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Impact of organic amendments on plant biomass and carbon transfer in the soil

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The demographic explosion, together with the increase of the CO_2 concentration in the atmosphere require the development of agricultural systems allowing to intensify crop production while maintaining soil quality. The agricultural use of organic amendments, such as (vermi)composts (i.e. organic wastes resulting from a biological decomposition with or without earthworms), provides a sustainable method to incorporate nutrients and organic carbon in soils and to potentially mitigate climate change (Abraham et al. 2014). However, (vermi)composting production and application to soil generates high quantities of greenhouse gases. These emissions were reduced by 40% using additives such as clay minerals during the production of co-(vermi)composts (Barthod et al. 2016). Little is known about the impact of co-(vermi)composts on plant growth and the soil carbon cycle. In the present study, we investigated (1) the effect of co-(vermi)composts (with clay mineral additives) on root and shoot biomass production of two contrasted plants (Fabaceae and Poaceae) and (2) the transfer of plant-derived carbon into different soil compartments.
Our conceptual approach consists of continuous stable isotope labeling (mean δ13C of the atmosphere 868‰ of ryegrass (Lolium perenne) and haricot (Phaseolus vulgaris L.) grown in microcosms filled with an Arenic Cambisol, which had been amended with four different composts: regular vermicompost, regular compost, vermicompost produced with 30% montmorillonite or compost produced with 30% montmorillonite (ratio soil:compost - 17.5:1, w:w). Six weeks after sowing, shoots, roots, rhizospheric and bulk soils were manually separated and the biomass of shoots and roots were quantified. Carbon, nitrogen and δ13C values were obtained for plant and soil samples using elemental analysis coupled to isotope ratio mass spectrometry (EA-IRMS). Two samples presenting contrasting elemental and isotopic results were selected for nano-scale secondary ion mass spectrometry (nanoSIMS) analyses in order to depict organo-mineral interactions and the incorporation of 13C at the root-soil interface. Secondary ion images of 12C, 13C, 12C14N, 16O and 56Fe16O were obtained for both resin embedded and soil suspension deposited on a silica wafer samples.
Our results showed that the addition of minerals during co (vermi-) composting increased root and shoot biomass production of both plants compared to regular (vermi)compost. The plant biomass was significantly reduced in the presence of vermicompost compared to co-vermicompost, especially for ryegrass (around six-fold lower for roots and shoots). The rhizosphere represented a hotspot for plant-derived carbon compared to bulk soil, as reflected by the higher δ13C values in this compartment, especially with co-(vermi)compost. The use of clay minerals during (vermi)composting has a beneficial impact on plant growth, likely reflecting the structuring, as well as organic carbon and nutrient adsorption capacities of clay minerals.

Abraham, B. et al., 2014. The system of crop intensification: reports from the field on improving agricultural production, food security, and resilience to climate change for multiple crops. Agriculture & Food Security, 3(1), p.4.
Barthod, J. et al., 2016. The effects of worms, clay and biochar on CO_2 emissions during production and soil application of co-composts. Soil, 2(4), pp.673–683.