Region, while Saint Ghislain is located at 50 km and Louvain-la-Neuve at 25 km from Brussels. At the end of autumn 2003, soil samples were collected using a soil core sampler (4 cm diameter, 0-10 cm depth) in six 1-m^2 plots in invaded and uninvaded situations at each site. Soil sample at each place is composed of a bulk sample made of 10 independent cores in 1 m x 1 m area. Soils were air-dried, crushed and passed through a 4 mm sieve (POM) and a 2 mm sieve (other analyses). There are six replicates at each location.

Particle-size distribution was determined using the pipette method after H_2O_2 pre-treatment and Na-citrate dispersion.

SOM was fractionated into POM (4000-50 µm) fractions according to the procedure described by Cambardella and Elliot [2] and modified by Vanlauwe et al. [12] and Koutika et al. [8]. The obtained coarse POM (4000-250 µm) and fine POM (250-50 µm) were dried at 45 °C and weighted. C respiration was determined after 1, 2, 4 and 6 weeks of soil incubation. Ten grams of sieved soil at 2 mm and moistened with 2 ml of distilled water were placed in the 150 ml plastic bottle with 10 ml of NaOH, and introduced in the small bottle. The CO_2 of the small bottle was captured by titration of C in the NaOH with 0.1 M H_2SO_4 on the Radiometer TIM 900 Titration Manager pH meter using an ABU 901 Autoburette Radiometer. Statistical analyses were made using Stastitica.

Table 2 *- Soil texture, pH and vegetation cover of Kauwberg and Louvain-la-Neuve (Prunus serotina)*

Sites and index	Vegetation cover	Sand (%)	Silt (%)	Clay (%)	pH_{H_2O}	PH_{KCl}	$\Delta pH(pH_{H_2O} - pH_{KC}$
Kauwberg and Kau-silty sandy	Grassland	14.6 ± 3.60	79.8 ± 3.31	5.6 ± 1.18	5.10 ± 0.17	3.97 ± 0.10	1.13 ± 0.08
Kauwberg and Kau-silty sandy	*Prunus serotina*	16.7 ± 2.97	71.8 ± 5.61	11.5 ± 5.27	5.38 ± 0.30	4.32 ± 0.33	1.05 ± 0.07
Louvain-la-Neuve and LLN-sandy	Forest	81.7 ± 4.47	12.4 ± 5.41	5.9 ± 1.20	3.96 ± 0.04	3.05 ± 0.12	0.90 ± 0.13
Louvain-la-Neuve and LLN-sandy	*Prunus* in hetero forest	85.6 ± 1.58	12.3 ± 1.85	2.1 ± 0.56	3.90 ± 0.04	2.85 ± 0.06	1.05 ± 0.07
Louvain-la-Neuve and LLN-sandy	*Prunus* in Pinus forest	86.6 ± 1.57	9.6 ± 4.32	3.8 ± 3.34	4.00 ± 0.07	2.95 ± 0.03	1.04 ± 0.05

3. RESULT AND DISCUSSION

Soils are of different textures from sandy to clay silty (Tables 1-4). C respiration was positively correlated to pH_{H_2O} after 1 week ($R^2 = 0.39$, $n = 120$, $p < 0.0001$), 2 weeks ($R^2 = 0.40$, $n = 120$, $p < 0.0001$), and 4 weeks ($R^2 = 0.25$, $n = 120$, $p < 0.0001$) and to pH_{KCl} after 1 week ($R^2 = 0.39$, $n = 120$, $p < 0.0001$), 2 weeks ($R^2 = 0.42$, $n = 120$, $p < 0.0001$), and 4 weeks ($R^2 = 0.26$, $n = 120$, $p < 0.0001$). The weight of coarse POM (4000-250 µm) was negatively correlated to pH_{H_2O} and pH_{KCl} while a positive correlation was found between coarse POM and $\Delta pH(pH_{H_2O} - pH_{KCl})$. The weight of fine POM was positively correlated to pH_{H_2O} and pH_{KCl} and the contrary was found for ΔpH. There are positive correlations between C respiration after 1 and 2 weeks of incubation and the weight of fine POM (Fig. 1). These results show that C respiration is strongly related to the weight of fine POM, and mainly fine POM contributed most to C respiration during the incubation of sieved soil (<2 mm) in the laboratory. C dynamics or SOM status are often overlooked in favour of long-term changes because analytical techniques used to examine changes in soil C or SOM status are often insensitive to detecting small changes [1,11]. For other purposes, the task of evaluating the contribution of different inputs in SOM status has been pursued effectively through isotopic approaches, which permit the separation of various sources of C [3-6]. In the present case, natural process of SOM fractionation was not estimated by techniques used to analyse long-term changes or by isotopic analyses, but by combining the weight of POM with C respiration.

It is appears that during the natural process of SOM fractionation, coarse POM (4000-250 µm) which constituted the primary material of SOM, fractionates into a small fraction, i.e., fine POM (250-50 µm). The latter fractionates into the smaller fractions afterwards. The last step seems to be enhanced during the C respiration in the laboratory, as shown by the positive correlation between the fine POM weight and C respiration. The relationship between the two variables indicates a further natural pathway of coarse SOM fractionation into a smaller fraction linked with mineral fraction <50 µm. Therefore, the weight of fine POM (250-50 µm) combined with C respiration may be a successful tool in SOM status evaluation under different vegetation covers and ecosystems.

Therefore, the correlation of POM status, mainly the weight of fine POM (250-50 µm) and C respiration, showed that fine POM contributed most to C respiration during the two first weeks of incubation of sieved soil (<2 mm) in the laboratory. Therefore, the present paper shows that the combination of the two variables simply obtained, i.e., C respiration and POM status, is of some importance when evaluating SOM status under different vegetation covers and ecosystems.

