Effect of Ph and vegetation cover in soil organic matter structure at a high-mountain ecosystem (Sierra Nevada National Park, Granada, Spain)

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Introduction:

During the last decade, soil organic matter dynamic and its determining factors have received an increased attention, mainly due to the evident implication of these parameters in climate change understanding, predictions and possible management.

High-mountain soil could be consider as hotspot of climate change dynamic since its high carbon accumulation and low organic matter degradation rates could be seriously altered by slight changes in temperature and rainfall regimens associated to climate change effects. In the particular case of Sierra Nevada National Park, this threat could be even more severe due to its Southern character, although its elevated biodiversity could shed some light on how could we predict and manage climate change in the future.

Quantitative and qualitative organic matter characterization and soil microbial activity were measure in order to evaluate the implication of soil pH and vegetation in soil organic dynamic at this particular high-mountain environment at Sierra Nevada National Park

Figure 2. Sampling areas location in Sierra Nevada National Park (Granada, Spain). Numbers meaning is described in table 1

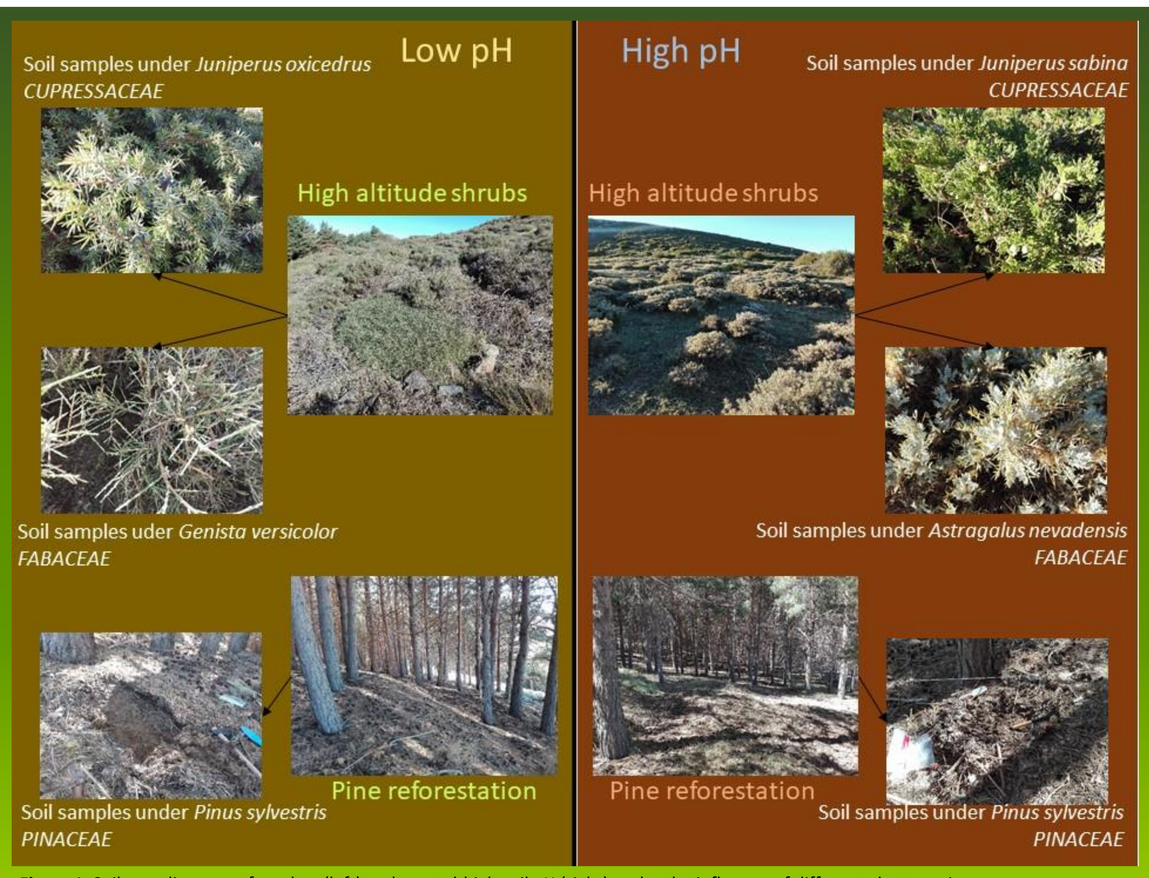

Figure 1. Soil sampling areas from low (left) and neutral-high soil pH (right) under the influence of different plant species

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Table 1. Vegetation and location of sampling areas. *Plant community according to Martinez-Parra y Peinado (1987).

