Soil Biology & Biochemistry 43 (2011) 693–696

Contents lists available at ScienceDirect

Soil Biology & Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Short Communication

Depolymerization and mineralization rates at 12 Mediterranean sites with varying soil N availability. A test for the Schimel and Bennett model

Manuel Delgado-Baquerizo*, Antonio Gallardo

Departamento Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Carretera de Utrera km. 1, 41013 Sevilla, Spain

ARTICLE INFO

Article history:
Received 27 July 2010
Received in revised form
16 November 2010
Accepted 26 November 2010
Available online 14 December 2010

Keywords:
Nitrogen cycle
Ammonification rate
Nitrification rate
Soil DON
Soil ammonium
Soil nitrate

ABSTRACT

It has been suggested that the relative abundance of soil nitrogen forms should change along an N availability gradient. This model was originally described at a biome scale, and few studies have tested it at other scales. Moreover, none of them has examined whether changes in the relative rates of ammonification, nitrification and depolymerization rates also occurs. Our goal was to test whether these N transformation rates change along an N availability gradient which is likely to exist between forest, shrubs and grasses. We used three N availability indexes (total K_2SO_4-extractable N, ion exchange membrane N and the sum of N mineralization and depolymerization rates). Depolymerization dominated over mineralization in the two poorest plant communities, while ammonification and nitrification rates dominated in intermediate and nutrient rich plant communities respectively. These results confirm that the Schimel and Bennett model can be applied at a regional scale, and that N availability may be modulating not only the dominant N form, but also the relative abundance of a particular N transformation rate.

Schimel and Bennett's (2004) model suggested a decrease in dissolved organic nitrogen (DON) released from soil organic polymers and parallel increase in importance of N mineralization with increasing N availability. This model integrated the importance of the microsite phenomena, where N-poor microsites would be dominated by dissolved organic nitrogen (DON) and N-rich microsites by NH_4^+ and on the richest by NO_3^-. These shifts in the relative abundance of N forms along a gradient of N availability are beginning to be corroborated by experimental data (Christou et al., 2005; Delgado-Baquerizo et al., 2010). However, changes in the relative abundance of related soil N transformation rates (such as ammonification, nitrification and depolymerization rates), have not been described before. While soil pools of N forms represent the complex balance between microbial production, plant and microbial consumption and losses from soil, N transformation rates of these N processes are the result of the microbial activity alone. The N depolymerization process (the N transformation from soil and litter polymers into dissolved monomers), is considered a critical step within the new paradigm of the soil N cycle, but it has been little studied (Berthrong and Finzi, 2006; McCulley et al., 2009; Rothstein, 2009). Our goal was to test whether the Schimel and Bennett model is directly applicable to the depolymerization and mineralization rates observed at the regional scale defined by a wide range of Mediterranean terrestrial ecosystems, including sites in south–west, central and north–west Spain. We intended to reach a better understanding of how the microbial processes modulating the presence of each N form are distributed along a natural N availability gradient, to develop a more complete picture of how N cycling varies among terrestrial ecosystems.

The study was conducted in 12 natural plant communities of Spain chosen to represent a wide spectrum of Mediterranean ecosystems, ranging from sand dunes to late successional evergreen forests. Table 1 shows the location, soil and vegetation characteristics for each plant community. The soil sampling was carried out in spring 2008, the most biologically active season. Five soil samples from the top 10 cm of mineral soil profile were collected for each plant community. Experimental determination of soil nutrient availability to plants and soil microbes is not straightforward (Frank and Groffman, 2009), therefore we chose three different approaches to the available N concept proposed by Schimel and Bennett: i) total $K_2SO_4^-$ extractable N (the sum of DON, NH_4^+–N and NO_3^-–N concentrations), already used in other papers (Christou et al., 2005; Delgado-Baquerizo et al., 2010); ii) ion exchange membrane N (IEM available N) which includes the effect of soil N diffusion (Subler et al., 1995), and iii) N transformation rates (the sum of potential net N depolymerization and mineralization rates), because both processes are responsible for the replenishment of available N within soils (Schimel and Bennett,

* Corresponding author.
E-mail address: mdelbaq@upo.es (M. Delgado-Baquerizo).