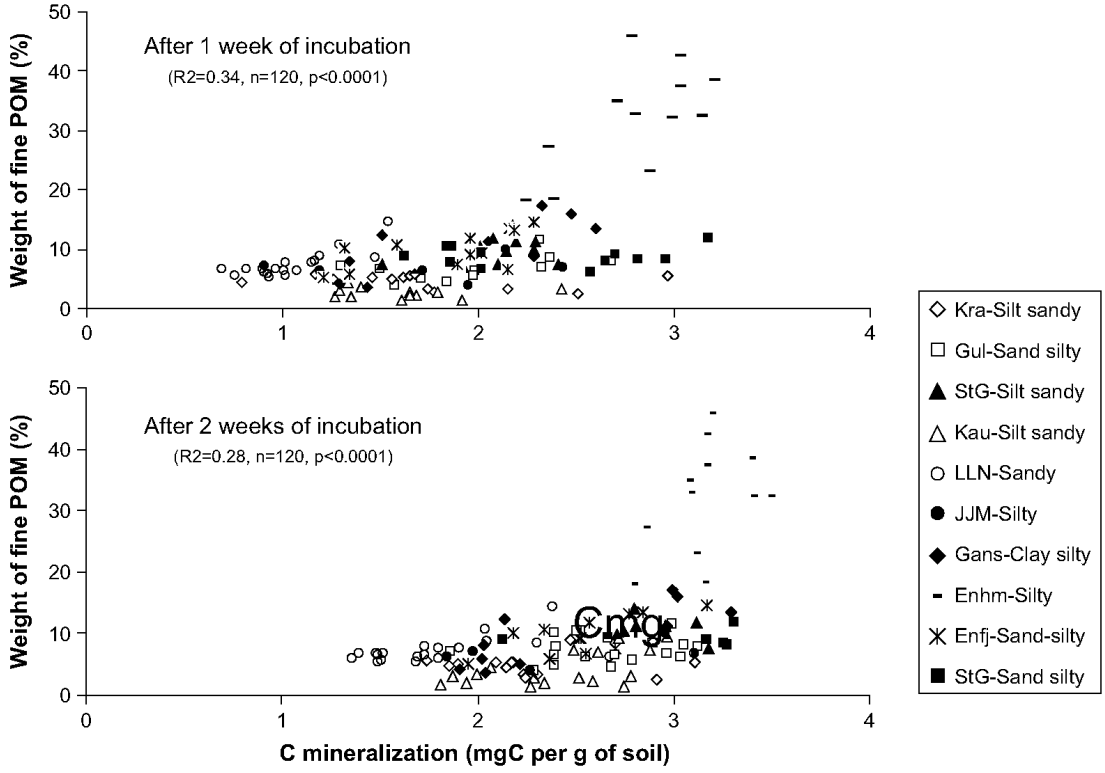
Table 3 *- Soil texture, pH and vegetation cover of Massart garden, Ganshoren and Enfants Noyés (Heracleum mantegazzianum)*

Sites and index	Vegetation cover	Sand (%)	Silt (%)	Clay (%)	pH_{H_2O}	pH_{KCl}	$\Delta pH(pH_{H_2O} - pH$
Massart garden and JJM-silty	Forest	10.3 ± 0.57	76.0 ± 1.02	13.7 ± 0.78	5.40 ± 0.11	4.48 ± 0.20	0.92 ± 0.15
Ganshoren and Gans-clay silty	Grassland	8.8 ± 2.05	64.3 ± 6.81	26.9 ± 7.61	7.82 ± 0.15	7.23 ± 0.04	0.59 ± 0.13
Ganshoren and Gans-clay silty	*Heracleum mantegazzianum*	30.7 ± 12.24	51.9 ± 7.98	17.4 ± 4.76	7.92 ± 0.30	7.36 ± 0.23	0.55 ± 0.08
Enfants Noyés and ENhm-silty	Forest	9.3 ± 2.56	73.6 ± 5.85	17.1 ± 6.11	7.39 ± 0.18	7.01 ± 0.13	0.38 ± 0.09
Enfants Noyés and ENhm-silty	Heracleum *mantegazzianum*	13.4 ± 5.92	66.3 ± 5.98	20.3 ± 2.40	7.70 ± 0.12	7.10 ± 0.04	0.60 ± 0.08

Table 4 *- Soil texture, pH and vegetation cover of Enfants Noyés and St Ghislain (Fallopia japonka)*

Sites and index	Vegetation cover	Sand (%)	Silt (%)	Clay (%)	pH_{H_2O}	pH_{KCl}	$\Delta pH(pH_{H_2O} - pH_{KCl})$
Enfants Noyés and ENfj-sand silty	Forest	49.7 ± 14.40	32.6 ±10.37	17.7 ±6.15	7.79 ±0.07	7.32 ±0.07	0.48 ± 0.07
Enfants Noyés and ENfj-sand silty	Fallopia *japonica*	50.1 ±16.61	35.3 ±11.91	14.6 ±4.89	7.39 ±0.44	6.99 ± 0.47	0.40 ± 0.08
St Ghislain and StG-Sand silty	Grassland	42.3 ±4.05	36.6 ±2.62	21.1 ±2.52	8.00 ±0.14	7.37 ±0.04	0.63 ±0.11
St Ghislain and StG-Sand silty	Fallopia *japonica*	47.5 ±4.59	32.8 ±4.71	19.7 ±4.70	7.94 ±0.12	7.37 ±0.03	0.57 ±0.11

Fig. 1 *- Correlation between C respiration and the weight of fine POM (250-50 µm) after 1 and 2 weeks of incubation.*



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