



## Post-fire mineral N allocation and stabilisation in soil particle size fractions in Mediterranean grassland and shrubland



Mireia Martí-Roura<sup>a,\*</sup>, Pere Rovira<sup>b</sup>, Pere Casals<sup>b</sup>, Joan Romanyà<sup>a</sup>

<sup>a</sup> Universitat de Barcelona, Dept. Productes Naturals, Biologia Vegetal i Edafologia, Joan XXIII s/n, 08028 Barcelona, Spain

<sup>b</sup> Centre Tecnològic Forestal de Catalunya, Ctra. St. Llorenç de Morunys, Km 2, 25280 Solsona, Spain

### ARTICLE INFO

#### Article history:

Received 5 September 2013

Received in revised form

2 April 2014

Accepted 6 April 2014

Available online 21 April 2014

#### Keywords:

Physical size fractionation

<sup>15</sup>N-recovery

Biochemical recalcitrance

N-fixing plant

### ABSTRACT

In the Mediterranean region, long-term post-fire soil N dynamics may be relevant in the stabilisation of soil organic matter and N cycling in the plant-soil system. Post-fire recycling of N may be retained by the retention of N in physically and/or chemically protected fractions of soil organic matter. We studied the allocation of post-fire <sup>15</sup>N-tracer among different soil organic matter fractions (coarse sand, fine sand, coarse silt and fine silt + clay) and <sup>15</sup>N-tracer dynamics for 12 years after prescribed fires in three different Mediterranean plant communities (grassland, mixed shrub-grassland and shrubland). We selected 6 plots for each community and we set experimental fires. Directly after the fires, we applied <sup>15</sup>NH<sub>4</sub><sup>+</sup>-N and we monitored the fate of <sup>15</sup>N-tracer over a period of 12 years. For this purpose, we carried out a physical size fractionation and we analysed the biochemical recalcitrance of N and <sup>15</sup>N by acid hydrolysis in the size fractions obtained. In both burned and unburned plots the finest soil particles (<20 μm) accounted for most soil N. Fire promoted N increases in the medium size fractions while the N pool in the finest and coarsest fractions did not change after the fires. Interestingly, <sup>15</sup>N-tracer was quickly incorporated into fine fractions from which, in the case of plant communities free of legumes, it was remobilised in the following years. Fire did not promote changes in recalcitrant N, but shrubland showed marked decreases in N recalcitrance 6 years after the fires. Despite the fact that the primary effects on soil fractions were detected just after the fires, these persisted for 12 years post-fire. Newly incorporated <sup>15</sup>N-tracer was less recalcitrant than total N and, surprisingly, fine fractions had very low recalcitrant <sup>15</sup>N values, similar to the coarse fractions. Apparently, the N transformations in the finest fraction (<20 μm) were mainly regulated by the quality of the <sup>15</sup>N compounds retained in the fraction.

© 2014 Elsevier Ltd. All rights reserved.

### 1. Introduction

Fire can cause complex alterations to the physical and chemical properties of soil. Fires immediately decrease the amount of labile organic matter (either by direct combustion or thermal breakdown) and enhance both the availability of plant N and the recalcitrance of organic matter pools (Almendros et al., 1992; Fernández et al., 1999). Although N volatilization is produced at relatively low temperatures (200 °C) and large amounts of N can be lost during fires, mineral N pools, mainly ammonium, increase in the uppermost soil layers as a consequence of temperature induced mineralization and ash deposition (Rapp, 1990; Martí-Roura et al., 2013). On the other hand, soil heating during fires can promote changes in soil N-forms to more chemically recalcitrant forms (Sánchez and

Lázari, 1999) by increasing heterocyclic and aromatic N (Knicker et al., 2005). The high biochemical stability of these fire-induced recalcitrant N-forms can render them difficult to mobilize by microbial processes, and therefore are able to remain in soils for years (Rovira et al., 2012). This effect may hold back primary production in the long-term (Knicker and Skjemstad, 2000).