Area	Plant community	Species sampled	Soil pH	Altitude (m.a.s.l.)	Location
1	Genisto-Junipereto nanae S. *	*Juniperus oxicedrus* (ENE) *Genista versicolor* (PIO)	5.6	2180	37º06'47.6"N 3º25'14.6"W
2	Pine reforestation	*Pinus sylvestris* (PSI)	5.8	2180	37º06'40.9"N 3º25'10.0"W
3	Daphno-Pineto sylvestris S. *	*Juniperus sabina* (SAB) *Astragalus nevadensis* (AST)	7.4	2105	37º07'18.9"N 3º25'21.2"W
4	Pine reforestation	*Pinus sylvestris* (PCA)	7.3	1870	37º07'45.3"N 3º25'38.4"W

Material and methods:

Study area:
The area of study was located in the surrounding of Sierra Nevada National Park, Granada, Southern Iberian Peninsula. Four sampling areas (Figure 2) were selected according to vegetation and soil pH.

Experimental design:
In this study, we selected two sampling areas with distinct soil pH (area A with pH<7 and area B with pH>7) and vegetation (high-mountain shrubs and pine reforested area). Soil samples were collected under the influence of plant species representatives of each vegetation series (Figure 1). Six samples (5 times replicated) were finally obtained. A description of the sampling sites is detailed in table 1.

Soil parameters studied:
Soil characterization was done in four areas in order to stablish possible influencing parameters different of soil pH or vegetation (data not show).
Qualitative and quantitative analyses of soil organic matter were made to stablish possible relationship with microbial activity estimated by respiration rate (alkali trap) and fungi-to-bacteria ratio (F:B) using a plate count method.
Soil easily oxidizable organic carbon content was determined by Walkley-Black method (SOC %) and organic matter amount was estimated by weight loss on ignition (LOI %).
Analytical pyrolysis (Py-GC/MS) was used to analyse in detail soil organic carbon composition as described in Gonzalez-Perez et al. (2015). Briefly, a direct pyrolysis–gas chromatography–mass spectrometry (Py-GC/MS) analysis was performed using a double-shot pyrolyser attached to a GC/MS system Agilent 6890 N. Samples of 10 mg were placed in small crucible capsules and introduced into a preheated micro-furnace at 500 ◦C for 1 min. The evolved gases were transferred into the GC/MS for analysis.

RESULTS AND DISCUSION

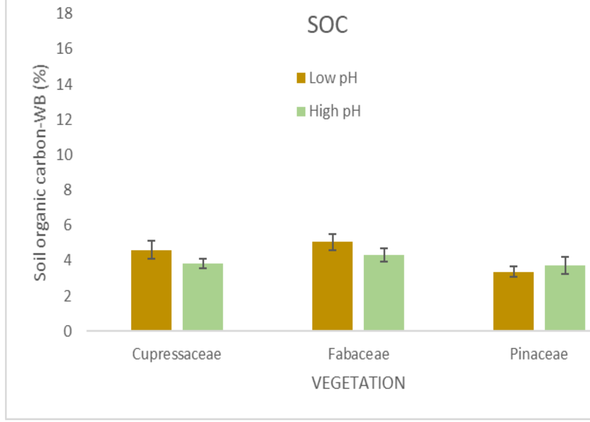

Figure 3. Soil organic carbon content (Mean +/- SE)

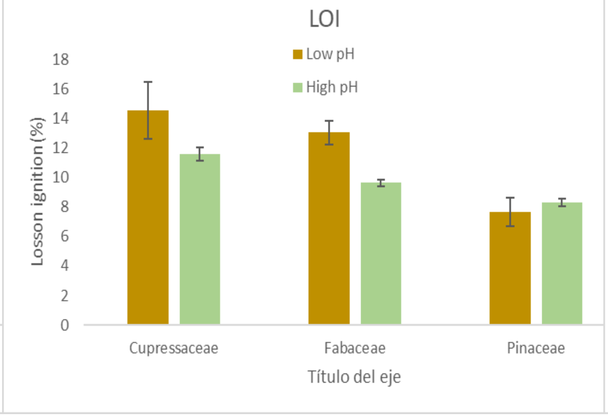

Figure 4. Organic matter by loss-on-ignition. (Mean +/- SE)

