BIOCHEMICAL CHARACTERISATION OF MINIMALLY DISTURBED SOILS UNDER MEDITERRANEAN CONDITIONS

UNIVERSITAT POLITÈCNICA DE CATALUNYA

Patricia Jiménez [1](*), Graciela Marando[1], Ramon Josa[1], Maria Julià[1], Marta Ginovart[2], Manuel Bonmatí[1]

1 *Departament d'Enginyeria Agroalimentària i Biotecnologia (DEAB), Escola Superior d'Agricultura de Barcelona (ESAB), Universitat Politècnica de Catalunya (UPC),*
2 Departament de Matemàtica Aplicada III, Escola Superior d'Agricultura de Barcelona (ESAB), Universitat Politècnica de Catalunya (UPC),

II International Meeting of Soil Enzymology (SGSE'08) Burgos, 11-12th December 2008

Introduction

Soil quality indexes are developed to describe native soils or to reflect any soil disturbance such as agricultural management, degradation or contamination. In Spain many recent publications provide knowledge about the usefulness and limitations of biological quality indexes in soils under diverse geographic conditions (Trasar-Cepeda et al., 2008; Gil-Sotres et al., 2005; Bastida et al., 2008; Zornoza et al., 2008). Some of these authors suggest the use of native soils as a reference for the highest soil quality because these soils represent a natural ecosystem that has reached equilibrium among key soil properties. In this work, we characterised ten native soils with the aim of providing information about the biochemical properties of minimally anthropogenic disturbed soils of Catalonia (NE Spain) and to study the behaviour of these parameters when describing the differences between soil type and location. Our results are part of a project of the Spanish Group of Soil Enzymology (SGSE), which seeks to elaborate a database of biochemical properties of soils with different geographic conditions in Spain by using analytical methods standardized by the group (Garcia et al., 2003).

Material and Methods Superficial layer samples of ten soils were collected in spring 2006 from different zones including a wide range of plant cover, climatic conditions and lithologic characteristics. An overview of the sites, land uses employed in each site and soils characteristics are given in Table1 and Figure 1. Soil organic carbon (SOC) was determined by Walkley-Black procedure (Nelson and Sommers, 1982). Content of total carbohydrates (TCH) was determined as reported by Cheshire and Mundie (1966) and extractable (soluble in 0.5 M K_2SO_4) carbohydrates (ECH) by Badalucco et al. (1992). Microbial biomass carbon (MBC) was determined by the fumigation-extraction method (Vance et al., 1987) and basal respiration (BR) as the CO_2 produced during 7 days of incubation at 28º C, as reported by Hernández and García (García et al., 2003) . For the determination of enzyme activities, β-D-glucosidase (GLU) and β-D-galactosidase (GAL) , Urease activity (UR) and BAA(α-benzoyl-N-argininamide)-protease activity (BAAP) we used analytical methods that had been previously standardized by the SGSE group (Garcia et al., 2003).

Table 1 Sites and soils characteristics

Soil	Location	Parent Rock	Soil type‡	Habitat type	Soil use type	Texture	pH (1:2.5)	E.C (1:5)	$CaCO_3$ %
LT	Litoral	Granodiorite	Cambisol	MF Qi	f	LSa	6.95	0.064	-
CR	Corredor	Limestone	Ranker	MF Qs	f	L	6.45	0.129	-
MN	Montnegre	Granodiorite	Ranker	MF Qs	f	SaL	6.45	0.092	-
VC	Vic	Marls	Cambisol	AG	dg	L	8.50	0.163	37
OR	Ordal	Limestone	Luvisol	MF Pf	f	C	8.00	0.191	-
IG	Igualada	Marls	Cambisol	DG	ab	CL	8.50	0.159	64
PN	Panadella	Limestone	Xerosol	MF Qi	f	SaCL	7.80	0.243	-
BL	Balaguer	Gypseous marls	Xerosol	RGa	dg	SaL	8.15	2.000	12
LG	La Granja	Marls	Cambisol	SS	s	CL	8.40	1.377	35
SG	Segre	Alluvial deposits	Fluvisol	RP	f	SaL	8.65	0.121	33

2006 average air temperature; **2006 average precipitation; ‡FAO – Unesco, 1974. MF: Mediterranean forests; Qi: Catalo-provençal lowland holm-oak woodlands; Qs: Catalan cork-oak woodlands; AG: Aphyllanthes grasslands; Pf: Iberian aleppo pine forests; SS: Sparto steppes; RP: Riparian poplar galleries; DG: Dry calcareous grasslands; RGa: Rosemary garrigues. f: Forests; dg : dry grasslands; ab: abandoned lands; s: steppe.
Sa: Sand; L: Loam; C: Clay; EC: Electrical conductivity at 25ºC in $dS.m^{-1}$

Figure 1. Location of the different zones chosen for soil sampling

I. MICROBIAL AND BIOCHEMICAL CHARACTERISATION OF SOILS

Results of one-factor ANOVA (soil location) for the studied parameters. ***Significant at $p < 0.001$. Means within a row followed by the same lower case letter are not significantly different at $p = 0.05$ SNK.