Post-fire soil mineral N, if not lost by leaching or volatilization, can be assimilated by regrowing plants or incorporated into soil organic matter (SOM) and stabilized. SOM stabilisation can occur through physical protection or by chemical recalcitrance (Dungait et al., 2012). Physical protection can take place through SOM incorporation within aggregates through nanopores too small for organisms or enzymes to enter and function (Skjemstad et al., 1993; Mayer, 1994) by encapsulation into hydrophobic macromolecules (Knicker and Hatcher, 1997), or by the formation of organo-mineral-associates (Baldock and Skjemstad, 2000). This latter mechanism has been considered the most important for the physical protection of organic matter (Kögel-Knabner et al., 2008).

\* Corresponding author. Tel.: +34 934024494.

E-mail address: [mmarti@ub.edu](mailto:mmarti@ub.edu) (M. Martí-Roura).

The chemical recalcitrance of decomposition residues can also delay SOM decomposition. Aromatic and/or O-alkyl compounds can be difficult to be metabolized by soil microbes (Almendros et al., 1984; Kalbitz et al., 2003). The prevailing view is that chemical recalcitrance plays a secondary role in SOM stabilisation (Mikutta et al., 2006; Marschner et al., 2008; Rovira et al., 2010; Dungait et al., 2012). However, in a recent field study it has been shown that N-rich labile organic matter from an incubation of labelled roots within the soil was recovered primarily in the protected fractions whereas the more recalcitrant fraction remained mostly unprotected (García-Pausas et al., 2012). Therefore, physical protection and chemical recalcitrance may work simultaneously and sometimes in a complex manner since labile and recalcitrant organic pools are not evenly distributed among the physical fractions (Rovira and Vallejo, 2007; Rovira et al., 2010).

Quick plant regeneration and N use post-fire can largely reduce N losses from the system. After this, N will return to the soil through plant litter deposition and, depending on SOM quality, will be retained in the soil over the short and long-term. The interactions between plant litter and SOM pools of different nutrient richness or chemical recalcitrance can shape the microbial processes thereby transforming the pools of soil organic matter and nutrients (Madritch and Cardinale, 2007). These interactions are likely to occur in diverse plant communities with contrasting litter quality such as in those with a significant presence of legumes or a combination of woody and green plant material. The quality of the soil organic matter pools and of the new plant litter produced post-fire in the regrowing plant communities can regulate the post-fire allocation and stabilisation of mineral N in SOM (Zhu and Wang, 2011).

We hypothesise that after fire the stabilisation of the mineral N pool allocated in soil particle size fractions will depend both on the physical protection and the chemical recalcitrance of the SOM pools in each fraction. While N allocated to coarse fractions will be stabilized mainly by its biochemical recalcitrance, N held in fine fractions will mostly be physically protected with little influence on its biochemical quality. Different plant communities and especially those with the presence of legumes can also influence the quality of the organic sources and SOM pools and, consequently, N stabilisation processes.

Our aim was to study the allocation and physical and chemical stabilisation of the N pool which appears shortly after fire among different particle size fractions over a 12-year period in three different Mediterranean plant communities (grassland, mixed shrub-grassland, shrubland). With this purpose in mind, we applied  $^{15}\text{N}$  isotopic labelling on ashes just after a fire and we assessed changes in the total N and  $^{15}\text{N}$ -tracer in different physical size fractions and in the recalcitrant pool of each fraction in the following 12 years post-fire.

## 2. Material and methods

### 2.1. Study site

The study was carried out at three different plant communities located in abandoned fields in the North East of Iberian Peninsula ( $41^{\circ} 56' \text{ N}$ ,  $0^{\circ} 37' \text{ E}$ , 460 m a.s.l.). These terraced fields were abandoned in early 1960s. The three different plant communities which now occupy the old fields are representative of Mediterranean set-aside land: grassland dominated by the perennial grass *Brachypodium retusum* (Pers.) Beauv.; mixed shrub-grassland dominated by the legume shrub *Genista scorpius* L. in Lam et DC and the grass *B. retusum* and shrubland dominated by *Rosmarinus officinalis* L. The climate is dry Mediterranean continental, with a mean annual temperature of  $13.5^{\circ}\text{C}$  and mean annual precipitation of 516.9 mm

(observation period: 1996–2008; Monestir de les Avellanès,  $41^{\circ} 52' \text{ N}$ ,  $0^{\circ} 45' \text{ E}$ , 580 m a.s.l.). Rainfall distribution is markedly seasonal, with maximum values in spring and autumn and a dry season that usually lasts from June to September. The soils are Calcaric Cambisol (FAO, 2006), developed from a fine textured Eocenic limestone and marl colluvium, with a pH ( $\text{H}_2\text{O}$ ) of 8.2, 60% calcium carbonate content and the soil is loam. The study areas had been free of fire and grazing by domestic animals for at least 10 years before the study began.

