Comparative study of soil respiration in soil samples from pine and holm oak ecosystems

Fernández-Getino A., Guerrero F., Gascó J.

in

Zdruli P. (ed.), Steduto P. (ed.), Kapur S. (ed.).
7. International meeting on Soils with Mediterranean Type of Climate (selected papers)

Bari : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 50

2002
pages 121-125

Fernández-Getino A., Guerrero F., Gascó J. **Comparative study of soil respiration in soil samples from pine and holm oak ecosystems.** In : Zdruli P. (ed.), Steduto P. (ed.), Kapur S. (ed.). *7. International meeting on Soils with Mediterranean Type of Climate (selected papers).* Bari : CIHEAM, 2002. p. 121-125 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 50)

COMPARATIVE STUDY OF SOIL RESPIRATION IN SOIL SAMPLES FROM PINE AND HOLM OAK ECOSYSTEMS

ANA-PATRICIA FERNÁNDEZ-GETINO, FRANCISCA GUERRERO, AND JOSÉ-MARÍA GASCÓ

Dpto. de Edafología. E.T.S.I.Agrónomos
Universidad Politécnica de Madrid. Ciudad Universitaria,28040 Madrid,Spain
Tel:+34-91-3365692, Fax:+34-91-3365680, E-mail: fguer@eda.etsia.upm.es

Introduction

The evolution of forest soil is related to the environmental conditions and the nature of the vegetation as source of the soil organic matter. The aim of this study is to study the soil organic matter mineralization of a holm oak (*Quercus ilex* sp. *Rotundifolia)* soil with *mesic-xeric* pedoclimate and a pine (*Pinus pinea*) soil with *cryic-udic* pedoclimate, in an incubation experiment at controlled temperature and soil moisture.

Materials and Methods

The soil samples were taken from the A_0 epipedon of both the pine and the holm oak soils, placed in the mountain area of Guadarrama, in Madrid (Spain). To simulate aerobic condition we used the Guckert's et al. device (1968), adapted by Polo et al. (1982). Air-dried and sieved through a 2 mm, soil samples (35 g) by quadruplicate were placed into 500 ml vessels.

Three vessels without soil were used as blanks. Soil samples moisturized at 2/3 of the field capacity were placed into a thermostatic bath at 282 ºC. CO_2- and NH_3-free air was used to drag the evolving CO_2. The evolving CO_2 was collected in 50 ml of 1M NaOH. Carbonates were precipitated with $BaCl_2$, and each day the trapped CO_2 was titrated with 1M HCl.

Electric conductivity (EC) and pH were determined in soil/H_2O 1:2.5 (w/w) extract. Total organic carbon (TOC) was measured by dry combustion at 540 ºC (Nelson and Sommers 1996) and nitrogen (N) by Kjeldahl digestion (Bremmer 1996). Total humic substances (THS) were extracted with a mixture of 1M $Na_4P_2O_5$ and 0.1M NaOH, centrifuged at 3.000 rpm and filtered using Whatman No. 42 filters (Swift 1996).

An aliquot of this extract was acidified to pH 1 with concentrated H_2SO_4, centrifuged to separate humic acids (HA), and the coagulated HA was re-dissolved with 0.1M NaOH. THS, HA and total oxidable C were determined by the Walkley-Black method, after they were dried in a thermostatic bath at 60 ºC. Extractable bases and cation exchange capacity (CEC) were determined using the ammonium acetate (pH 7) method (Sumner and Miller 1996). Results, analysed by quintuplicate, were referred to dried matter at 105 ºC.

According to USDA Soil Taxonomy (1998) the pine soil was classified *Humic Lithic Dystrocryept* and the holm oak soil *Humic Lithic Dystroxerept*. The differences in soil characteristics were mainly due to the topoclimatic effect, related to the altitude.

The *Humic Lithic Dystrocryept* under pine of *Pinus sylvestris* had more content of soil organic matter and also oxidable carbon, with a similar distribution in the profile (Table 1 and 2). Base saturation percentage (BS %) was also bigger in the pine soil. The N content and the % of THS and HA were lower in pine soil than in holm oak soil, and only THS and HA contents in the surface horizon were higher in pine soil. The ratio HA/FA showed that the polimerization level of humic substances (9.1; 0.9; 1.3; 1.0; 1.1; from O_l to B_w-C respectively) was higher in the surface horizon for holm oak soil than in deep horizons.

