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Effects of associating a N-fixer species to monotypic oak plantations on the quantity and quality of organic matter in minesoils

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Abstract

Two soils developed over 21 years on a homogeneous mine spoil bank — one under a pure plantation of *Quercus robur* L., the other under a mixed plantation *Q. robur* L. and N-fixer *Alnus cordata* Loisel. — were compared and contrasted in terms of quantity and quality of organic matter. The amount of both organic C and N are significantly higher in the mixed stand, with the differences confined to the mineral topsoil. Soil organic matter (SOM) was extracted by alkali and fractionated on a molecular weight basis. In terms of C, the extracted SOM amounted to about half of the total and the fraction <50,000 Da was more abundant than the >50,000 Da in the organo-mineral aggregates from the forest floor while the two fractions were equivalent in the mineral soil. In the mixed stand, the soil sampled under the oak canopy and that sampled under the alder canopy were processed separately. The whole extracted SOM and the soil residue were analysed for C/N ratio and spectroscopic properties (CP/MAS ^{13}C NMR). The qualitative differences are less evident than the quantitative ones, and often hardly interpretable. Nonetheless, some of the differences are clear and, together with morphological features, such as the presence only in the mixed stand of patches of a darker A material, indicate an effective role of the N-fixer species on both pedogenic processes and C cycle in this human-made environment.

Keywords: Alder; Afforestation; C sequestration; Nuclear magnetic resonance (NMR); Minesoils; Oak

1. Introduction

The increasingly negative impacts of climate change require countermeasures to limit the release of greenhouse gases and/or favour their sequestration from the atmosphere into relatively inert pools. Photosynthesis removes CO_2 — the most important greenhouse gas — from the atmosphere and converts it into organic compounds that, once in the soil, can be stabilized against decomposition for long periods of time (Scharpenseel, 1993). Minesoils typically have negligible initial organic matter content, but a considerable potential to accumulate it. Afforestation is an effective land use to introduce organic C in these anthropogenic soils (see the review by Rhoades et al., 2001, on C storage in U.S. post-mining reclaimed lands). However, the effectiveness of only a few tree species to achieve this has been studied (Fettweis et al., 2005; Nicolini and Topp, 2005). Hence there is a serious lack of knowledge in this regard. Even less is known about the effects of including a N-fixer species in monotypic plantations on reclaimed minesoils. Based on the findings collected in natural soils, these effects should be positive. In fact, it has been demonstrated that the natural invasion or human-induced introduction of N-fixer species in forests of non-fixer ones not only improves biomass productivity (DeBell and Radwan, 1979; Hanson and Dawson, 1982; Cote and Camire, 1984; Kimble et al., 2003) but, more importantly in terms of atmospheric CO_2 abatement, induces an increase in soil organic matter (Binkley, 1983; Cote and Camire, 1984; Johnson, 1992; Cole et al., 1995; Fisher and Binkley, 2000; Torbert and Burger, 2000). From a meta-analysis of data reported in 16 different publications, Johnson and Curtis (2001) concluded that the introduction of N-fixers causes a statistically significant positive increase in the concentration of both soil N and C. However, this analysis did not take into account minesoils, likely because there is little in the literature dealing with the amount of organic matter that can be accumulated by

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