### 2.2. Experimental design, soil $^{15}\text{NH}_4^+$ labelling and soil sampling

Six pairs of plots (from 20 to 60  $\text{m}^2$ ) of each vegetation type were selected in different terraces (18 pairs of plots in total). In 1996 a plot of each pair was experimentally burned while the other remained as a control plot, representing the undisturbed state. Fire intensity was low to medium, with maximum temperatures at ground level from 300 to 526  $^{\circ}\text{C}$ . See Romanyà et al. (2001) for more details.

Three days after the fires, one subplot of  $2 \times 2 \text{ m}$  was bordered in each burned plot and a highly  $^{15}\text{N}$ -enriched solution ( $^{15}\text{NH}_4\text{Cl}$ , 99 atom%, 1 kg N  $\text{ha}^{-1}$ ) was applied on the ashes of these subplots in order to label the post-fire mineral N pool. Subplots were divided in 64 squares ( $25 \times 25 \text{ cm}$ ); each square was sprinkled with 18.75 ml of  $^{15}\text{NH}_4\text{Cl}$  solution (1 l  $\text{m}^{-2}$  of 0.333 mg  $^{15}\text{N l}^{-1}$ ) in order to homogenize  $^{15}\text{N}$  labelling on the subplots surface. See Casals et al. (2005) for more details.

From each plot, three soil cores ( $5 \times 5 \text{ cm}$ ) from 0 to 5 cm depth were taken and pooled into one sample. Sampling was carried out 3 days (just 10 min after labelling), 6 years and 12 years post-fire in  $^{15}\text{N}$ -labelled and burned plots and 3 days post-fire in unburned plots. Then soil samples were air-dried and sieved (2 mm) before fractionation.

### 2.3. Particle size fractionation of soil organic matter

The size fractionation method follows essentially that given in Rovira et al. (2010), with the main difference that, as in this experiment we did not attempt to separate fine silt from clay, the strength of the ultrasonic treatment was lower than in the original procedure (600 J  $\text{ml}^{-1}$  vs 1200 J  $\text{ml}^{-1}$ ). Size fractionation methods by wet sieving have been successfully used as alternative methods to other fractionation methods such as density fractionation (Rovira and Vallejo, 2007; García-Pausas et al., 2012; López-Sangil and Rovira, 2013). This simple, reliable and inexpensive method uses water as the only solvent that may affect the obtained fractions and, for this reason, fractions are chemically unaltered and can be used in further analyses.

Briefly, 10 g of air dried 2 mm sieved soil were softly shaken for 1 h with 50 ml water and two glass beads. Then the beads were removed, and the soil-water mixture was placed in an ice bath and dispersed with a sonifier Branson model 250 (5 min, 600 J  $\text{ml}^{-1}$ ). The dispersed mixture was then passed through a column of meshes (200, 50 and 20  $\mu\text{m}$ ) under magnetic agitation and an extensive water flush, thus obtaining the 2000–200 (coarse sand; CSa), 200–50 (fine sand; FSa), and 50–20  $\mu\text{m}$  (coarse silt; CSi) size fractions. All of these fractions were collected in 20 ml flasks. The <20  $\mu\text{m}$  fraction (fine silt plus clay; FSi + C) was collected in 1-l jar, flocculated with a minimum amount of a saturated solution of  $\text{AlK}(\text{SO}_4)_2$  and recovered by centrifugation. After the fractionation method 4 fractions were obtained: CSa, FSa, CSi and Fsi + C. All fractions were dried at  $60^{\circ}\text{C}$ , until constant weight. A subsample of each obtained size was finely ground to analyse the total organic C (TOC), and the total N and  $^{15}\text{N}$  enrichment. TOC was analysed by dichromate oxidation (Mebius, 1960) adapted to a colorimetric

Download English Version:

<https://daneshyari.com/en/article/8364718>

Download Persian Version:

<https://daneshyari.com/article/8364718>

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