Table 1. Physicochemical characteristics of pine soil

Soil horizon	pH	% TOC	% C oxidable	% C THS	% C HA	% N	% Base saturation
O_l	5.6±0.2	20.3±2.7	5.0±1.2	1.6±0.5	1.4±0.2	0.40±0.03	40.8±3.5
A_0	5.9±0.2	11.9±2.2	3.8±0.5	1.3±0.5	1.0±0.1	0.28±0.01	46.3±2.1
A_1	5.7±0.2	5.9±0.7	2.8±0.9	0.7±0.3	0.4±0.1	0.14±0.01	40.2±2.6
A_2	5.3±0.1	2.7±0.1	1.3±0.2	0.3±0.1	0.2±0.1	0.06±0.01	29.4±4.5
B_w	5.3±0.2	3.1±0.1	1.1±0.1	0.1±0.1	0.1±0.1	0.01±0.01	21.2±1.1

Table 2. Physicochemical characteristics of holm oak soil

Soil horizon	pH	% TOC	% C oxidable	% C THS	% C HA	% N	% Base saturation
O_l	5.5±0.1	14.8±2.7	4.6±0.3	1.4±0.1	1.3±0.1	0.53±0.01	40.6±1.8
A_0	5.8±0.1	12.3±0.7	4.3±0.4	2.5±0.1	1.2±0.1	0.49±0.02	41.7±1.6
A_1	5.4±0.1	4.3±0.2	2.8±0.2	1.0±0.1	0.6±0.1	0.18±0.01	22.1±0.8
A_2-B_w	4.9±0.1	2.7±0.1	1.2±0.1	0.5±0.1	0.3±0.1	0.08±0.01	4.9±1.4
B_w-C	4.9±0.1	2.6±0.1	1.0±0.1	0.4±0.1	0.2±0.1	0.06±0.01	6.4±0.7

Results and Discussions

The soil characteristics (Table 3) affected the soil organic matter mineralization as it was shown by the evolving CO_2 (Fig. 1). The ratio C/N is larger in the soil under pine (42.36) than in the soil under holm oak (25.04).

Table 3. Physicochemical characteristics of the studied soils

Sample	pH	EC (s/cm)	% TOC	% N	C/N	%C THS	%C HA	%C FA	HA/FA
Pine	5.9	114.6	11.86	0.28	42.36	1.30	1.02	0.28	3.64
Holm Oak	5.8	165.9	12.27	0.49	25.04	2.47	1.20	1.27	0.94

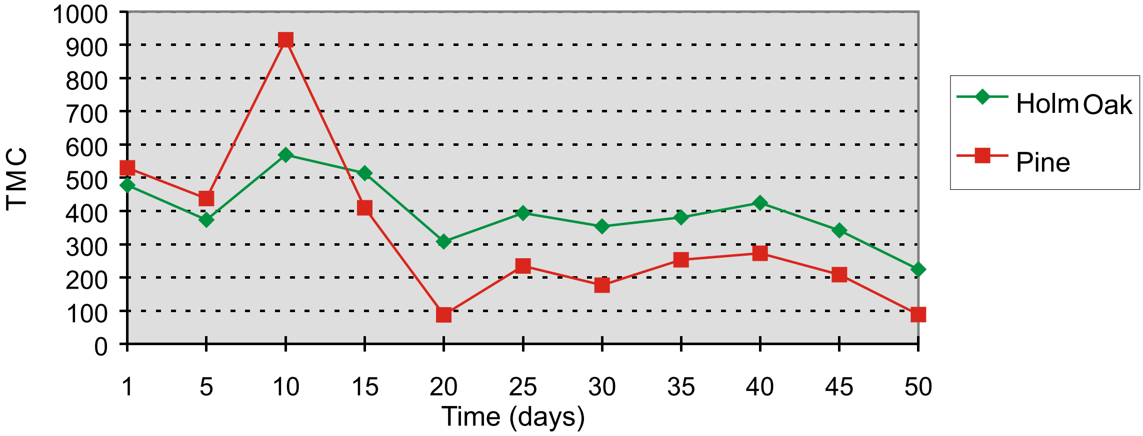

Figure 1. Total mineralisation coefficient

The total mineralisation coefficient (TMC) defines the C-CO_2 evolved each day (Cx) in relation to the oxidable total carbon (Ct), TMC = $(Cx/Ct)*10^5$. This rate shows that the mineralization of the incubated samples has different stages; first intense, an intermediate slower and less intense, and the last is almost constant, very slow and little intense until the conclusion of the experience.

The regression coefficinet of the linear relation $\log_{10}(C)$-t was r=0.99 for the holm oak soil and r=0.98 for the pine soil (CL= 99%), so the cumulative mineralization adjusted to the power model: $C = k * t^m$, where C is the total C-CO_2 evolved per 100 g of sample, t is the time in days, and k and m are constants which depend on the environmental conditions and the nature of the organic matter (Hernández-Apaolaza et al., 2000). The value of m was higher for the holm oak soil than for the pine soil, but both were less than one. In the holm oak soil it is bigger than in the pine soil, what agrees with the maximum values of the total mineralisation coefficient.