Parameter*	F value	Soil location									
		LT	CR	MN	VC	OR	IG	PN	BL	LG	SG
SOC	3835***	3.07f	6.20d	7.23c	4.15e	7.81b	2.31g	10.74a	1.21i	0.85j	1.82h
ECH	2685***	0.22f	0.57c	0.69b	0.25e	0.48d	0.27e	1.50a	0.17g	0.11h	0.16g
TCH	1688***	4.13e	8.60c	11.87b	5.19d	11.64b	3.33f	23.00a	1.81h	0.99i	2.51g
ECH/TCH	57***	0.05ef	0.07d	0.06de	0.05fg	0.04g	0.08c	0.07d	0.09b	0.11a	0.06de
GLU	717***	1.34f	2.37c	2.84b	1.89d	1.73e	1.15g	3.83a	0.53h	0.39i	1.06g
GAL	473***	0.33d	0.89b	0.98a	0.24e	0.16f	0.16f	0.56c	0.05g	0.03g	0.12f
UR	888***	1.96e	5.20b	6.21a	2.18d	1.63f	2.07de	3.72c	1.16g	0.71h	0.80h
BAAP	601***	3.52b	5.46a	5.52a	2.25c	0.82e	1.64d	5.64a	0.83e	0.45f	0.90e
MBC	78***	439e	946c	1344b	802cd	592de	741cd	2170a	415e	338e	343e
BR	204***	27.0de	67.8a	62.5b	29.7d	31.7d	52.9c	23.5e	26.5de	13.9f	30.2d
qCO_2	13***	2.6bc	3.0ab	1.9bc	1.5c	2.3bc	3.1ab	0.5d	2.7b	1.9bc	3.8a

*Units: SOC: Soil Organic C in % , ECH: Extractable carbohydrates in mg glucose g^{-1} dry soil , TCH: Total carbohydrates in mg glucose g^{-1} dry soil, GLU: β-D-glucosidase in µmol pNP g^{-1} dry soil h^{-1} , GAL: β-D-galactosidase in µmol pNP g^{-1} dry soil h^{-1},UR: urease in µmols NH_3 g^{-1} dry soil h-1, BAAP: BAA-protease in µmols NH_3 g^{-1} dry soil h^{-1}, MBC: microbial bioamass C in mg kg^{-1} dry soil, BR: basal respiration in mg C-CO_2 kg^{-1} dry soil h^{-1} , qCO_2: microbial metabolic quocient.

VALUE RANGE

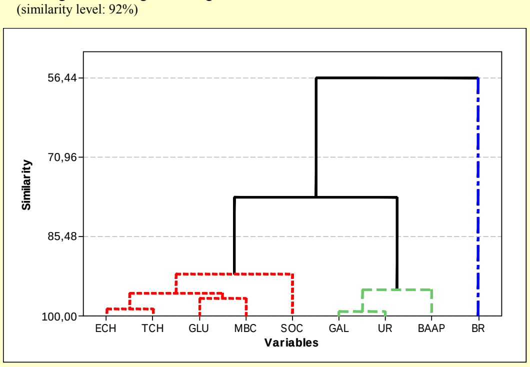
- Six of the nine measured variables differed about 10-fold between lowest and highest values, while BR showed the lowest range (5-fold) and TCH and β-galactosidase activity the highest range (25-fold and 35-fold respectively).

F VALUE

- All the parameters were significantly ($p<0.001$) influenced by soil location
- SOC, ECH and TCH had the highest variability, while BR and MBC had the lowest variability

II. CLUSTER ANALYSIS OF VARIABLES

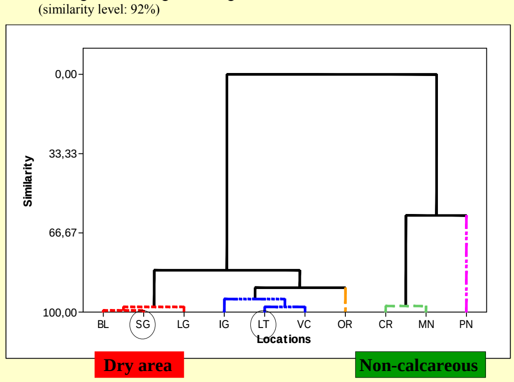
Dendogram showing clustering of variables
(similarity level: 92%)



ECH: Extractable carbohydrates, TCH: Total carbohydrates, GLU: β-D-glucosidase, MBC: C-Biomass SOC: Soil Organic C ,GAL: β-D-galactosidase , UR: urease BAAP: BAA-protease , BR: Basal respiration .