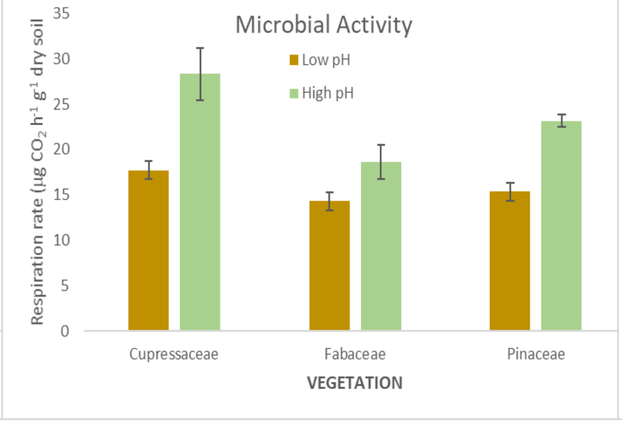

Figure 5. Microbial activity by respiration rate. (Mean +/- SE)

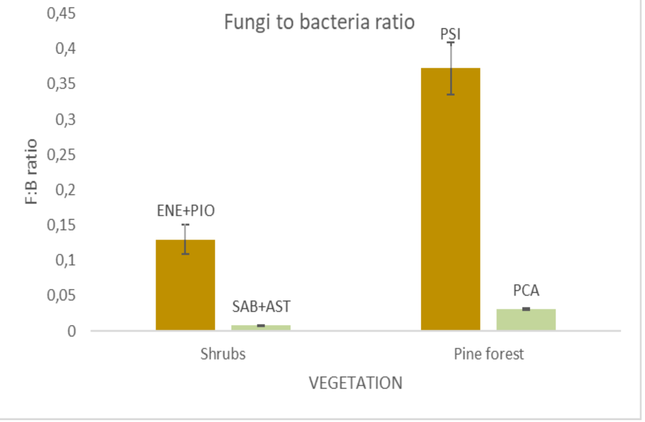

Figure 6. Fungi-to-bacteria ratio estimated by plate count method (Mean +/- SE)

Preliminary result show conspicuous differences among the study areas related to both, vegetation and pH influence. Soil organic carbon content and loss-on-ignition (Fig. 3-4) evidence a higher organic matter accumulation in low pH areas which is also supported by lower respiration rates observed in soils with low pH compared to the microbial activity recorded for high pH soils (Fig. 5).

Py-GC/MS chromatograms normalized to C16 fatty acid (palmitic acid) show marked differences in the SOM from acid and basic reaction soils. A neat difference in the distribution of lignin derived pyrolysis compound is apparent at first sight of the pyrograms (Fig 7a). The relative abundance of main compounds identified from SOM (Table 2) show higher abundance of lignin biomarkers in high pH soils compared to low pH one (Fig. 7a). This could be related to the higher F:B ratio found in low pH soils (Fig 6), since several fungi species present varied ligninolytic activities that may imply an advantage in the efficiency to degrade this biopolymer compared with bacteria. Other relevant difference found is an apparent selective preservation of mid-long chain alkanes in SOM in acid soils compared to the higher pH ones (Fig 7b) that may indicate a preferential degradation of lipids and waxes in soils with an alkaline reaction. Also, quantitative and qualitative differences are found when examining the fatty acid series (*n*-alkanoic acids) that seems to be better preserved in acid soils (Figure 7c).

The biomarkers released from the fast pyrolysis of SOM are still under study and will be completed including an assessment of SOM degradation status with a detailed analysis of the lignin derived compounds as well as the study of geochemical proxies calculated from the relative chromatographic abundance of alkyl series released after SOM pyrolysis.

Table 2. Main compounds identified from the pyrograms with an indication of its probable biogenic origin. PS: Polysaccharides; PR: Proteins and peptides; ARO: Aromatics of unknown origin; LIG: Lignin and polyphenols; FA: Fatty acids; LIP: Alkane/Alkene doublets from waxes.

Peak	Compound	Origin
1	2-Butenal, 3-methyl-	PS
2	FURFURAL	PS
3	2-Furancarboxaldehyde, 5-methyl-	PS
4	3-Methyl hydantoin	PR
5	p-Cresol	ARO
6	Phenol, 2-methoxy- (GUAIACOL)	LIG
7	Anhydrosugar (LEVOGLUCOSENONE)	PS
8	Anhydrosugar	PS
9	Phenol, 2-methoxy-4-methyl-	LIG
10	Benzofuran, 2,3-dihydro- (Coumaran)	PS
11	2-Methoxy-4-vinylphenol	LIG
12	Phenol, 2,6-dimethoxy- (SIRINGOL)	LIG
13	trans-Isoeugenol	LIG
14	Acetovanillone	LIG
15	n-Dodecanoic acid (FA12)	FA
16	2,6-Dimethoxy-4-vinylphenol	LIG
17	Phenol, 2,6-dimethoxy-4-(2-propenyl)-	LIG
18	Pyrocoll	PR
19	Acetosyringone	LIG
20	n-Tetradecanoic acid (FA14)	FA
21	Alkylfuran (C14)	LIP
22	Branched alkane	LIP
23	Branched alkane	LIP
24	n-Hexadecanoic acid (FA16)	FA
25	Alkene (C22)	LIP
26	Isomer of 25	LIP
27	Alkene (C24)	LIP
28	Erucic acid (13-Docosenoic acid, (Z)-)	FA
29	n-Alkane (C27)	LIP
30	n-Alkane (C29)	LIP
31	n-Alkane (C31)	LIP
32	n-Alkane (C33)	LIP