0038-0717/$ – see front matter
doi:10.1016/j.soilbio.2010.11.030

Table 1
Location, soil properties, and plant composition of the sampled plant communities arranged according to decreasing C-to-N ratio. Vigo and Aranjuez sites are located at NW and Center Spain, respectively. All other sites are located at SW Spain.

Plant community	Type	Location	Coordinates	FAO soil classification[a]	Dominant vegetation	pH (H_2O)	C (%)	N (%)	Silt (%)	Clay (%)	Sand (%)
Ammophila arenaria (AA)	Costal sand dunes	Matalascañas	36°59′N 6°31′W	Cambic arenosol	*Ammophila arenaria subsp. Australis. Medicago marina. Corema álbum*	7.83	0.2	0.01	4.6	3	91.5
Mediterranean Shrubland (MS)	Shrubland	Matalascañas	37°01′N 6°34′W	Eutric regosol	*Lavandula stoecha. Corema album. Rosmarinus officinalis*	7.15	0.87	0.05	6.7	6	87.3
Mediterranean cork-oak Dehesa (COD)	Oak grassland	Almonte	37°15′N 6°28′W	Orthic luvisol	*Quercus suber. Chamaerops humilis. Cistus salvifolius. Lavandula stoecha*	6.61	0.72	0.05	2.5	3	95.7
Olea europaea (OE)	Evergreen forest	Alcalá de los Gazules	36°28′N 5°37′W	Eutric cambisol	*Quercus suber. Labandula stoechas. Digitalis purpurea. Ruscus hypophyllum*	6.45	1.38	0.11	76.0	14.1	9.9
Pinus pinaster (PPI)	Pine forest	Vigo	42°10′N, 8°40′W	Humic cambisol	*Pinus pinaster*	4.99	13.26	1.12	11.0	12.5	75.5
Juniperus phoenicia (JP)	Juniper forest	Matalascañas	37°01′N 6°34′W	Eutric regosol	*Juniperus phoenicia. Lavandula stoecha. Corema album. Rosmarinus officinalis*	7.15	1.71	0.15	6.7	6	87.3
Pinus pinnea (PP)	Pine forest	Hinojos	37°16′N 6°23′W	Eutric planosol	*Pinus pinnea. Chamaerops humilis. Ruscus Aculeatus. Rosmarinus officinalis*	6.48	0.76	0.07	2.0	5	93.0
Mediterranean floodplain forest (FPF)	Deciduous forest	El Rocío	37°08′N 6°32′W	Eutric fluvisol	*Fraxinus angustifólia. Salix atrocinerea. Frangula alnus*	6.67	5.4	0.50	9.4	0.6	88.3
Mediterranean holm-oak Dehesa (HOD)	Oak grassland	Villamanrique de la Condesa	37°14′N 6°17′W	Eutric planosol	*Quercus ilex. Pinus Pinnea*	7.02	0.2	0.02	3.2	7.3	90.7
Cork-oak forest (QS)	Oak forest	Los Barrios	36°16′N 5°34′W	Eutric cambisol	*Quercus suber. Labandula stoechas. Digitalis purpurea. Ruscus hypophyllum*	5.93	3.33	0.36	0	33	67.0
Stipa tenacissima (ST)	Semi arid grassland	Aranjuez	39°59′N, 3°37′W	Xeric haplogypsisol	*Stipa tenacísima. Retama sphaerocarpa*	7.65	1.50	0.18	29.2	6.7	64.1
Retama sphaerocarpa (RS)	Shrubland	Aranjuez	39°59′N, 3°37′W	Xeric haplogypsisol	*Stipa tenacísima. Retama sphaerocarpa*	7.49	3.2	0.40	28.4	7.9	63.7

[a] Soil type was classified according to FAO (1974).