III. CLUSTER ANALYSIS OF OBSERVATIONS

Dendogram showing clustering of soil locations
(similarity level: 92%)



CLUSTER ANALYSIS

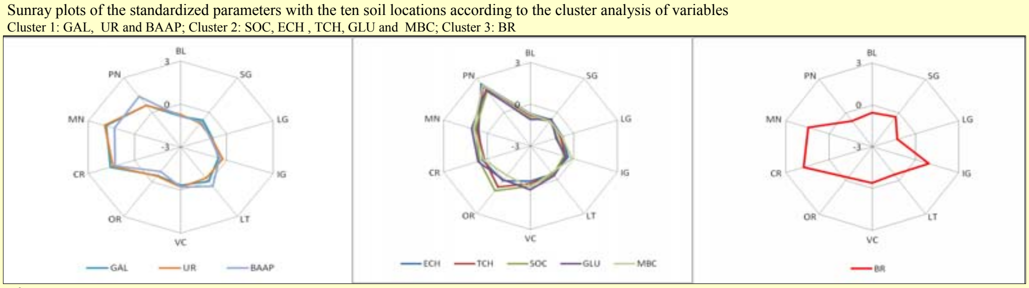
Cluster 1: GAL, UR and BAAP group of enzyme activities that were highly correlated among them, even when MBC was held constant..

Cluster 2: TCH, ECH, SOC ,GLU and MBC group of variables representing the organic matter and the microbial content and its activity.

The five groups of soils that appear in the dendogram are, on the whole (*), in correspondence with the field observations and the soil physicochemical properties

(*) The position in the dendogram of LT and SG soils are anomalous

Sunray plots of the standardized parameters with the ten soil locations according to the cluster analysis of variables
Cluster 1: GAL, UR and BAAP; Cluster 2: SOC, ECH , TCH, GLU and MBC; Cluster 3: BR



CONCLUSIONS

The biochemical properties studied were highly variable between sites, nevertheless two groups of variables were useful to biochemically characterize the ten studied soils

Overall, the studied biochemical parameters were found to be suitable for reflecting the main differences (pH, salinity and $CaCO_3$ content) between soils

References

Badalucco L, Gelsomino A, Dell'Orco S, Grego S, Nannipieri P., 1992. Biochemical characterization of soil organic compounds extracted by 0.5 M K_2SO_4 before and after chloroform fumigation. Soil Biol Biochem 24: 569-578
Bastida, F., Zsolnay, A., Hernández, M.T. García, C., 2008. Past, present and future of soil quality indices: A biologycal perspective. Geoderma 147, 159-171.
Cheshire MV, Mundie CM , 1966. The hydrolytic extraction of carbohydrates from soil by sulphuric acid. J Soil Sci 17: 372-381.
Garcia, C., Gil, F., Hernández, M.T., Trasar, C., 2003 .Técnicas de Análisis de Parámetros Bioquímicos en Suelos. Mundi-Prensa. Madrid
Gil-Sotres, F., Trasar-Cepeda, C., Leirós, M.C.,Seoane, S, 2005. Different approaches to evaluating soil quality using biochemical properties. *Soil Biology and Biochemistry* 37, 877-887
Nelson, D.W., Sommers L.E., 1982. Total carbon, Organic carbon and Organic matter. In Page, A.L., Miller R.H., Keeney D.R. (Eds). *Method of Soil Analysis* Part 2: Chemical and Microbiological Properties Nº9. Agronomy Series. Soil Science Society of America. pp. 570-571.
Trasar-Cepeda, C., Leirós, M. C., Gil-Sotres, F., 2008. Hydrolityc enzyme activities in agricultural and forest soils. Some implications for their use as indicators of soil quality. *Soil Biology and Biochemistry* 40, 2146-2155.
Zornozaa, R.,., Mataix-Solera, J., Guerrero, V., Arcenegui, V., J., Mataix- Beneyto, J., Gómez I., 2008. Validating the effectiveness and sensitivity of two soil quality indices based on natural forest soils under Mediterranean conditions. *Soil Biology and Biochemistry* 40, 2079-2087.

Acknowledgment: We thank Dr M.Mas and Dr. AMC. Verdú for their assistence inthe habitat type classification