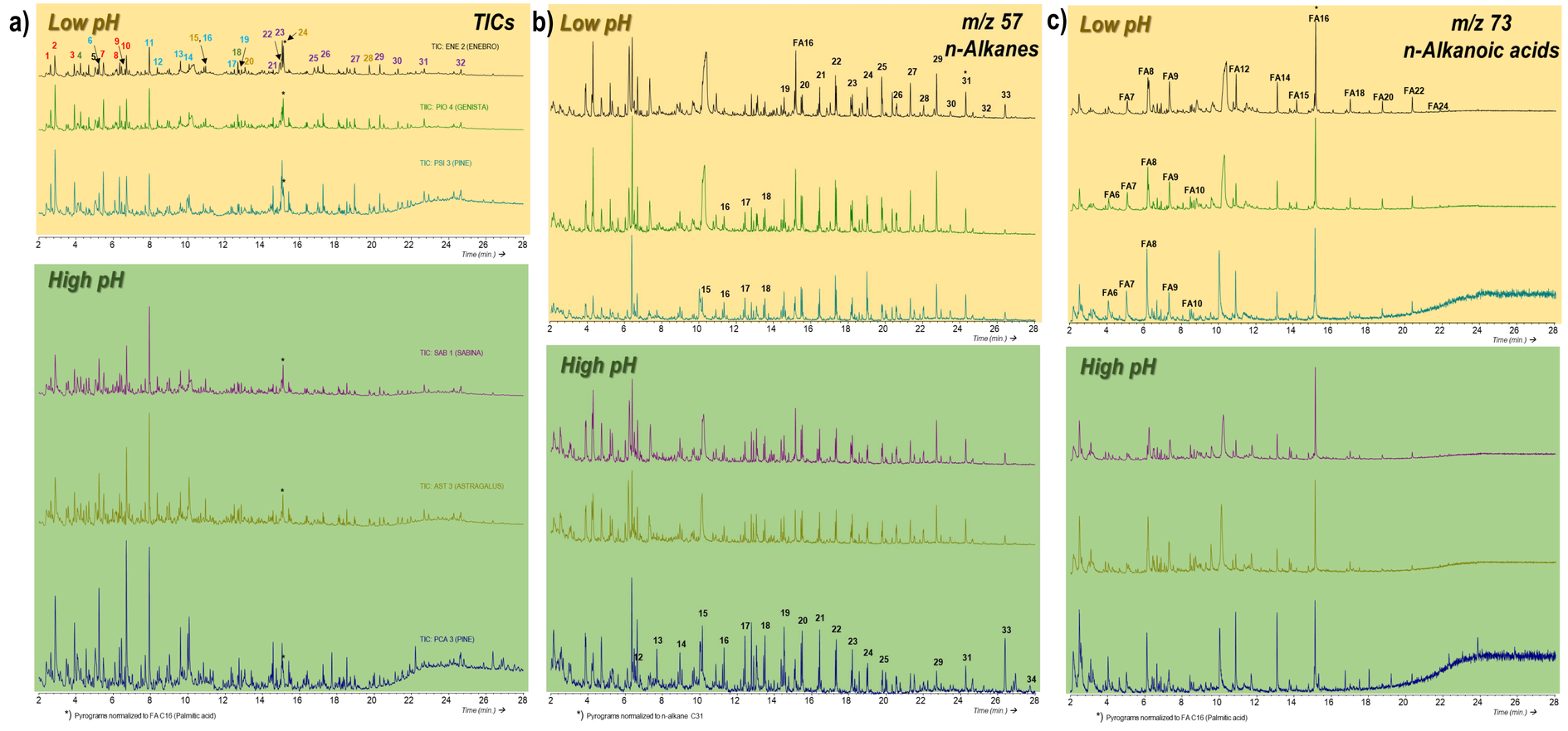

Figure 7. Chromatograms showing the compounds released from the pyrolysis of untreated soil samples. a) Total current ion chromatogram (TIC) numbers on peaks correspond with compounds listed in Table 2. b) Chromatogram showing the series of *n*-alkanes with m/z 57. c) Chromatogram showing the series of *n*-alkanoic acids (fatty acids) with m/z 73.

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