Figure 2 represents the cumulative mineralisation as a function of time, and shows higher mineralisation in the holm oak soil than in the pine soil.

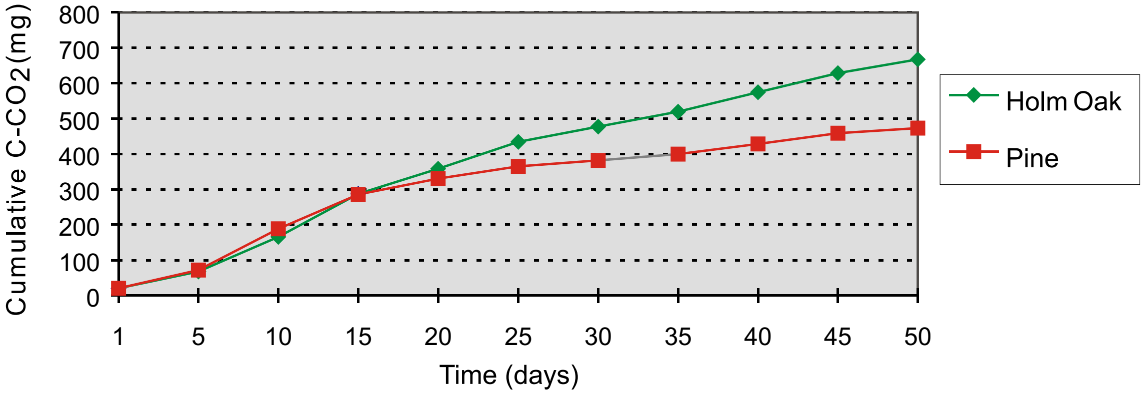

Figure 2. Cumulative amount of mineralized C

The mineralisation in the holm oak soil is bigger than in the pine soil, what is related to the existence of a smaller ratio C/N in the holm oak soil. The ratio pH Ol-A/pH BwC was bigger in the holm oak soil than in the pine soil. This concurs with the character of this soil. Although both soils were clasiffied within *dystric* subgroup, the behaviour of them with increasing depth was very different. This was related mainly to the soil organic matter evolution.

Conclusion

Total mineralisation coefficient and mineralised C showed that the microorganisms' activity in the pine soil at the begining of the incubation experiment was more intense than in the holm oak soil. This was related to the humification index defined by C/N ratio.

After aproximately two weeks, the microorganisms' activity was more intense in the holm oak soil, due to the adaptation of the microbial population that it was related to the base saturation ratio (BS A_0 horizon/BS B_w horizon) of the soil horizons with respect to the B_w horizon. It was 6.52 for the holm oak soil and 2.18 for the pine soil.

References

Bremmer JM (1996) Nitrogen-Total. In: Bigham JM (ed) Methods of soil analysis, part 3. Chemical Methods, (SSSA Book series: 5) ASA, Madison,WI, pp 1085-1121

Gascó JM, Fernández-Getino AP, Guerrero F (2001) Comparison between the soil organic matter from two forest soils (Pine soil and Holm oak soil) from the mountain area of Guadarrama, Madrid. I World Congress on Conservation Agriculture, Spain

Gilmour JT, Clark MD, Sigua GC (1985) Estimating net nitrogen mineralization from carbon dioxide evolution. Soil Sci Soc Am J 49:1398-1402

Guckert A, Roger P, Jacquin F (1968) Contribution à l'utilisation des techniques radioisotopiques pour l'etude de la matière organique du sol. Bull. ENSA, Nancy 10:69-100

Hernández-Apaolaza L, Gascó JM, Guerrero F (2000) Initial organic matter transformation of soil with composted sewage sludge. Biol Fertil Soils 32:421-426

Nelson DW, Sommers LE (1996) Total carbon, organic carbon and organic matter. In: Bigham JM, pp 961-1010

Polo A, Almendros G, Dorado E (1982) Dispositivo de incubación para el estudio de la mineralización de la materia orgánica del suelo. An. Edaf. Agrobiol. 42:1335-1340

Soil Taxonomy. NRCS-USDA (1998) Keys to Soil Taxonomy. USDA-Natural Resources Conservation Service. 8th Ed.

Stanford G, Smith SJ (1972) Nitrogen mineralization potentials of soils. Soil Sci Soc Am Pro 36:465-472

Sumner ME, Miller WP (1996) Cation Exchange Capacity and Exchange Coefficients. In: Bigham JM, pp 1201-1230

Swift RS (1996) Organic matter characterisation. In: Bigham JM, pp 1011-1069