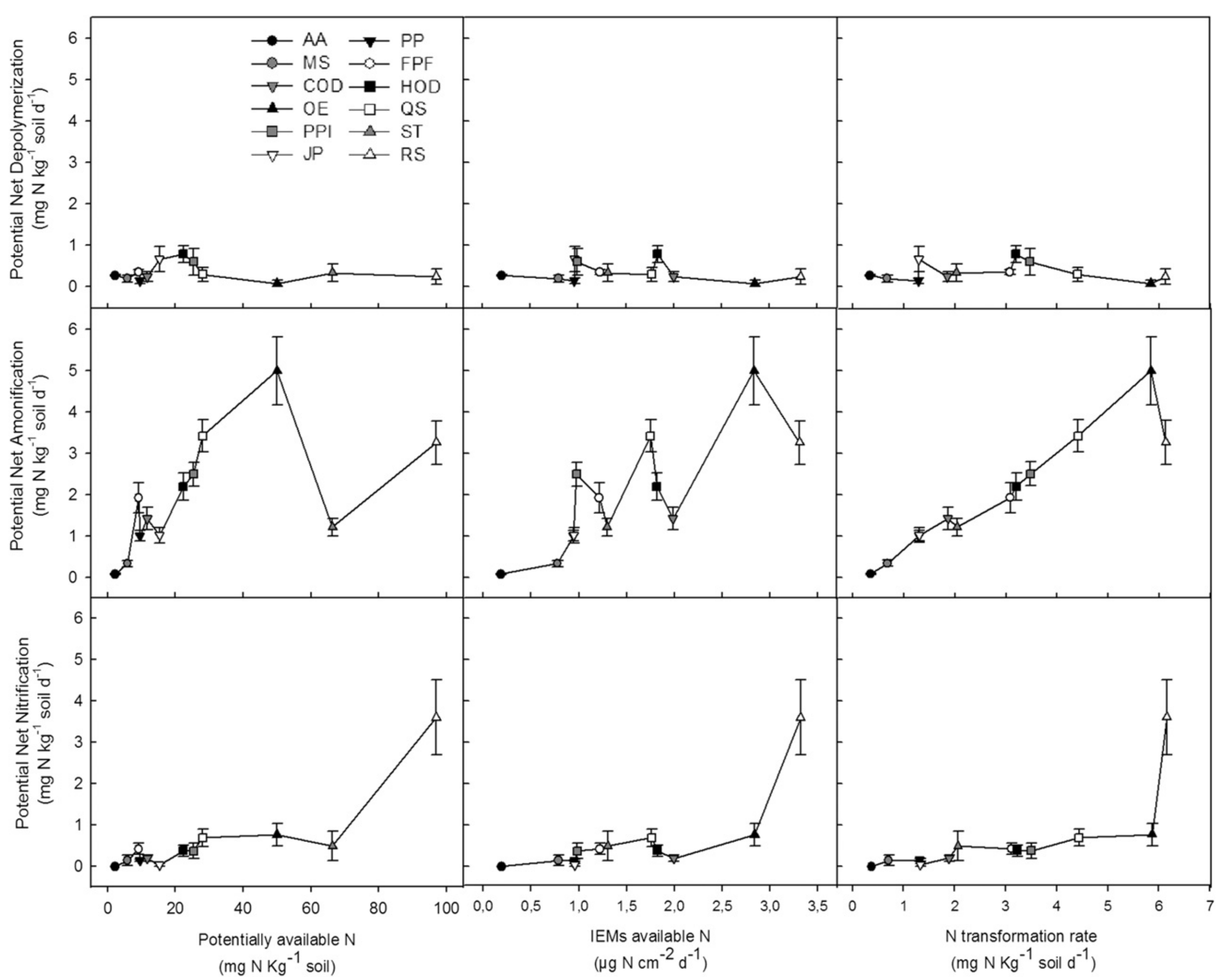

Fig. 1. Potential net depolymerization, ammonification and nitrification rates as a function of N availability gradients. Site legends as in Table 1. Letter codes arranged according to decreasing C-to-N ratio. Data represents means ± SE. Potentially available N refers to K_2SO_4-extractable N.